SELF CHECKOUT SYSTEM

Capstone Project Report

END-SEMESTER EVALUATION

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ABSTRACT

In today's world, there is a dire need to revolutionize how we shop in our daily lives, majorly how we shop at super markets, where we have to stand in long queues just to checkout.

The traditional ways of shopping not only suffers from long waiting queues at the checkout counter but also, some poor user experiences like customers cannot see their bill in real time because of which people might overshoot their budget which alleviates wastage of time on removing redundant items at the checkout counter, furthermore there is no privacy in current ways of shopping and no personalized suggestions based on shopping.

Our solution to this problem is the self checkout system where there is real time bill generation so that no one overshoots their budget,full privacy enabling customers to buy whatever they want without the judgment of others and no long queues.

We are going to make a mobile application which will scan the products before you put it into the cart and you will be seeing a real time bill as you keep on shopping and the trolley will keep on checking for fraudulent cases.

DECLARATION

We hereby declare that the design principles and working prototype model of the project entitled SELF CHECKOUT SYSTEM is an authentic record of our own work carried out in the Computer Science and Engineering Department, TIET, Patiala, under the guidance of Dr. Sharad Saxena during 6th and 7th semester (2021).

Date: 17 December, 2021

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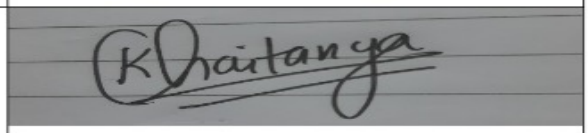
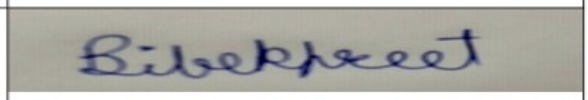
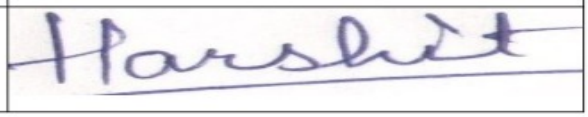
101803269	Chaitanya Kaushal	
101803272	Bibekpreet Singh	
101803276	Harshit Bansal	

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We are also thankful to CSED, Head, Computer Science and Engineering Department, entire faculty and staff of Computer Science and Engineering Department, and also our friends who devoted their valuable time and helped us in all possible ways towards successful completion of this project. We thank all those who have contributed either directly or indirectly towards this project.

Lastly, we would also like to thank our families for their unyielding love and encouragement. They always wanted the best for us and we admire their determination and sacrifice.

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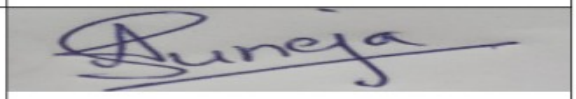
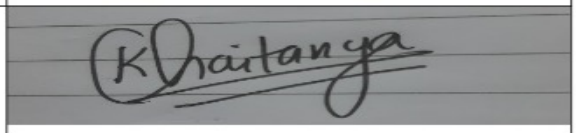
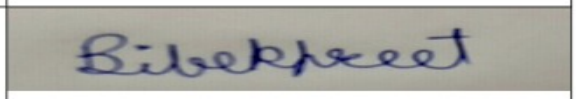
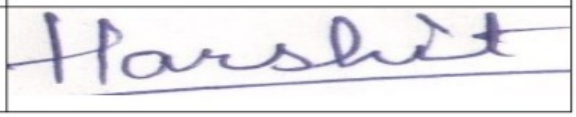
101803268	Ajat Suneja	
101803269	Chaitanya Kaushal	
101803272	Bibekpreet Singh	
101803276	Harshit Bansal	

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LIST OF ABBREVIATIONS

VER	Version
RFID	Radio Frequency Identification
LED	Light- emitting diode
LCD	Liquid Crystal Display
GPS	Global Positioning System
GUI	Graphical User Interface
IOT	Internet of Things
RF	Radio Frequency
CASE	Computer- aided Software Engineering
EEPROM	Electronically Erasable Programmable Read Only Memory
IEEE	Institute of Electrical and Electronics Engineers
MOOC	Massive Open Online Course

CHAPTER 1 : INTRODUCTION

1.1 Project Overview

A stitch in time saves nine. Time is the most valuable resource which needs to be saved. Shopping at market stores expends ample amounts of time at the billing counters by standing in long queues. Thus, self-checkout systems are the need of the hour. In a traditional retail store, much of the employer's cost goes on providing staff to run checkouts. Self service checkout transfers the workload to the customer. Some stores see this opportunity to reduce labor costs and it is often more cost-effective to transfer those staff to other duties, particularly customer service.

Shopping at market stores expends a lot of time at the billing counters by standing in long queues which leads to poor user experience. The employees at the billing counters do the payment work which could otherwise be handled by the customers themselves and are more convenient and in trend. Moreover, a customer does not know what the current bill amount is for the items in the trolley. Thus, the problem statement is to simplify the shopping process and scrutinize ways to tackle and optimize ways for the above-stated problems.

The main purpose of the Shopping Cart Program is to manage Train Information, Orders, Payments, Customer, Category. Contains all information about the Cart Product Category, Cart. The project is built entirely at the end of management and thus only the administrator is guaranteed access. The aim of the project is to create an application system to reduce the manual handling of Cart, Orders, Products, Payments. Tracks all the details about Payment, Customer, Category.

The aim of the project is to implement a self-checkout system which accomplishes the following goals:

- Removal of waiting queues, thus, saving time.

- Handling of fraudulent cases efficiently.
- Real-time bill generation.
- Implementation of online payment options.

This record examines and demonstrates how the technical set of rules model was used to evaluate the commercial business opportunity from a projected period perspective on proposed sales activities. Conceptual technology is made using a double diamond method to guide the team in identifying the technical concept for this challenge. There are four basic strategies within the dual diamond method known as vision, requirements, repetitive planning and vision implementation. Those strategies have been implemented with the help of a team to implement an amazing technical concept, a great way to focus on all the great stores in the United Kingdom. The double diamond method helped the team develop a number of ideas to summarize the concept of a clever trolley based on wording from a target organization among employees. An accurate idea has emerged from the list of technologies selected for this business.

The report discussed the selection of a smart trolley concept using an algorithm application process to evaluate unique business benefits against its risks. In order to come up with clever and modern ideas, the team has transformed it into smaller groups to produce ideas. Each small group was responsible for providing feedback that was managed in such a way as to ensure the needs set for the project. As a group, all ideas have been used and carefully processed to match the scope of using useful technology within the global business.

The concept of a clever chariot is reflected in the many ideas offered to employees primarily on how the concept will be developed into a delightful, easy-to-use, clean and efficient technology product, such as an existing human add-on. -get the gadget. Since the idea was based on generation, it was important to get the consumer opinion that the idea was designed for. The purpose of this was to analyze the state of mind, ideas and expectations of stores and their customers regarding the proposed concept of smart carts in supermarkets in the United Kingdom and perhaps in various European countries. The group had a good response from

major retailers such as Tesco, Asda and Sainsbury after the club's main center contacted them.

The smart trolley idea is based on the most popular automated self-checkout machine in a maximum of United kingdom retail shops. The concept is designed into a smaller version of the automatic self-checkout system on a buying trolley with a consumer interface screen which lets customers make a fee for objects scanned and placed in the trolley before leaving the doorway of the store. That is to release strain at the tills in the course of height.

The clever trolley comes with all the traditional offerings such as scanning an object to take a look at for price and info, also there are other additional functions that could be covered in the layout which includes locating an object in the shop via typing in the item's call in the search discipline on the consumer interface display screen so one can routinely show the object's place in the shop. The smart trolley is designed with security measures to prevent it being wheeled out from the store's premises and additionally to protect purchaser's card information as it's far designed to accept the simplest card fee for items sold in the shop.

Features of buying a cart device are as follows:

- Affords the look of facilities based on various factors which include cart, payment, patron, category.
- It tracks all of the data of orders, merchandise, customers and many others.
- Control the records of orders.
- Indicates the data and outline of the cart, charge.
- All the fields, inclusive of cart, payment, and class, are proven and do no longer take invalid values.
- It generates reports on carts, orders, and products.
- Provide filter reports on payment, purchaser, and class.
- You could easily export the pdf for the cart, merchandise, and customer.
- Utility additionally presents Excel export for orders, fee, class.

- You can additionally export the record into csv layout for carts, orders, and categories.
- To improve the performance of dealing with the cart, orders.
- It offers tracking the information and transactions of clients.
- Modifying, including and updating facts is progress which results in the right aid management of cart records.
- Control the information of clients.
- Integration of all records of class.

1.2 Need Analysis

The problems listed below contribute to poor user experience and thus, arise a much needed solution to make things simpler and easy to use.

- Real-Time Bill Generation: The existing systems do not provide information on what the current bill is. In some cases, the customer might exceed his/her budget and would only be able to know about it at the time of checkout. This leads to poor user experience.
- Long Waiting Queues: The existing systems are unable to tackle this problem. Consider a queue of say three people where the first one has A products in his cart and the second person has B products but the third has only a single item in his cart. In this case, he must wait for a long time till his turn comes.
- Cost to the company: In a traditional retail store, much of the employer's cost goes on providing staff to run checkouts. It is often more cost-effective to transfer those staff to other duties, particularly customer service which promises good user experience.
- Ease-of-use: has been described as the diploma to which a person believes that the usage of a specific device is free of effort. Ease-of-use for that reason relates to the efforts a purchaser needs to make on the way to efficiently use the new provider process and enjoy its anticipated advantage. Self checkout System effort perceptions may be inspired by means of e.g., the bodily vicinity, operating hours, and overall availability of the Self checkout System.
- Ease-of-use reflects the quantity to which clients assume the Self checkout System to be smooth to research and use, and is definitely linked to clients willingness to reuse the Self

checkout System.

- Reliability: It is an important measurement of carrier best, which includes technology-based total offerings. Reliability entails consistency of performance and dependability, or the potential to perform the promised provider dependably and as it should be, as a result lowering perceived risk . consult with reliability as the volume to which the sst constantly and as it should be performs the anticipated project. Reliability accordingly refers to the correct technical functioning of a Self checkout System and the accuracy of carrier shipping. The risks of malfunctioning the Self checkout System include dissatisfaction and lack of income.

1.3 Research Gaps

Title	**Research Gap**	**References**
A Proposed Technique for Implementing Smart Cart Based on Artificial Intelligence	1) Usage of RFID tags for identification 2) Adding extra workload of putting RFID tags on products 3) Every cart has an LCD display adding further cost and removing the possibility of more personalized shopping.	[1]
The RFID Based Cart	1) Usage of RFID tags adds further cost and work to the setup.	[4]
IoT Applications on Secure Smart Shopping	1) RFID, LCD and RFID tagged shelves and payment gateway. 2) Smart shelves are redundant as inventory can be managed on purchase information directly.	[6]
Interactive Shopping Cart Using RFID And ZIGBEE Modules	1) RFID tags are again used along with LCDs, adding further cost and work. 2) Adding LCDs to the carts itself adds a risk factor and less customer personalization.	[7]
An IOT Based Smart Shopping Cart for Smart Shopping	1) It uses RFID, LCD and android applications altogether but the mobile app has no real use. 2) Mobile app is only for making a list from the database.	[8]

TABLE 1: Research Gaps

1.4 Problem Definition and Scope

Shopping at market stores expends a lot of time at the billing counters by standing in long queues which leads to poor user experience. The employees at the billing counters do the payment work which could otherwise be handled by the customers themselves and are more convenient and in trend. Moreover, a customer does not know what the current bill amount is for the items in the trolley. Thus, the problem statement is to simplify the shopping process and scrutinize ways to tackle and optimize ways for the above-stated problems.

The planned realistic booking out tram device intends to assist looking out in-character that is in a function to decrease the extensive amount of it sluggish spent in searching out nevertheless on time required in bcating the desired product comfortably. The purchaser merely should type the call of the products he wants to e book on the automaton device, and so the cart will robotically guide him/her to the product/s locations.

Smart carts could be interfaced with wi-fi technology to make them completely transportable within the near future. Fee of bills victimization can be enforced. A coffee value mobile scanner may be manufactured unit-made and used which may additionally experiment with a couple of tags (products) at the identical time for a faster system and lesser assets. Computerized scanning & accessibility of products could be introduced. Pay programming features are going to be the maximum current fashion in coming years because of the improvement inside the e-trade enterprise.

We also are planning to feature a webcam for detecting the character's face so that the trolley knows its owner. If a GPS is mounted in the system then the proprietor also can understand in which his/her trolley is presently. An interactive LCD, which can display the location of the objects a client wants to shop for, and other information about the scanned product, may be the concept of appending alongside.

The machine which could experiment a couple of tags at a time with 100% accuracy continues to be under development. As soon as it's available, this generation can gain new heights with less time consumption and higher security.

1.5 Assumptions and Constraints

Sr. No.	Assumptions and Constraints
1	Users should have a Smart Phone with internet connection all the time.
2	No two products have similar weight.
3	Shop has a dedicated server.

TABLE 2: Assumptions and Constraints

1.6 Standards

Phase or Activity Group	Number	Standard Title
Requirements Specifications	IEEE 830	Recommended procedure for software requirements.
	IEEE1233	A guide to developing information on system requirements
Design	IEEE 1016	Software design descriptions
	IEEE 1062	Software acquisitions
Implements ,acquisitions and tools	IEEE 1462	Guidelines for evaluations and selection of CASE tools
ESP 12E Module	IEEE 802.11	Microcontroller module for the Internet of Things (IOT)
Testing	IEEE 829	Software test documentation
	IEEE 1008	Software unit testing
	IEEE 1012	Software verification and validation

TABLE 3: Standards

1.7 Objectives

- Scanned items are added to the database and displayed in the mobile application with its price and information.
- Item is removed by scanning it after pressing the delete button.
- System is able to detect fraudulent cases.
    - Unscanned items added in the trolley are detected.
    - Unscanned items removed from the trolley are detected.
    - Scanning item A but putting item B instead of A is detected for unequal weights of A and B.
- The shopping time is reduced by removal of queues.

1.8 Methodology

- Customer enters the mall with the mobile application installed.
- Customer gets a trolley from the trolley stack and enters the trolley number in the application to connect with the trolley database.
- On successful connection the user is directed towards the items list, otherwise the user has to enter the correct trolley number.
- Now the customer proceeds towards shopping and if he wants to add the item in the cart he should press the add button and scan the product barcode and put the product in the cart.
- On successful scan the product is added to the list and the weight of the product is measured with the weight sensors and is transmitted to the database by the arduino installed on the trolley.
- If the weight on cart and product weight is not within the specified range the cart LED is turned red implying there is a problem; otherwise the addition of the product is successful and the LED turns green.
- If the customer wants to remove the item from the list then he would press the delete button in the application and scan the product to be removed.

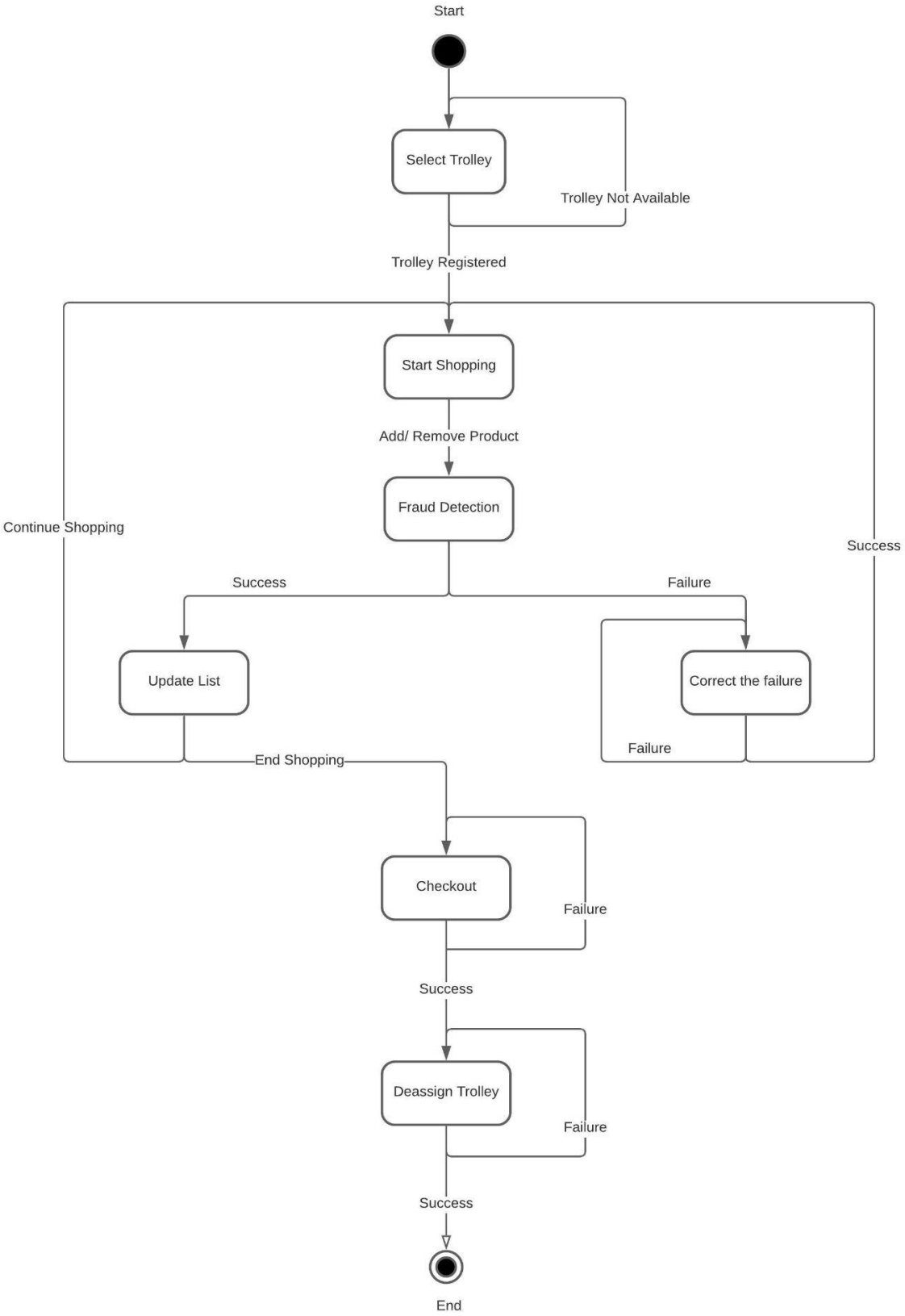


FIGURE 1: Product Overview

- On removing the product from the cart the new weight is transferred to the database and is checked against the weight of the product, if the weight matches the LED turns green otherwise it turns red.
- When the customer is done with his shopping, if the cart LED is green then he would be able to proceed with the bill payment through the application and for that purpose he would have to enter the checkout zone where the guard would only allow those people to enter whose cart LEDs are green and then while the customer is paying the bill the guard would empty the cart products in a bag and on successful payment he would hand over the bag to the customer.

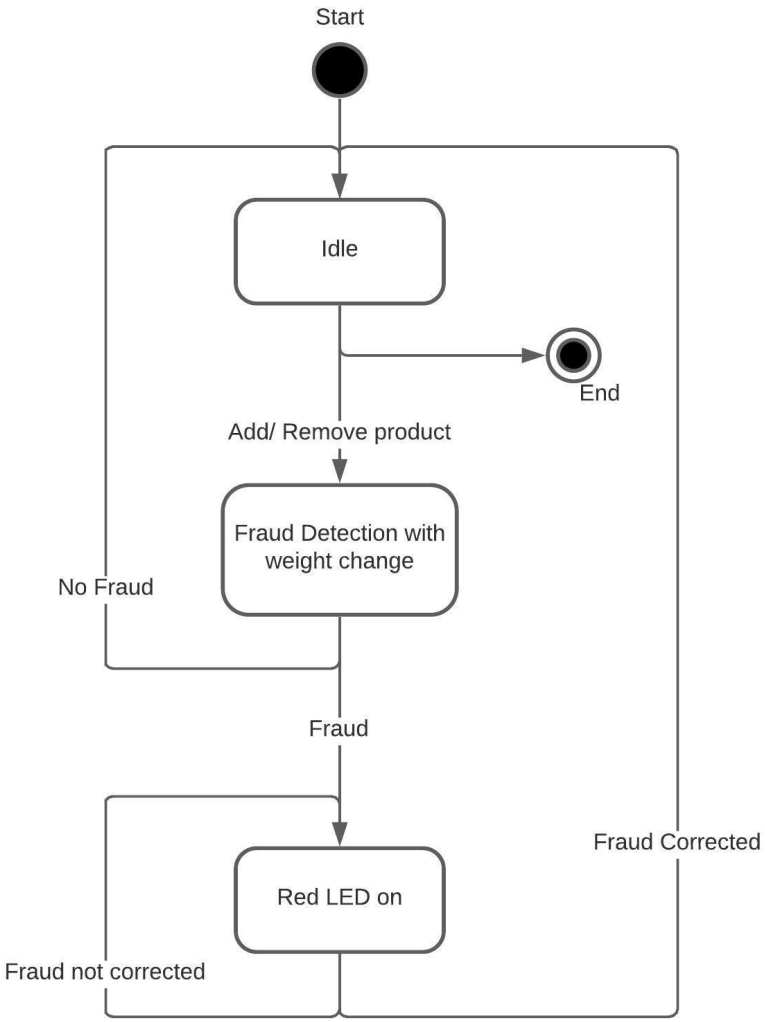


FIGURE 2: Fraud Testing

1.9 Project Outcomes

- The proposed system implements self-checkout with online bill payment options.
- The mobile application is fully-functional and the hardware is working.
- The proposed system is able to detect fraudulent cases.
    - unscanned items added in the trolley are detected.
    - unscanned items removed from the trolley are detected.
    - scanning item A but putting item B instead of A is detected for unequal weights of A and B.

1.10 Novelty of Work

The following modifications have been made to the existing research work which improvises on both user-experience and security.

- The proposed system is fully automated with the mobile application. Instead of the display screen, the product list and the bill amount is displayed on the mobile application itself. In addition, the barcode is scanned with the mobile's camera.
- The proposed system discards the smart shelves and utilization of RFIDs. It follows basic insert and delete operations as is followed in the traditional systems. So, no extra cost is incurred for RFIDs.
- The proposed system adopts the method of the system. However, instead of barcodes, the mobile application is used and no payment counter is utilized.

CHAPTER 2 : REQUIREMENT ANALYSIS

2.1 Literature Survey

2.1.1 Theory Associated With Problem Area

In most of the cities there are supermarkets and shops where the customer carries a trolley to shop. When the customer is done shopping they go to the billing counter for payment and completion of shopping.

Disadvantages

- The customers have to stand in long queues to get their bill done.
- The customers have no way to know about their bill in real time.

2.1.2 Existing Systems and Solutions

2.1.2.1 Amazon Go

Amazon in the USA opened a store which is known as Amazon Go, where the customer just has to enter the store, grab the product they want and walk out. Despite being able to handle the queues and self checkout system there are technical and economical faults.

Disadvantages

- High Deployment Cost.
- Implementation of an honor system in which they expect customers to be honest with shopping.

2.1.2.2 Kroger and Caper Cart

Microsoft and Kroger designed and introduced Caper smart car testing kits. Caper also put the sensors under the shelf. Bingo Box in China is a private shop that operates at the discretion of the consumer. Bingo Box uses cameras and RFID tags on everything on the shelves. 7-11 has reopened its staff store which relies on IoT technology and technology to serve customers but still faces technical problems due to errors and inefficiencies.The

automatic cart is also the same new device designed to help customers track their purchasing information using Fusion sensor technology.

Disadvantages

- These systems rely on RFID sensors and markers for everything that increases costs and lowers the profit margin.
- RFID readers are not able to read the tags sometimes due to signal blocking and incorrect packaging.

2.1.3 Research Findings for Existing Literature

S. No.	Roll No.	Name	Paper Title	Tools/ Technology	Findings	Citation
1	101803268	Ajat Suneja	A Proposed Technique for Implementing Smart Cart Based on Artificial Intelligence	RFID tag, reader, Raspberry Pi, LCD display	used RFID to track the products that are bought and display on trolley screen only	[1]
2	101803268	Ajat Suneja	Smart Shopping Cart	Raspberry Pi, Ultrasonic Distance Sensor, Weight Sensor, PiCamera	Deep learning is used for real time detection of objects while placing them in a cart.	[2]
3	101803269	Chaitanya Kaushal	Smart Shopping Carts Based on Mobile Computing and Deep Learning Cloud Services	Raspberry Pi, PiCamera, artificial Intelligence	use of artificial intelligence and deep learning for detection of products.	[3]
4	101803269	Chaitanya	The RFID Based	RFID tags ,readers ,	using RFID for tracking the	[4]

		Kaushal	Smart Shopping Cart	microcontroller , LCD display	products bought and displaying on trolley connected LCD	
5	101803272	Bibek Preet Singh	Smart shopping cart with automatic billing system through RFID and ZigBee	RFID tags, reader, ZigBee, EEPROM, micro controller	data read by RFID is written by EEPROM and is sent to the database with ZigBee	[5]
6	101803272	Bibek Preet Singh	IoT Applications on Secure Smart Shopping	RFID tags, reader, ZigBee, micro controller, LCD	RFID tags apart from products are also placed on shelves for inventory management and also at payment gateways for payment verification.	[6]
7	101803276	Harshit Bansal	Interactive intelligent shopping cart using RFID and ZIGBEE modules	RFID tags, reader, ZigBee, micro controller, LCD	Using RFID for tracking the products bought and displaying on trolley connected LCD	[7]
8	101803276	Harshit Bansal	An IOT Based Smart Shopping Cart for Smart Shopping	RFID tags, reader, LCD, micro controller, android application	RFID tags are used for product tracking and shown on LCD, and mobile applications are connected to store databases for list creation and can be shared with others as well.	[8]

TABLE 4: Research Findings for existing Literature

2.1.4 Problem Identified

The problems listed below contribute to poor user experience and thus, arise a much needed solution to make things simpler and easy to use.

- Real-Time Bill Generation: The existing systems do not provide information on what the current bill is. In some cases, the customer might exceed his/her budget and would only be able to know about it at the time of checkout. This leads to poor user experience.
- Long Waiting Queues: The existing systems are unable to tackle this problem. Consider a queue of say three people where the first one has A products in his cart and the second person has B products but the third has only a single item in his cart. In this case, he must wait for a long time till his turn comes.
- Cost to the company: In a traditional retail store, much of the employer's cost goes on providing staff to run checkouts. It is often more cost-effective to transfer those staff to other duties, particularly customer service which promises good user experience.

2.1.5 Survey of Tools and Technologies Used

Software :-

- React Native - For the creation of mobile applications.
- Firebase - This is for databases as well as authentication.
- Arduino Programming - For the connection of all hardware and database with trolley.

Hardware :-

- Arduino Uno - Microcontroller which will connect all the hardware components.
- Weight Sensor - For measuring the weight of the products.
- NodeMCU - For connection with firebase using Wifi.
- Battery - To keep arduino active.
- Breadboard and wires for hardware connections.

2.2 Software Requirement Specification

2.2.1 Introduction

2.2.1.1 Purpose

- To develop a self-checkout system where a user buys items and checks out without waiting in long queues.
- To reduce total time for the entire shopping process including but not limited to adding and removing items from trolleys and making a final checkout.
- To build a fraudulent system which tackles checks against

  1. Unscanned items added or removed from the trolley,

  2. Wrong items added or removed from the trolley on a successful scan of different items with an assumption that items of different categories have different weights.

2.2.1.2 Intended Audience and Reading Suggestions

- The proposed system is intended for all the places that use shopping carts and where people have to stand in lines for checking out.
- The audience includes shoppers, shopping malls, grocery store owners and other commercial places where buying and selling activities are held.

2.2.1.3 Project Scope

- The system must detect fraudulent cases.
  - Unscanned items added in the trolley are detected.
  - Unscanned items removed from the trolley are detected.
  - Scanning item A but putting item B instead of A is detected for unequal weights of A and B.
- The shopping time is reduced by removal of queues.
- The system is able to provide real - time bills.

2.2.2 Overall Description

2.2.2.1 Product Prospective

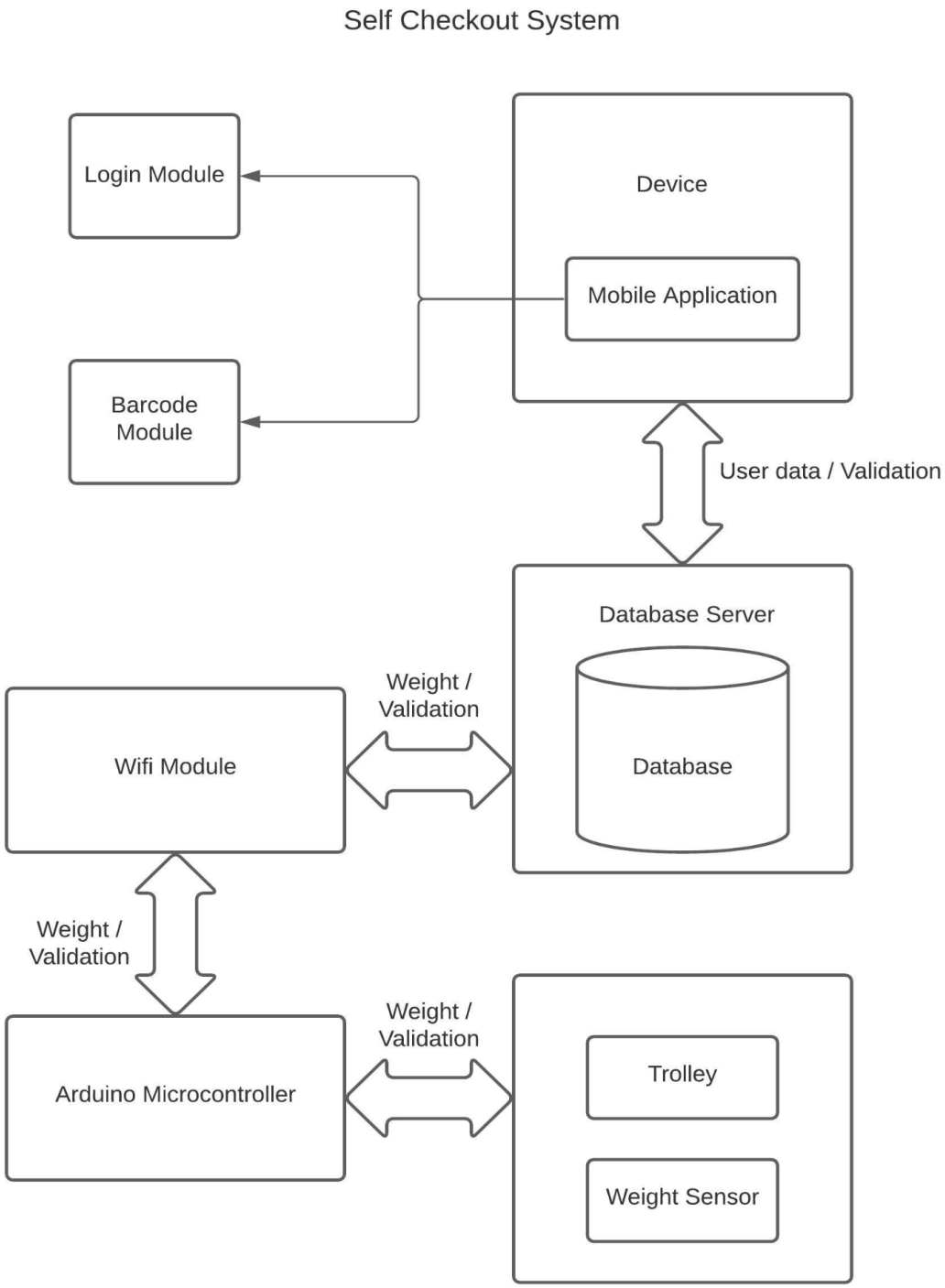


FIGURE 3: Product Perspective

2.2.2.2 Product Features

- The proposed system implements self-checkout with online bill payment options.
- The mobile application is fully-functional and the hardware is working.
- The proposed system is able to detect fraudulent cases.
    - Unscanned items added in the trolley are detected.
    - Unscanned items removed from the trolley are detected.
    - Scanning item A but putting item B instead of A is detected for unequal weights of A and B.

2.2.3 External Interface Requirements

2.2.3.1 User Interfaces

- The mobile application has the following screens
    - For Admin
        - Product List Screen showing list of all products available at the store whose quantity can be added.
        - Product Creation Screen where admins can insert attributes of a new product that is to be added in the store.
    - For User
        - Product List Screen showing list of all products available at the store for purchasing purposes.
        - Discounts Screen showing available offers.
        - Orders Screen which shows the history of all transactions.
        - Checkout Screen which performs the payment action.
    - The Authentication Screen.
- A side drawer is available for all users which helps in navigation and logout.
- Important buttons for various screens
    - Logout Button
    - Authentication (Signup and Signin Buttons)
    - Checkout Button
    - Add and delete buttons for admin product screen

2.2.3.2 Hardware Interfaces

- Arduino would be connected to the ESP 12E to connect to the internet which in turn would connect Arduino to Firebase for data access.
- The HX711 and Load cell would continuously provide the current weight data of the trolley to the arduino by which the arduino would decide about the fraudulent checks and would display the results using LEDs.

2.2.3.3 Software Interfaces

- **React Native ver. 0.65 -** It is used to develop the application and its libraries are used to scan the barcode, for payment gateway, for connection with the Firebase to Login, Register and share cart and product data with Firebase.
- **Expo ver 41.0.0 -** It is for the testing and build release of the application.
- **Firebase**
    - **Realtime Database**
        - All the application data will be stored in the realtime database.
    - **Firebase Authentication**
        - This will authenticate the users securely.

2.2.4 Non - Functional Requirements

2.2.4.1 Performance Requirements

- 10 seconds are given to place or remove the product from the trolley after the scan.
- Self-checkout system has been realized in a user-understandable GUI i.e. a mobile application. Thus, the system has usability.
- The camera efficiently scans the barcode.
- With any change in the database, the corresponding change is reflected on the device affected by it.
- Database is updated automatically after scanning of products.

2.2.4.2 Safety Requirements

- No personal detail of the user is shared with anyone
- User passwords are stored in encrypted form only.
- Every user is assigned only one trolley.

2.2.4.3 Security Requirements

- A session is created for the user when he logs in. Thus, the system has security.
- On detection of weight change, the trolley performs fraudulent checks.

2.3 Cost Analysis

Sr. No.	Product Name	Quantity	Price/ unit (in Rs.)
1	Arduino Uno	1	535
2	Load Cell + HX711	1 + 1	525
3	Wifi Module (ESP 12E)	1	315
4	NodeMCU 8266	1	380
5	Bread board	1	155
6	Supporting Material (Trolley, Wires, Resistor, Bulbs)		200
Miscellaneous			130
Total Cost			2240

TABLE 5: Cost Analysis

2.4 Risk Analysis

- Failure in fraudulent checks like same weight yet differently priced products can incur losses to the company.
- Damage to the hardware like weight sensors and arduino can incur losses to the company.
- Loss in number of customers whose mobiles are not able to detect barcodes.

CHAPTER 3 : METHODOLOGY ADOPTED

3.1 Investigative Technique

- **Comparative Technique**

  Why Comparative?

  The project is the result of a comparative study of the traditional checkout systems that are already in place today. There is a need to introduce a better way to implement the checkout system and thus it led to a solution which is to create a self-checkout system.

- **Problems with traditional systems**
  - Shopping at market stores expends a lot of time at the billing counters by standing in long queues which leads to poor user experience.
  - The employees at the billing counters do the payment work which could otherwise be handled by the customers themselves and are more convenient and in trend.
  - Customer does not know what the current bill amount is for the items in the trolley. Thus,there is a need to simplify the shopping process and scrutinize ways to tackle and optimize ways for the above-stated problems.

- **Some already implemented solutions internationally**
  - Amazon in the USA opened a store which is known as Amazon Go, where the customer just has to enter the store, grab the product they want and walk out. Despite being able to handle the queues and self checkout system there are technical and economical faults.
  - Bingo Box in China is a private shop operating at the consumer's pleasure. The Bingo Box uses cameras and RFID tags on everything on the shelves.
  - Microsoft and Kroger designed and launched Caper smart carts that test carts. Caper also put the sensors under the shelf.

- **Research based solutions**

  However, there has been research going on regarding solutions to the problem. Several

research papers were published which revolved around the same ideas as the actual implemented solutions i.e. using RFIDs for each shelf and making use of proximity sensors.

- **Problems with Current Solutions**

  However, be it research based approach or company's implemented approach, all of them have at least one of following downfalls.

  - High Deployment Cost.
  - Implementation of an honor system in which they expect customers to be honest with shopping.
  - These programs rely on RFID sensors and markers for everything that increases costs and lowers the profit margin.
  - RFID readers are unable to read the tags at times due to signal blocking and improper packaging.

- **Why the proposed solution is better**

  The problems listed below contribute to poor user experience and thus, arises a much needed solution to make things simpler and easy to use.

  - Real-Time Bill Generation: The existing systems do not provide information on what the current bill is. In some cases, the customer might exceed his/her budget and would only be able to know about it at the time of checkout. This leads to poor user experience.
  - Long Waiting Queues: The existing systems are unable to tackle this problem. Consider a queue of say three people where the first one has A products in his cart and the second person has B products but the third has only a single item in his cart. In this case, he must wait for a long time till his turn comes.
  - Cost to the company: In a traditional retail store, much of the employer's cost goes on providing staff to run checkouts. It is often more cost-effective to transfer those staff to other duties, particularly customer service which promises good user experience.

3.2 Proposed Solution

The proposed system is primarily divided into three aspects namely, workflow, implementation and fraudulent system which are explained below.

- **Workflow**
    - Customer enters the mall with the mobile application installed.
    - Customer gets a trolley from the trolley stack and enters the trolley number in the mobile application to select an unassigned trolley.
    - Now the customer proceeds towards shopping.
    - The customer can add and remove items from the trolley by scanning them first with the mobile's camera.
    - After each add or remove, a fraudulent check is made in the trolley to verify the product added.
    - After doing the shopping, customers can simply make payment via the mobile application and checkout from the store without having to wait in long queues for their turn to come.
- **Implementation**
    - A customer can select a trolley from the mobile application which is communicating with the trolley database server through network protocols. The trolley database would contain status information for each trolley in the shop regarding whether it was assigned or unassigned.
    - On entering a valid trolley number, the trolley is assigned to the customer. If the check fails, the process has to be repeated again till a valid trolley number is entered.
    - The customer can invest in two activities: adding an item to the cart or removing an item from the cart.
    - The trolley has an LED bulb. The green color of the bulb would imply nothing is wrong while doing transactions until now. However, a red color would imply that a fraudulent check must have failed i.e. the user would have used dishonest means while shopping for items. For instance, removing or adding an item into a cart without a scan or adding wrong items by scanning some other items.

- Adding an item to the cart first involves scanning its barcode with the mobile's camera which is used by the application as a barcode scanner. On a successful scan, the mobile application sends the scanned item information like its name, id , weight and price to the server. Now a window of 10 seconds is given to the user for putting the item into the cart. If it is not done within the time slot, then the transaction would be canceled for the current item. Once the item is added, the weight sensors which are present at the base of the cart would detect an increase in the net weight of itself and would reflect the delta reading (difference between current and past weights of the trolley) to the server. If the delta reading matches with the weight of the scanned item that was sent via the mobile application then, it would be regarded as a successful transaction and the LED would remain green. However, if they do not match, then the LED would start blinking red representing a false transaction.
- The delta reading matching is done considering some specified error values.
- Similarly, for removing an item , the same scanning procedure would be repeated and the same checks for delta readings are performed.
- Once the shopper is done with the shopping, the security guard at the exit point of the store will see the color of the LED light. If it is green, the shopper is permitted to checkout via the mobile applications and if it is red, he would be denied and have to correct the wrong transactions.

- **Fraudulent System**
  - Fraud is detected by the trolley and conveyed to the Database.
  - It is detected by comparing the current weight of the trolley and the supposed weight from the database and after comparing the two weights a red/green LED would light up to convey an error/no error respectively.
  - If fraud is detected then the mobile application would also cease adding or deleting any other product to/from the list until the fraud is rectified.
  - At the time of the checkout if the LED is red, the customer would not be allowed to make payment and exit the shopping center with products.
  - If the LED is green only then the customer would be able to make payment and can leave the shopping center after payment verification.

3.3 Work Breakdown Structure

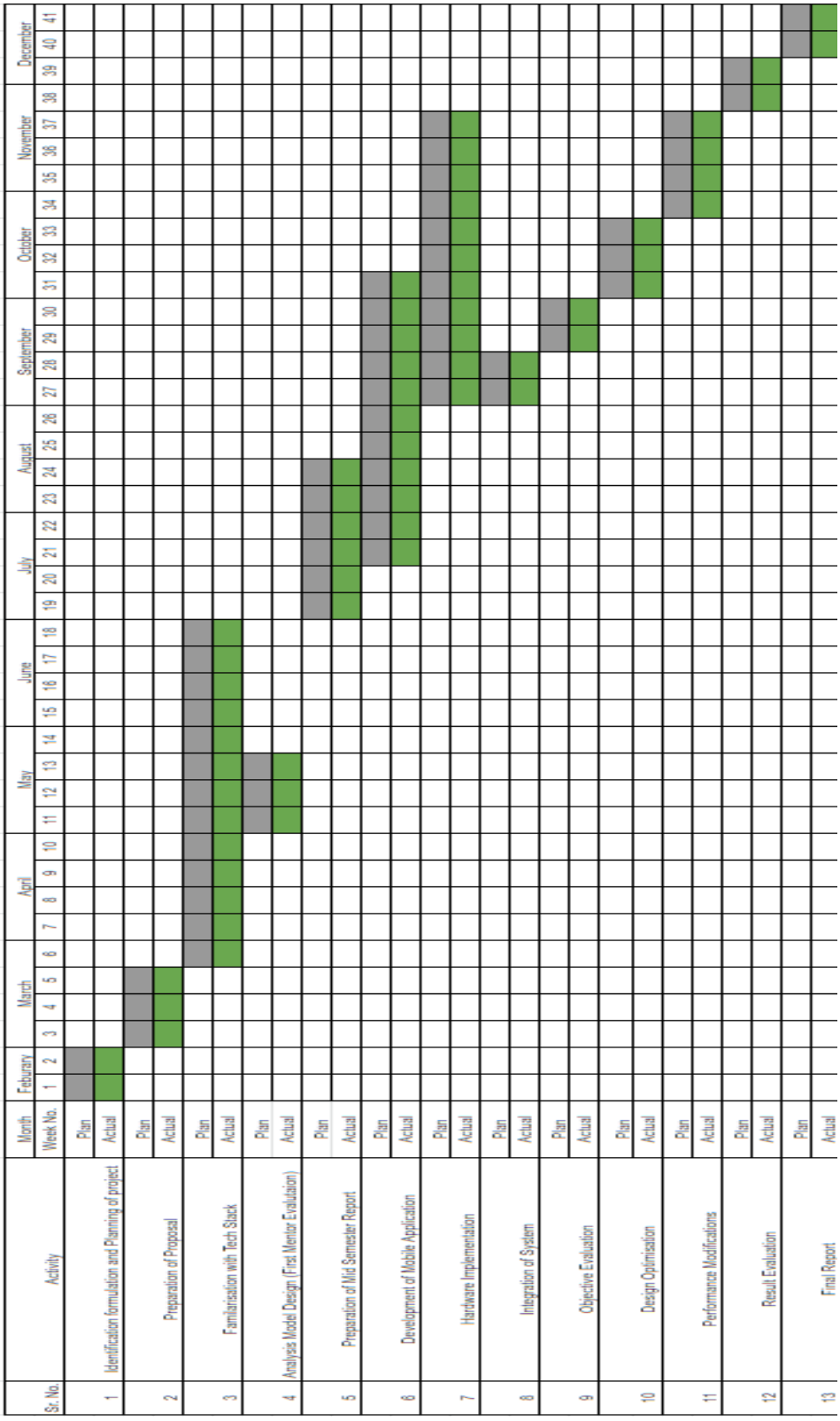


FIGURE 4: Work Breakdown Structure

3.4 Tools and Technology

3.4.1 Software

- React Native for mobile application.
- React Native Libraries for payment and barcode scanning.
- Arduino Programming for weight detection and fraudulent checks.
- Firebase as a database for real time data storage.

3.4.2 Hardware

- Arduino for connecting all the hardware components and syncing with the database.
- ESP 12E (Wifi Module) to connect the arduino with the internet.
- Load Cell and HX711 for measuring the weight.
- NodeMCU (ESP 8266) used for connecting with a firebase.

CHAPTER 4 : DESIGN SPECIFICATION

4.1 System Architecture

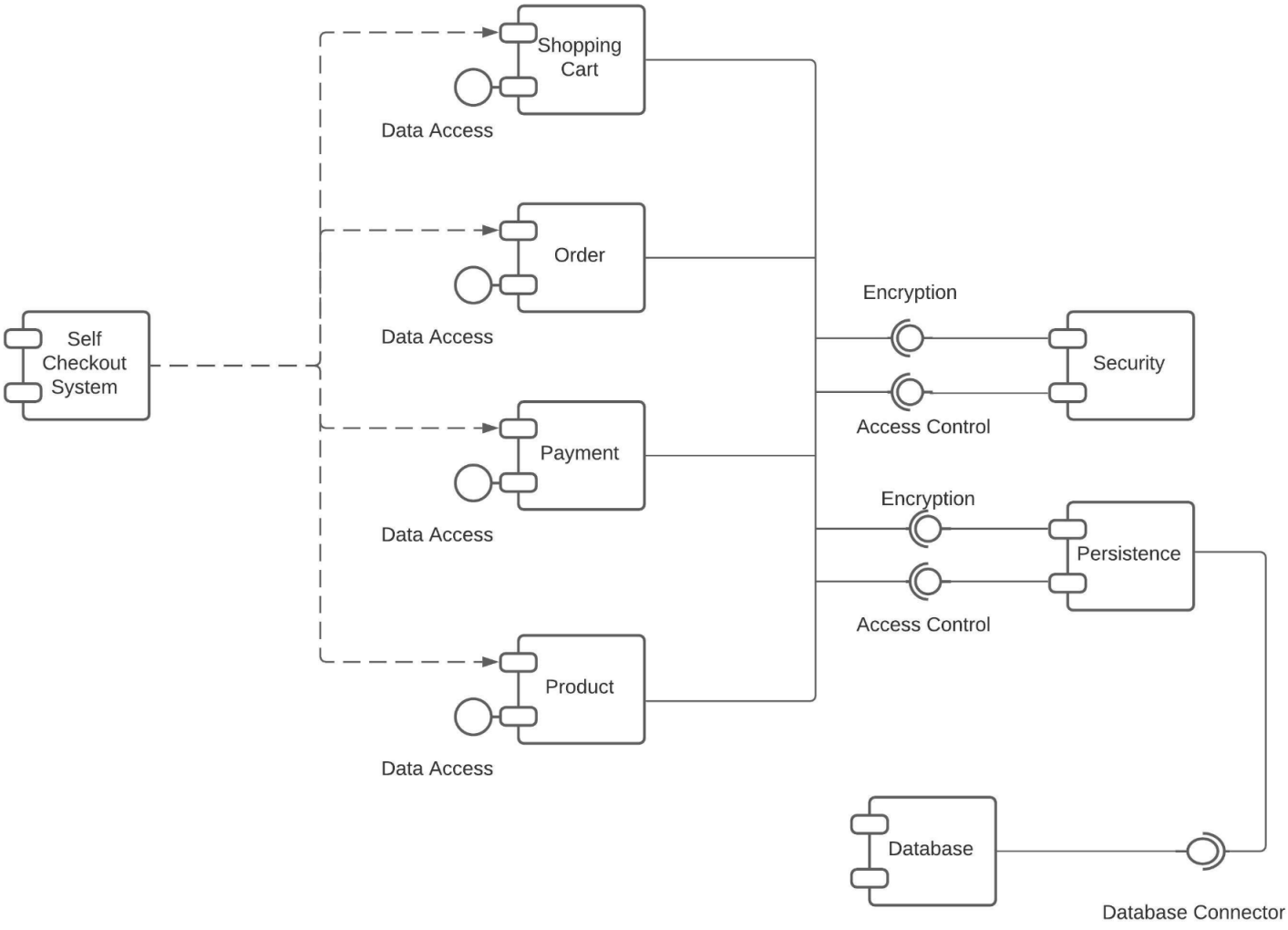


FIGURE 5: Component Diagram

4.2 Design Level Diagram

- **Class Diagram**

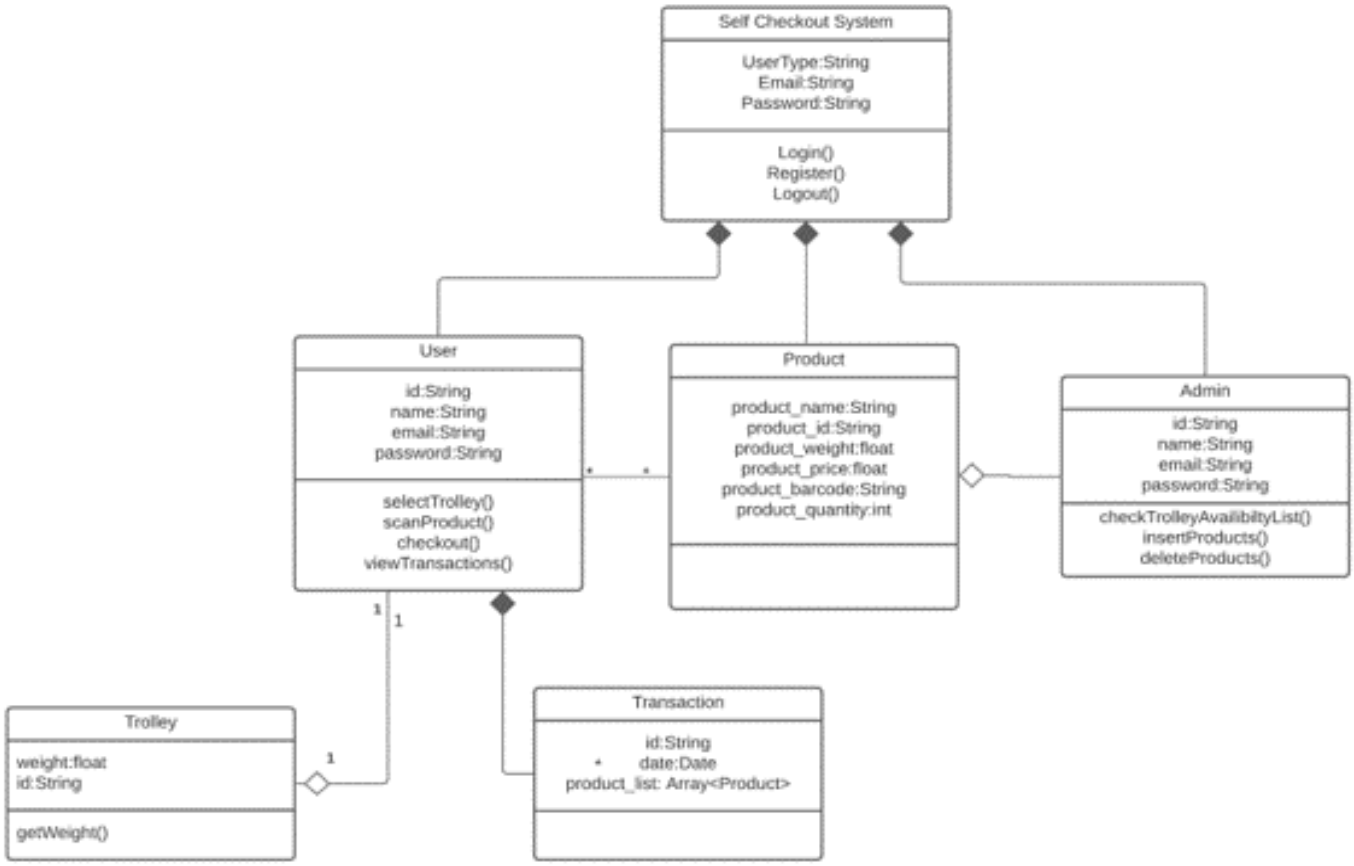


FIGURE 6: Class Diagram

- **Use Case Diagram**

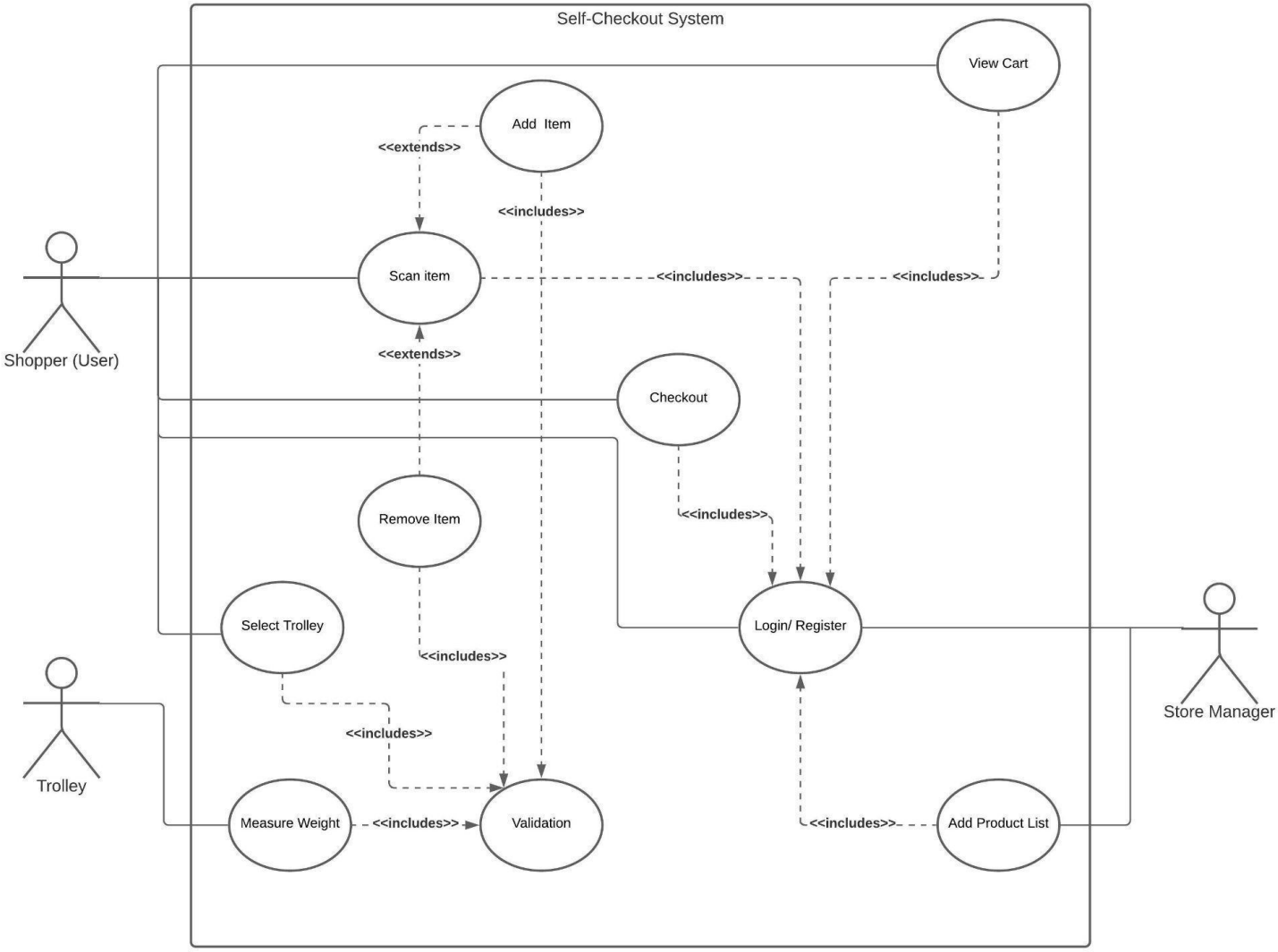


FIGURE 7: Use Case Diagram

- **State Chart Diagram**

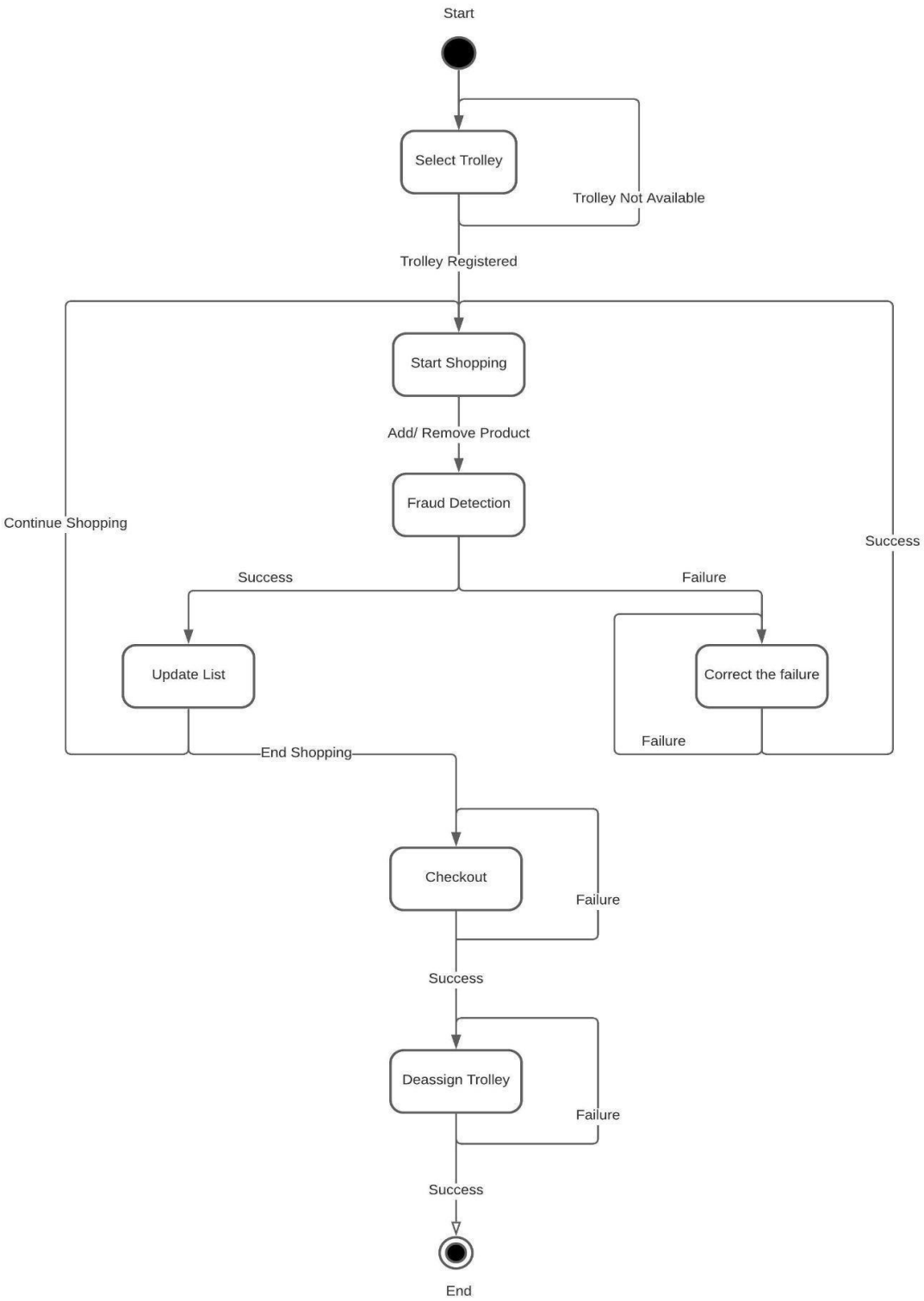


FIGURE 8: State Chart Diagram

- **Activity Diagram**

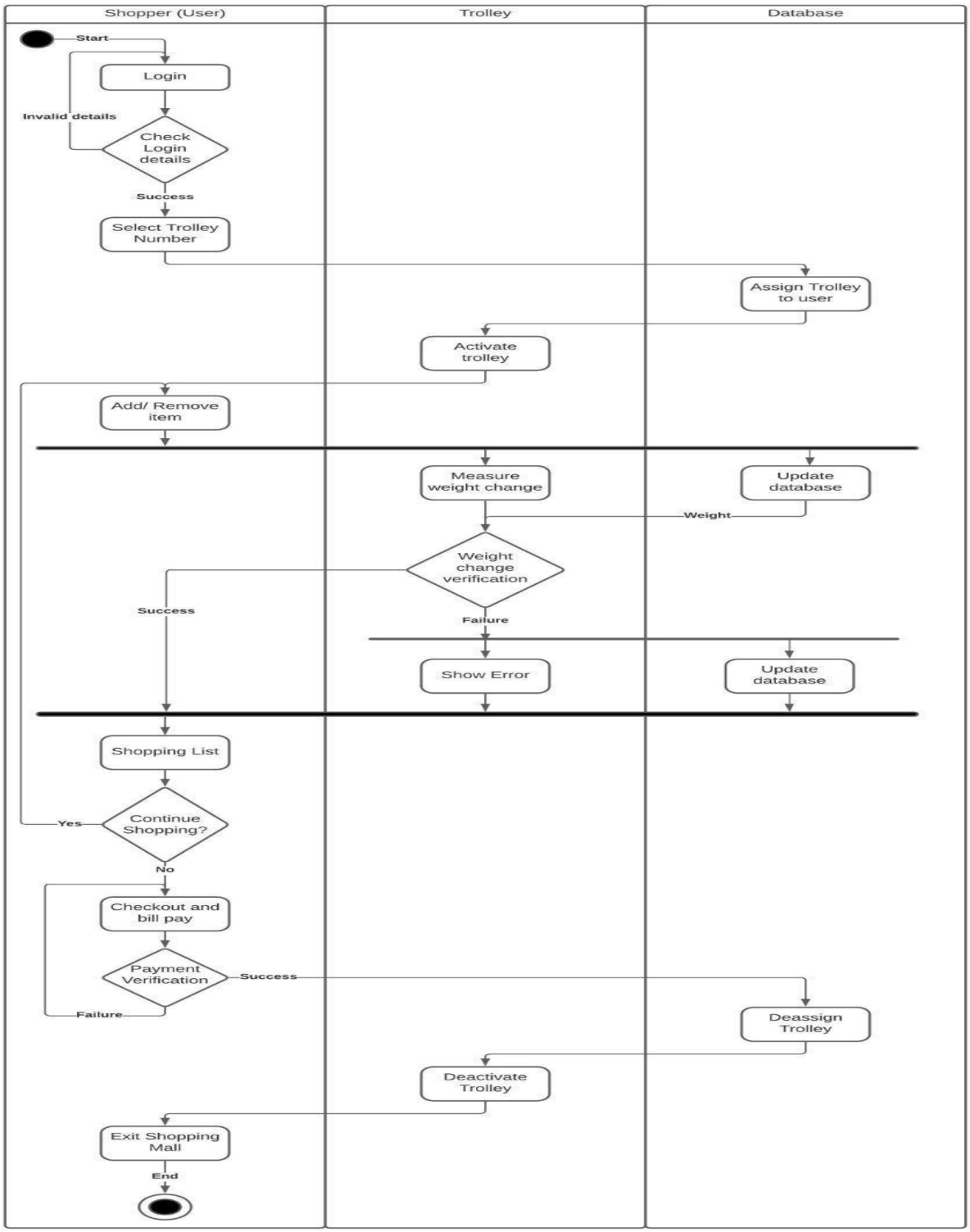


FIGURE 9: Activity Diagram

- **Sequence Diagram**

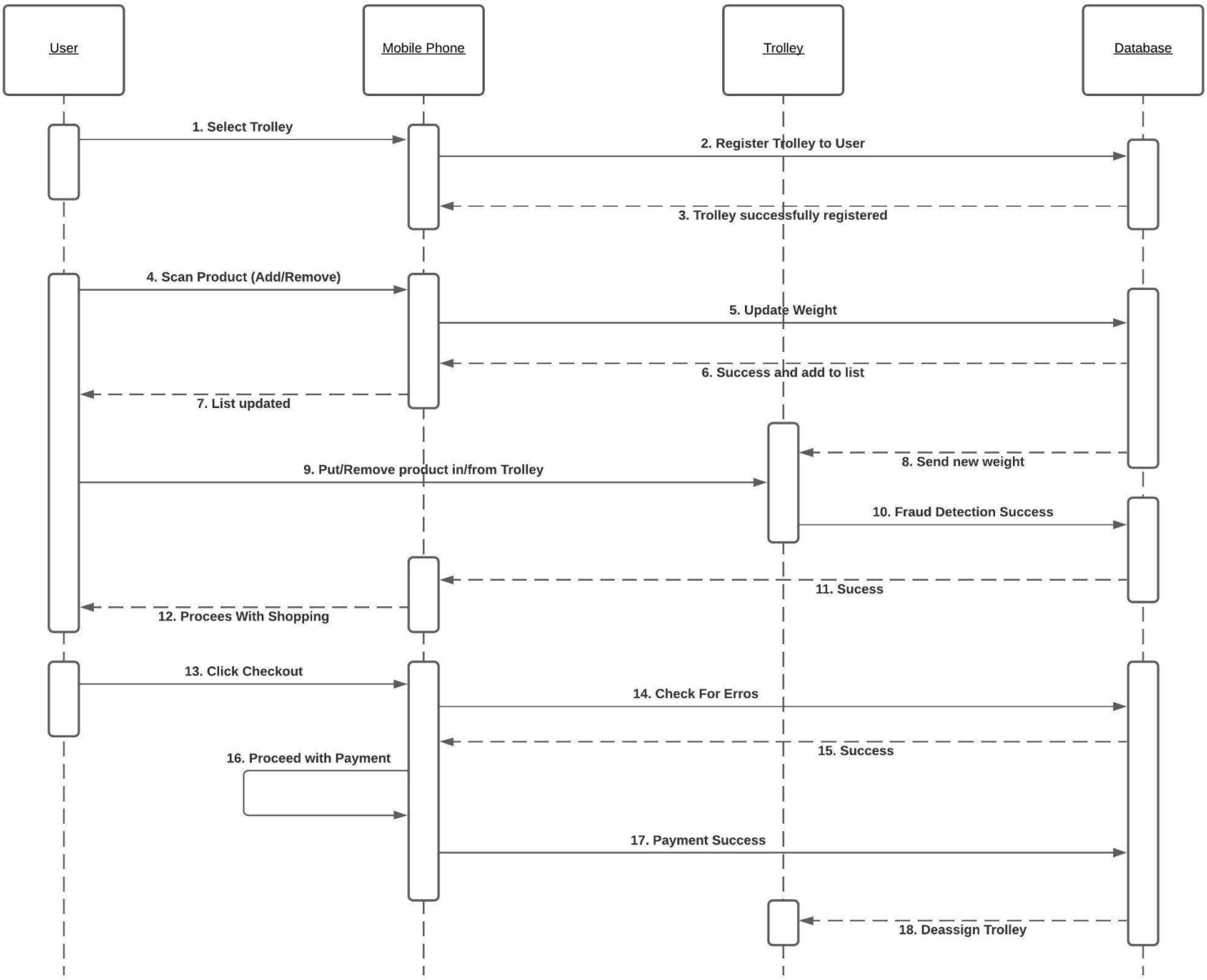


FIGURE 10: Sequence Diagram

4.3 User Interface Diagrams

- **ER diagram**

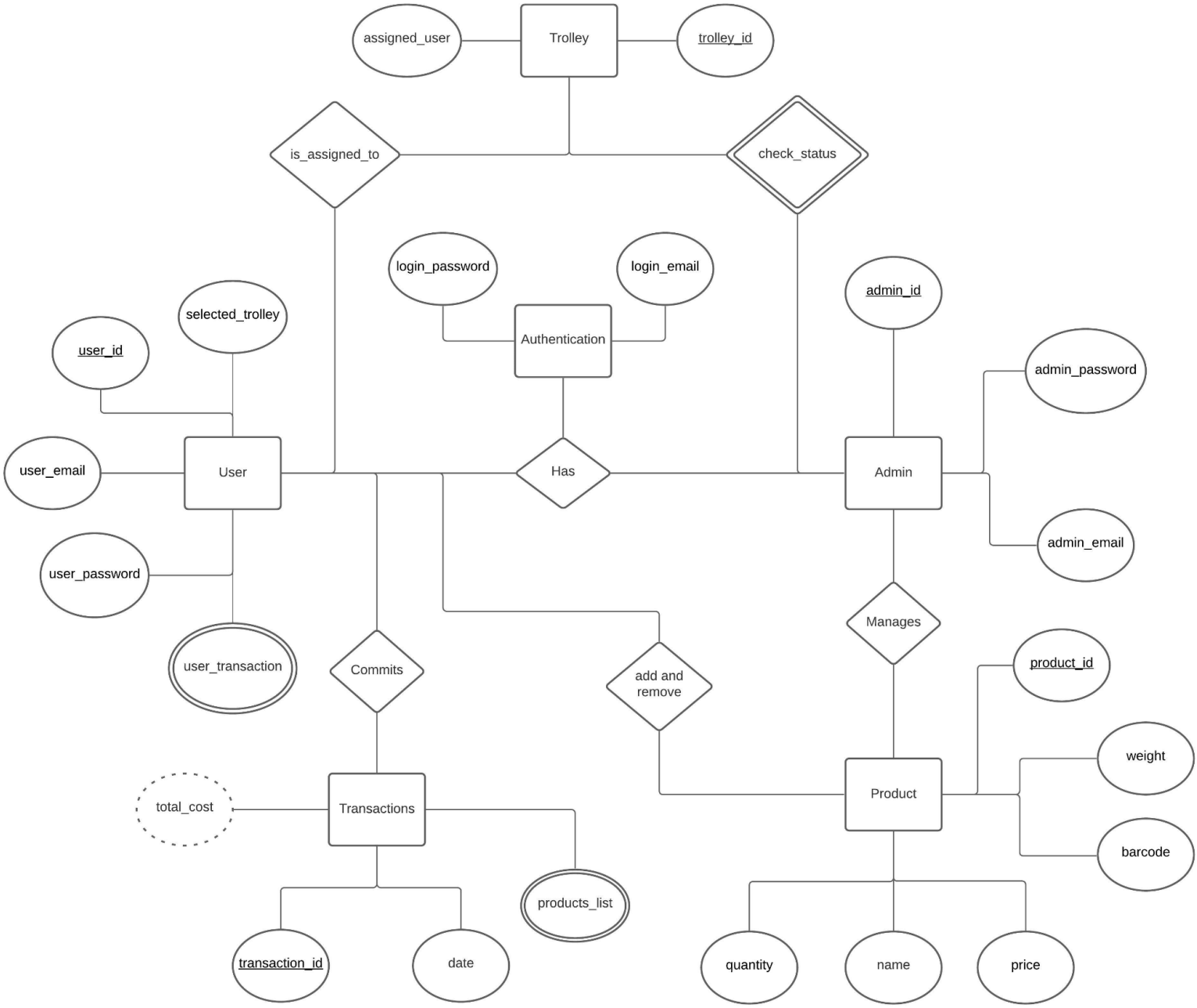


FIGURE 11: ER Diagram

- **Data Flow Diagram**

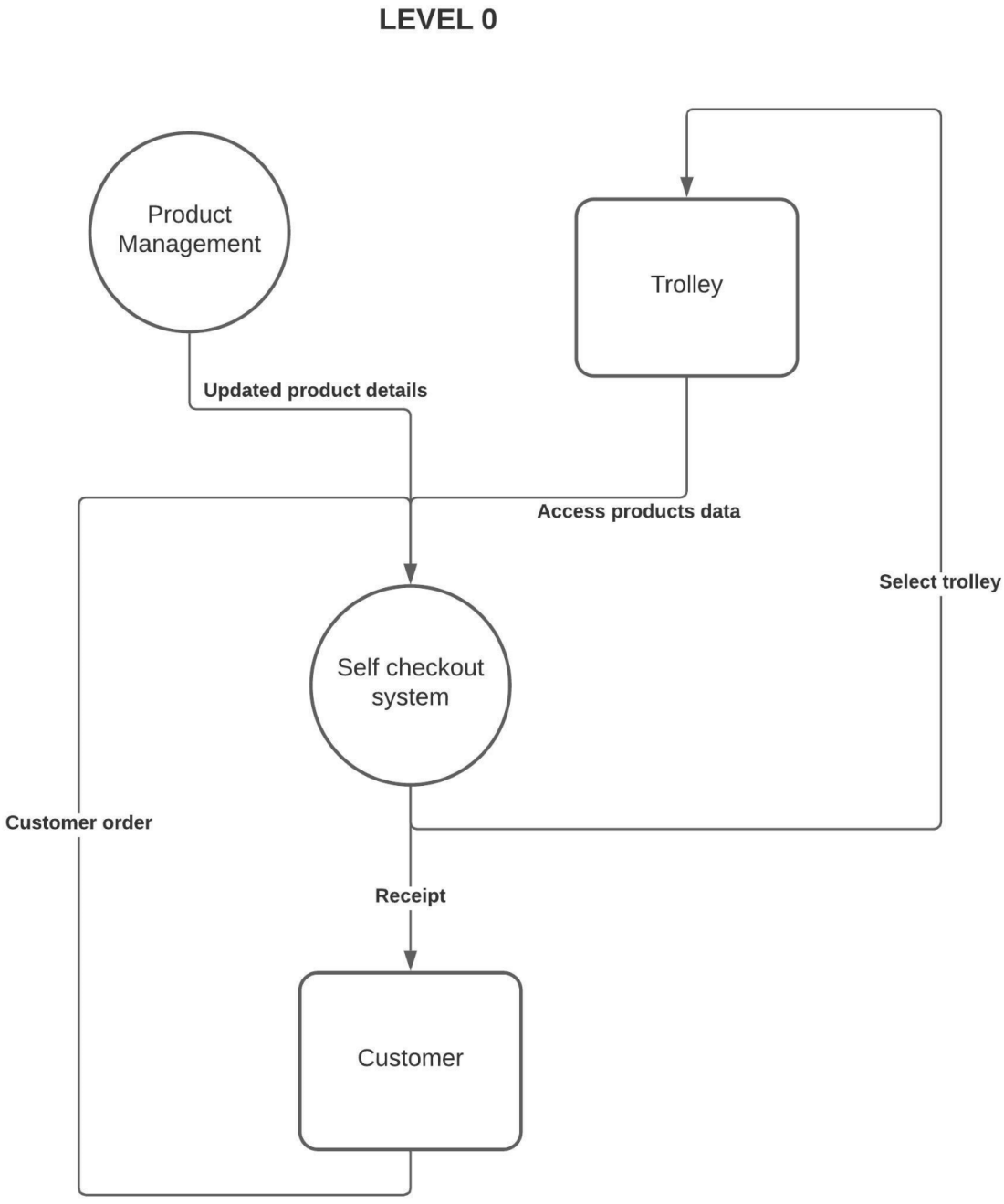


FIGURE 12: DFD Level 0

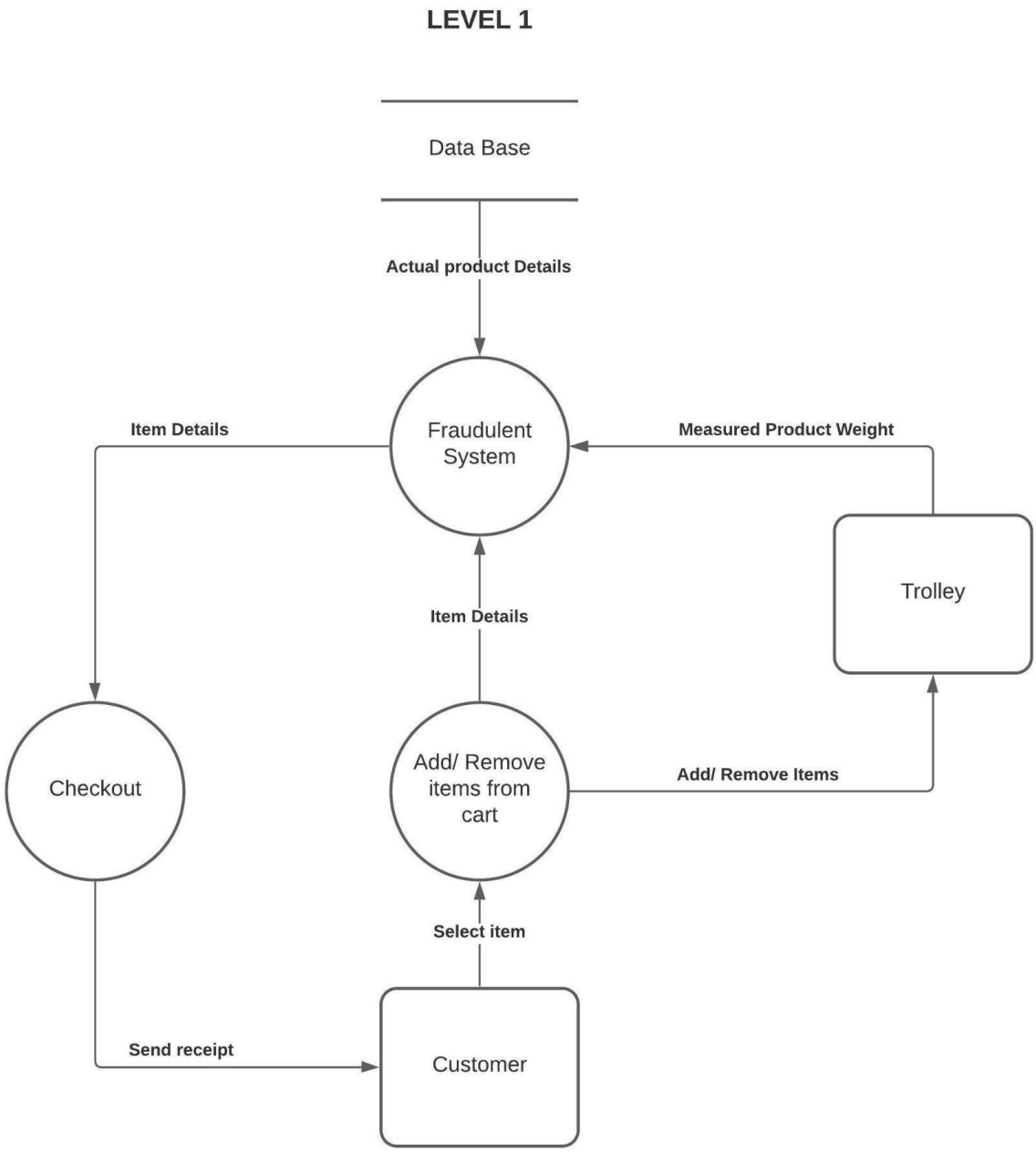


FIGURE 13: DFD Level 1

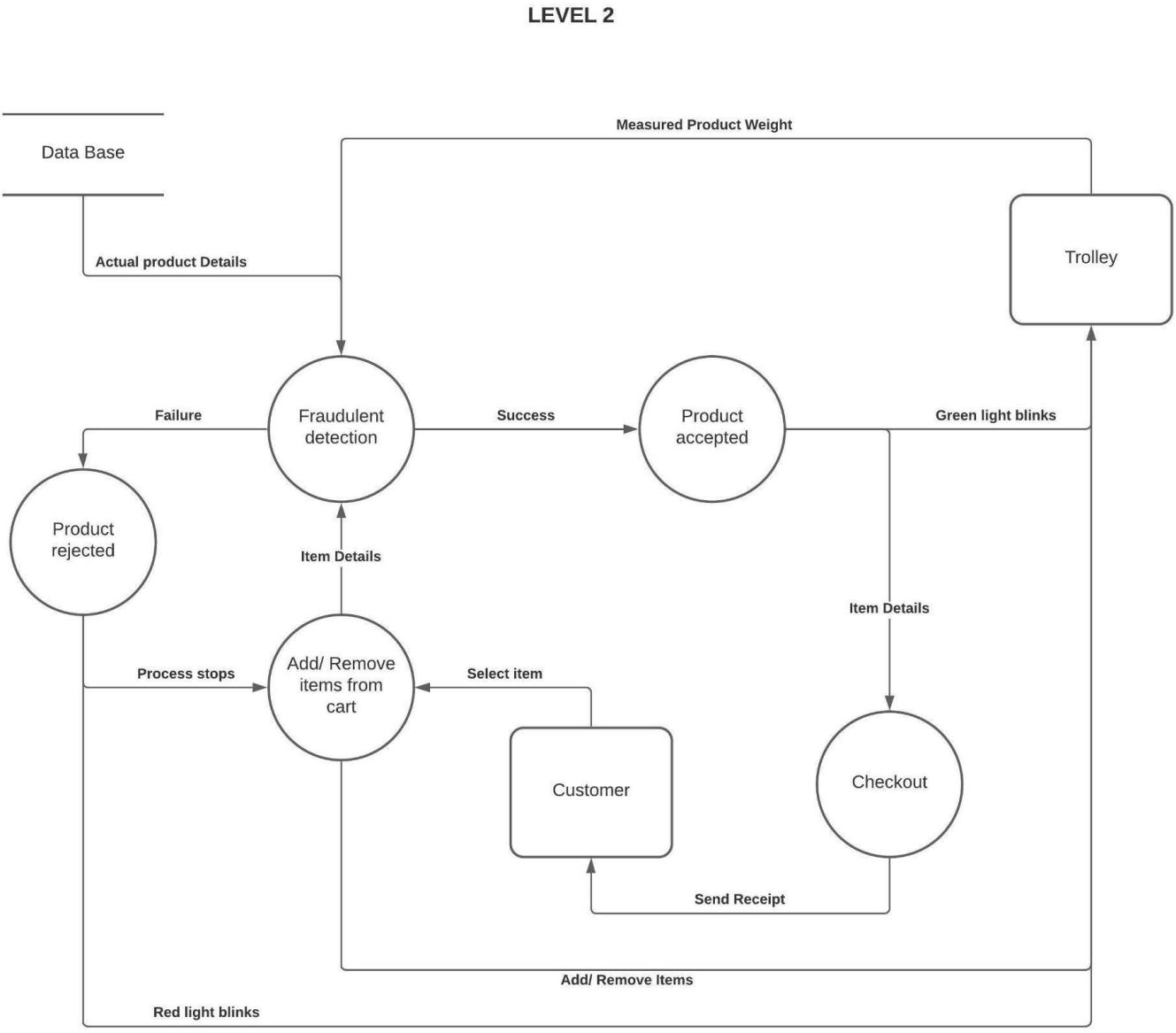


FIGURE 14: DFD Level 2

CHAPTER 5 : IMPLEMENTATION AND EXPERIMENTAL RESULTS

5.1 Experimental Setup

In order to proceed with this project, the mobile application React Native and Firebase as the database have been used. The setup of React Native is in VS Code and for the hardware, Arduino IDE has been used and hardware has been connected to the firebase using NodeMCU.

5.2 Experimental Analysis

5.2.1 Data

Data is created by logging in with admin credentials in the mobile application and only the products that have been registered by the admin would be accessible to users for purchase.

5.2.2 Performance Parameters

The performance of the project is calculated on the following parameters :-

- Accuracy :- It is the precision by which the weight of the products placed in the cart is compared with the weight specified on the pack or the weight entered by the Admin during product registration.
- Error Margin :- The error margin that is set for the products is able to distinguish between products.
- User Friendly :- The mobile application should be easily accessible and easy to use.

5.3 Work of the project

5.3.1 Procedural Workflow

This project provides the application to the user on which first they select a trolley for shopping and scan the items they wish to buy using their mobile cameras one by one and put the item in the trolley. The user can add or remove items at any time and real time bill generation will be shown on the users mobile everytime. Fraudulent cases will be timely

checked by the trolley software and it responds by blinking the LED. Red light will show that there is something wrong and Green light ensures that everything is fine. At the end of the shopping, if the trolley shows Red light means there is a problem and you have to match your trolley items with the billed items shown on the mobile application or if it shows Green Light means you can check out after making the payment through any mode you like.

5.3.2 Algorithmic Approaches Used

nodemcu | Arduino 1.8.16

File Edit Sketch Tools Help

nodemcu §

```
#include <ArduinoJson.h>
#include <ESP8266WiFi.h>
#include <FirebaseESP8266.h>
#include "HX711.h"

#define DOUT  D6
#define CLK  D5

#define Green  D3
#define Red  D2

#define FIREBASE_HOST "self-checkout-system-capstone-default-rtdb.firebaseio.com"
#define FIREBASE_AUTH "3kHjhwf4xmzoVCifW4hrEYLpIfSnReX6vCixKomt"
#define WIFI_SSID "FTTH-7310"
#define WIFI_PASSWORD "bb@2977310"

FirebaseData firebaseData;

int val=0;

HX711 scale(DOUT, CLK);
float calibration_factor = 207175; //207175   188075

void setup() {

  pinMode(Green, OUTPUT);
  pinMode(Red, OUTPUT);

  Serial.begin(9600);
  Serial.println("Serial communication started\n\n");

  WiFi.begin(WIFI_SSID, WIFI_PASSWORD);
  Serial.print("Connecting to ");
  Serial.print(WIFI_SSID);

  while (WiFi.status() != WL_CONNECTED) {
    Serial.print(".");
    delay(500);
  }

  Serial.println();
```

FIGURE 15 : Hardware Code ss1

FIGURE 16 : Hardware Code ss2

FIGURE 17: Hardware Code ss3

5.3.3 Project Deployment

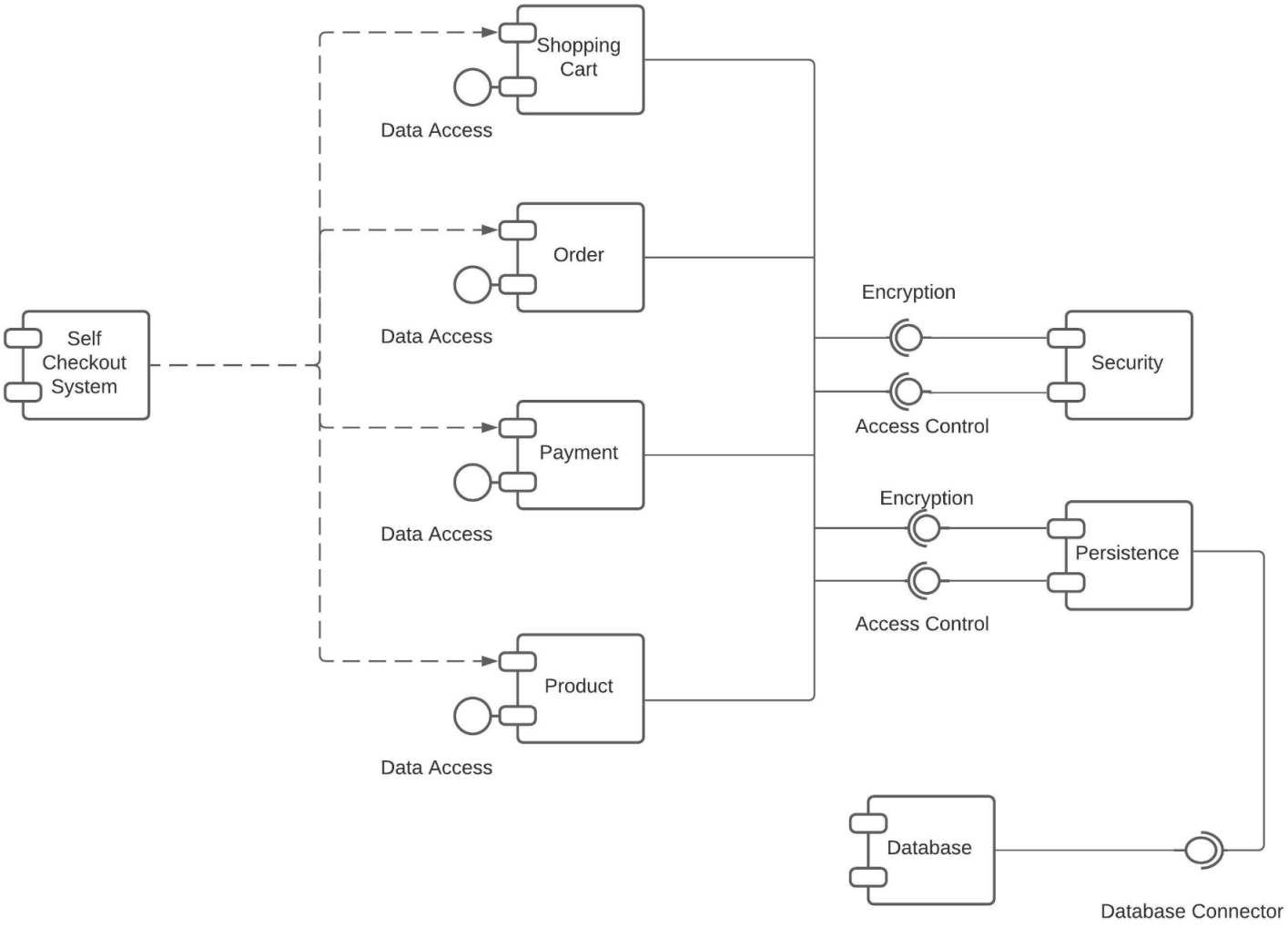


FIGURE 18 : Component Diagram

5.3.4 System Screenshots

- **Hardware Screenshots**

FIGURE 19 : Trolley

FIGURE 20 : Trolley side view

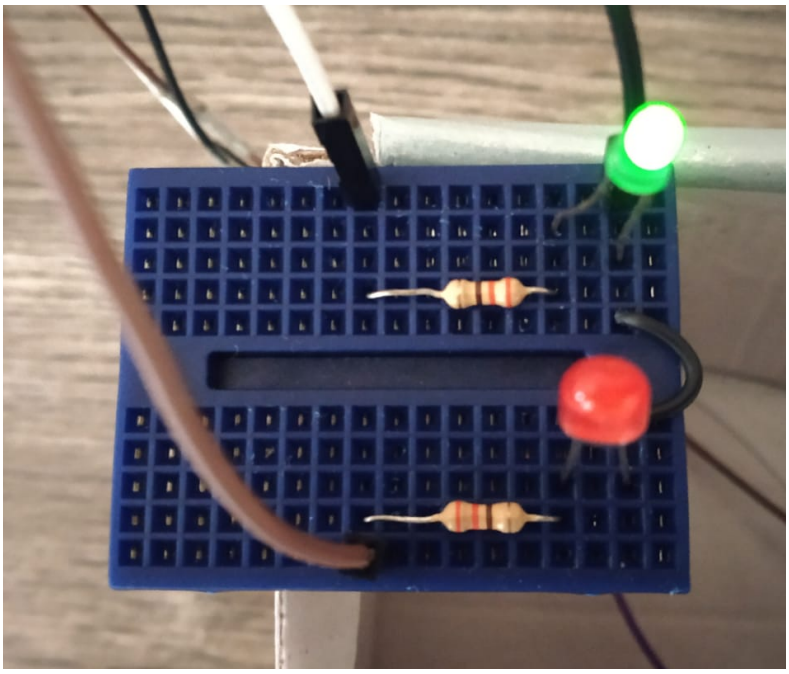


FIGURE 21: Green Light Glowing

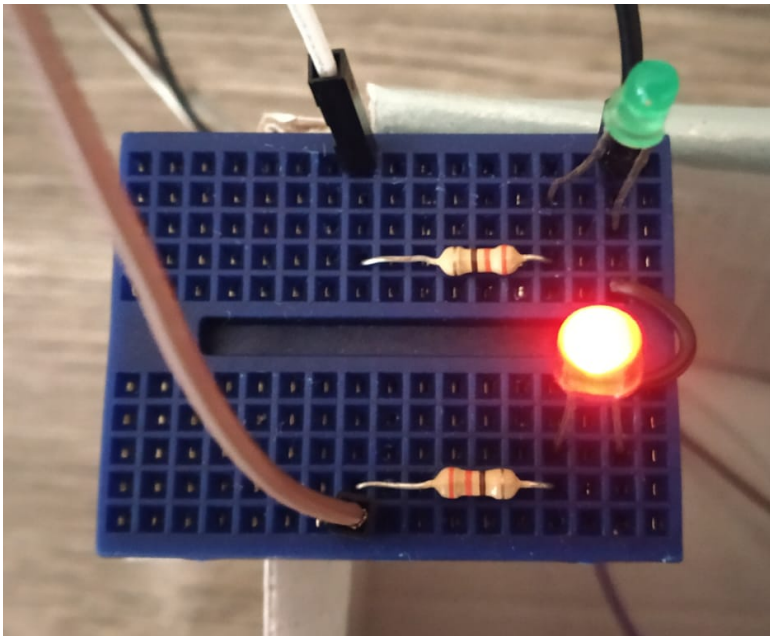


FIGURE 22: Red Light Glowing showing fraud

- **Software Screenshots**

FIGURE 23: Login Page

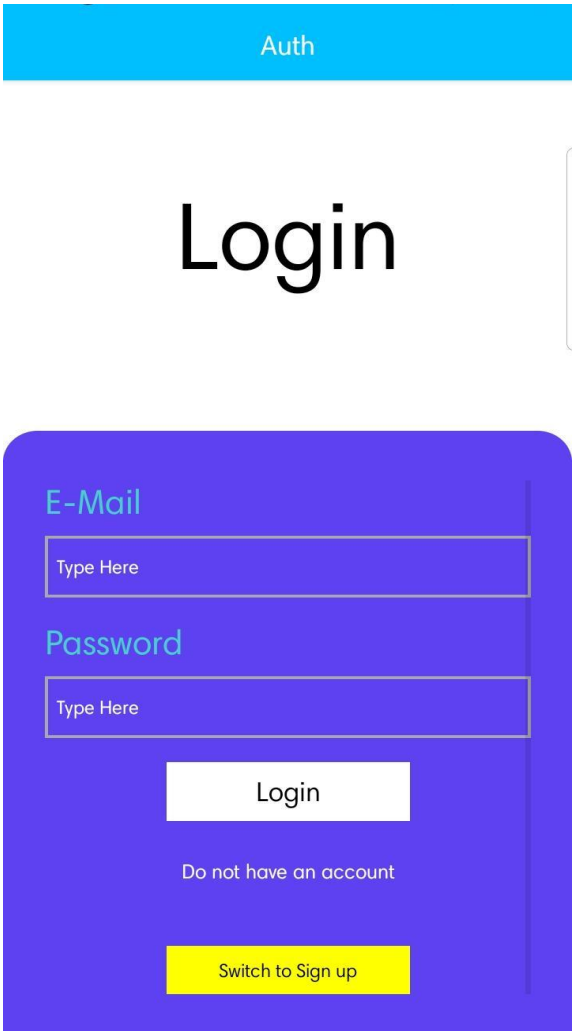


FIGURE 24 : Admin Add Product

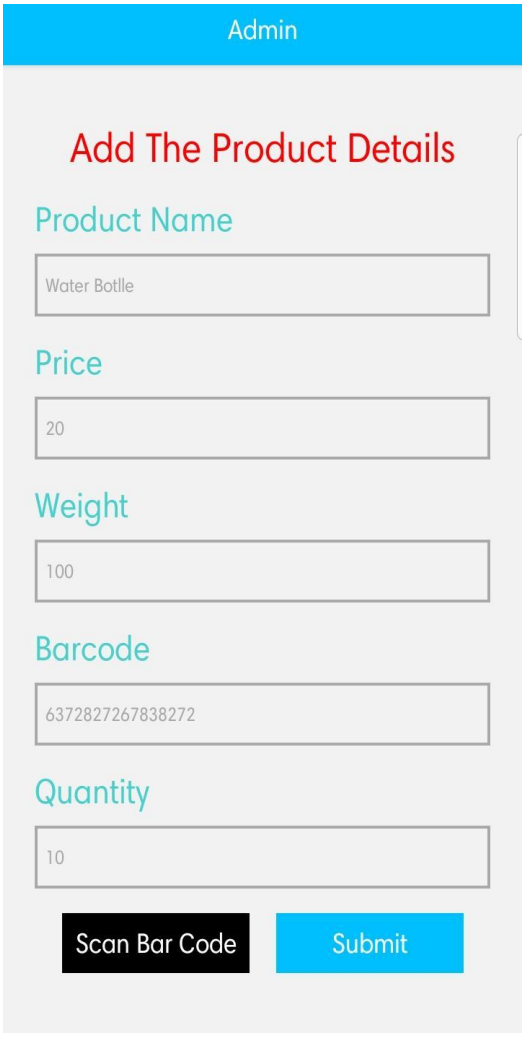


FIGURE 25 : Register Screen Inventory

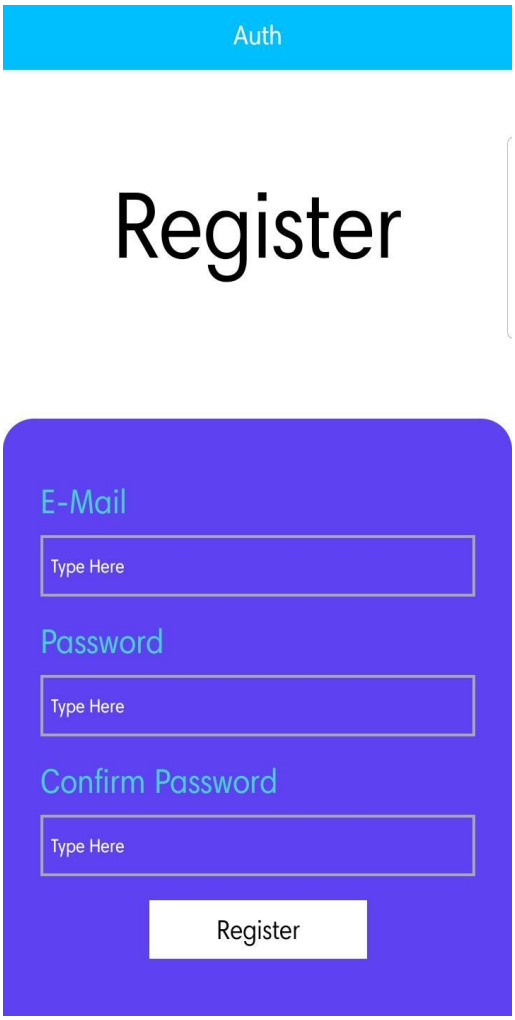


FIGURE 26 : Admin Inventory

FIGURE 27: Search Functionality Product

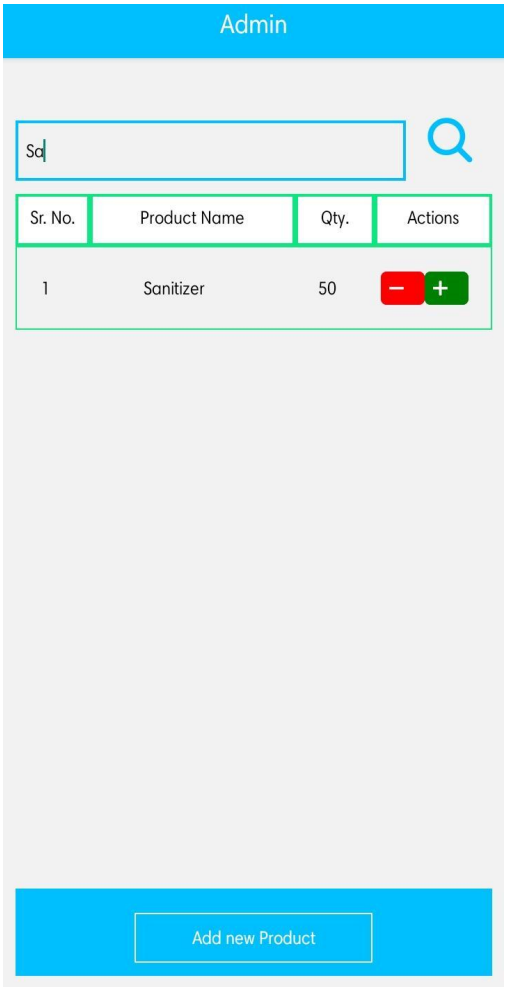


FIGURE 28 : Add new product in store

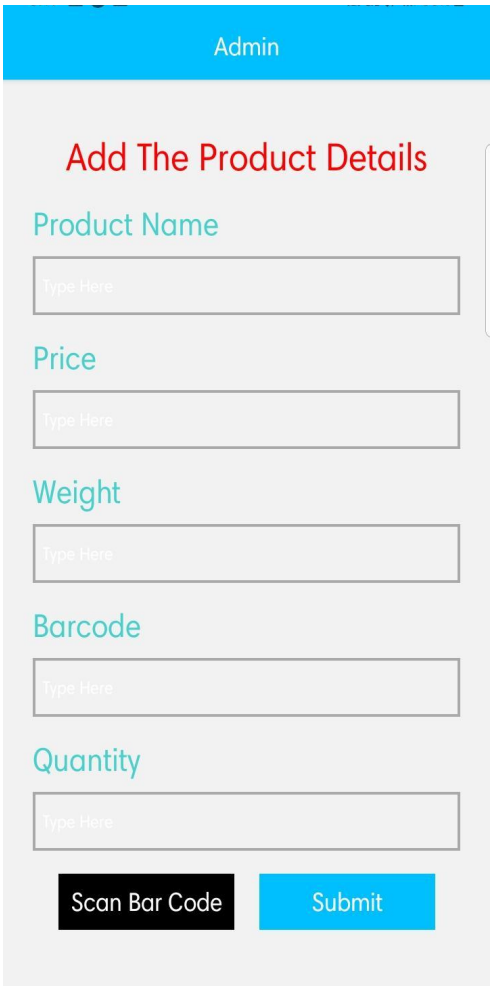


FIGURE : 29 Search

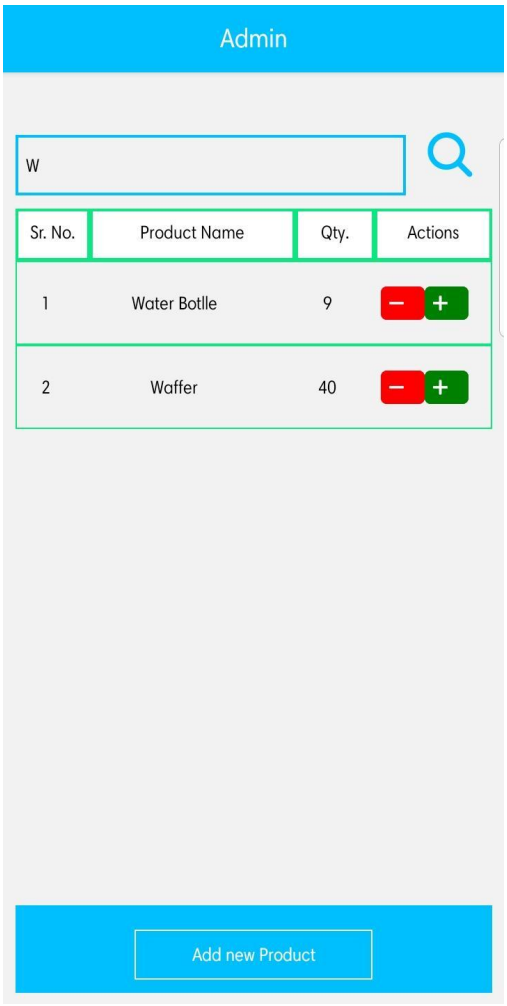


FIGURE 30 : User checkout page

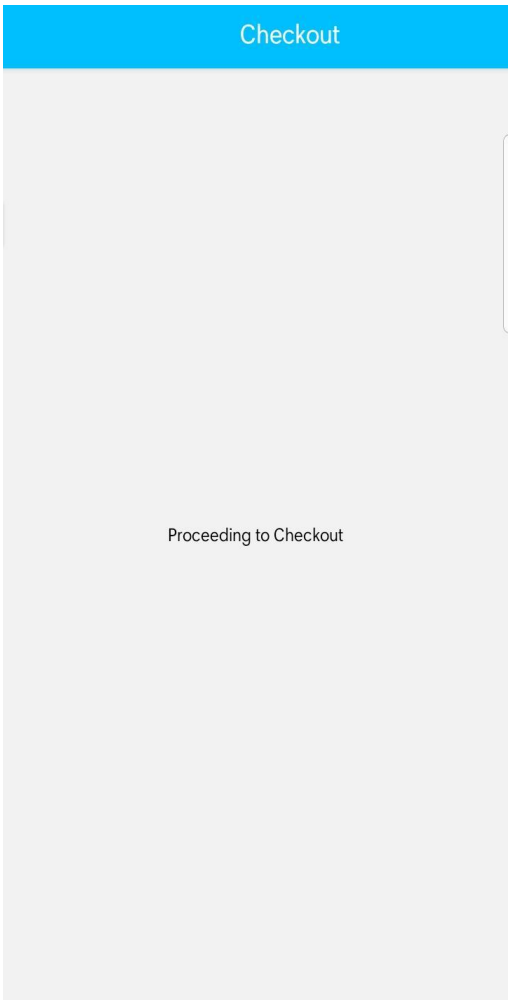


FIGURE 31 : User Page navigation

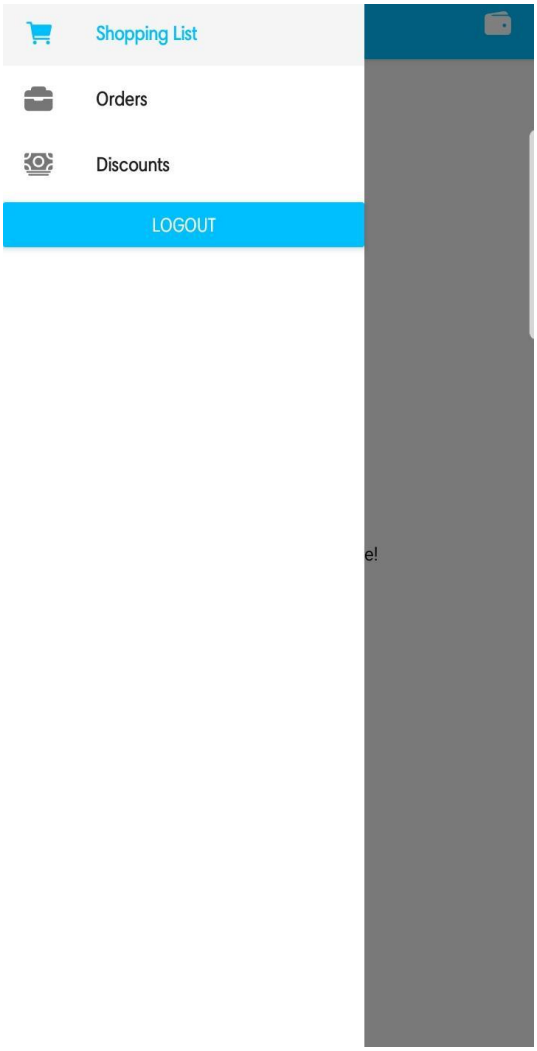
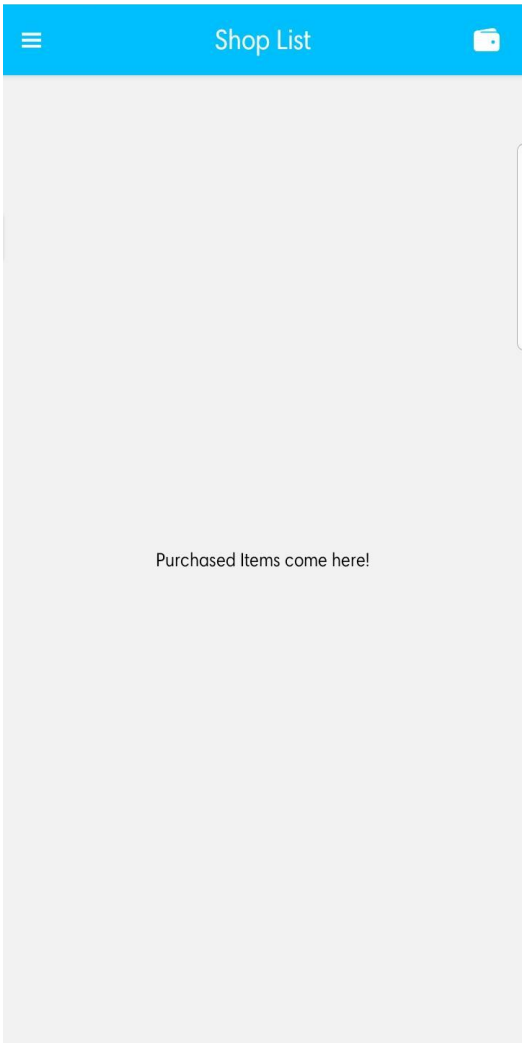


FIGURE 32: User Product List



5.4 Testing Process

5.4.1 Test Plan

The components that need to be tested are :-

- Hardware Fraudulent Check.
- Software and Database consistency.
- Products get added after scanning.
- Increase, decarese and delete product quantity and thus change total weight.

5.4.2 Features to be tested

Features to be Tested are as follows :-

- Admin and users should be able to login to the application.
- Products should be getting scanned correctly.
- There should be no inconsistency between the database and the mobile application.
- Admin should be able to update the product list properly and the user should be able to scan the products updated by admin only.
- Total price, weight and the products scanned should be visible to the users at all times.
- Weight Sensor should measure the weight correctly.
- Trolley should detect fraudulent cases and indicate such cases with a glowing red LED.

5.4.3 Test Strategy

The main focus of these tests is to increase the accuracy and correct error margin for a wider range of products and for a more user-friendly experience.

5.4.4 Test Cases

Test Case 1 :-

Description - Admin and user can login to the application.

Test Case 2 :-

Description - Products after correct scanning are added to the list.

Test Case 3 :-

Description - For correctly working green LED should glow.

Test Case 4 :-

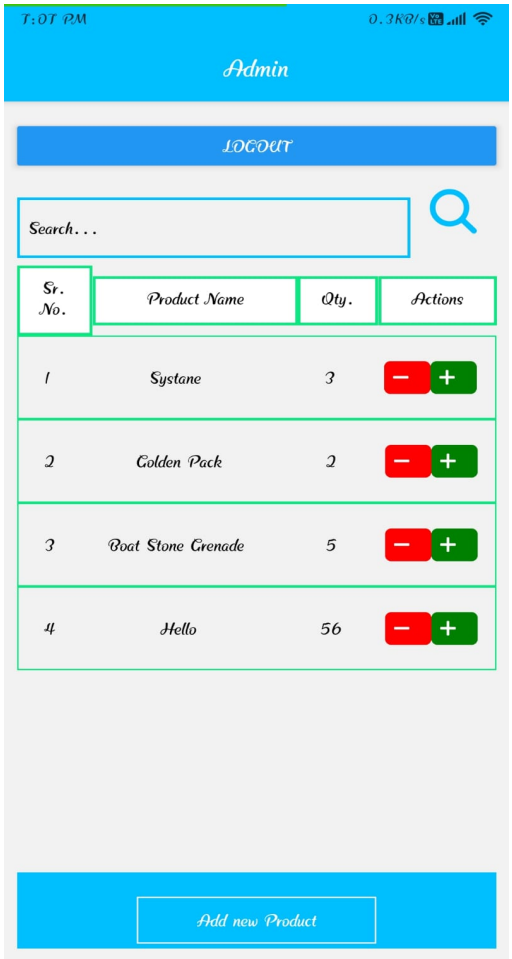
Description - With a mismatch in total weight on the database and trolley Red LED should glow.

Test Case 5 :-

Description - All Previous Orders are shown with full details.

5.4.4 Test Results

Result of Test Case 1 shown above :- (Successful)



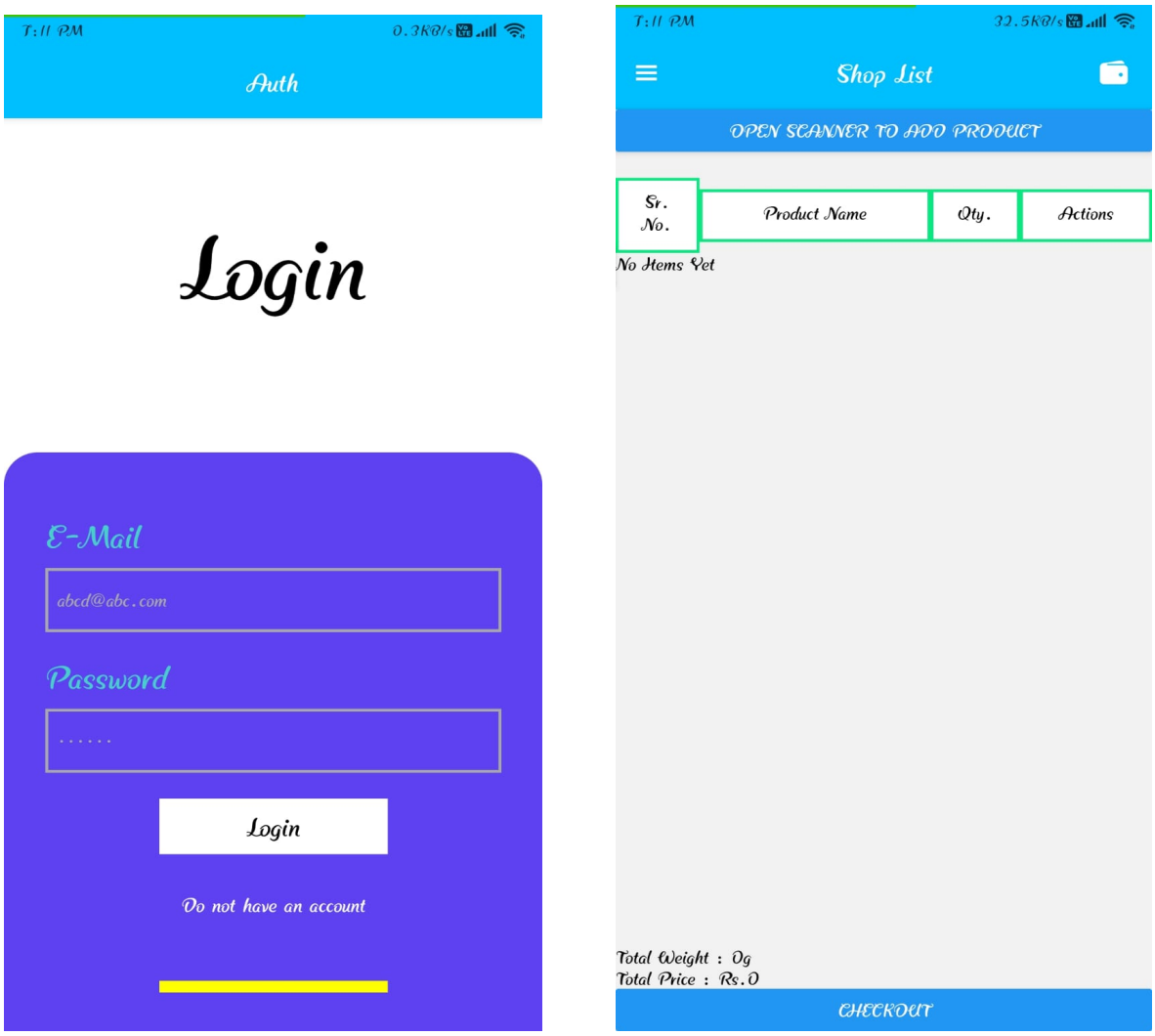


FIGURE 33: Test Case 1 Result

Admin after login will go to the page where all the stored products will be shown and he can add other items on that page.

Users after login end up in the user inventory where they can add or remove desired items and can check out at the end.

Result of Test Case 2 shown above :- (Successful)

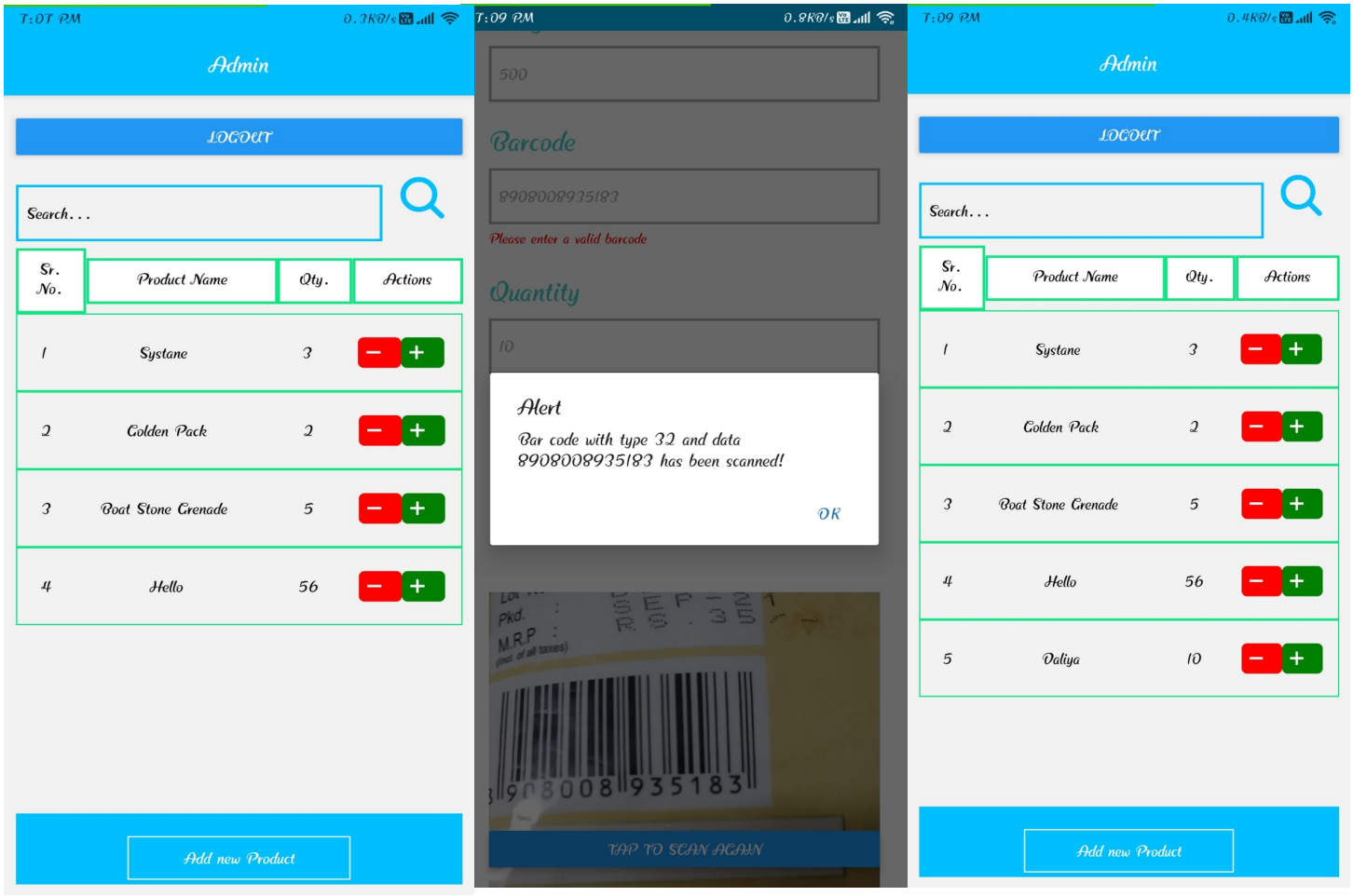
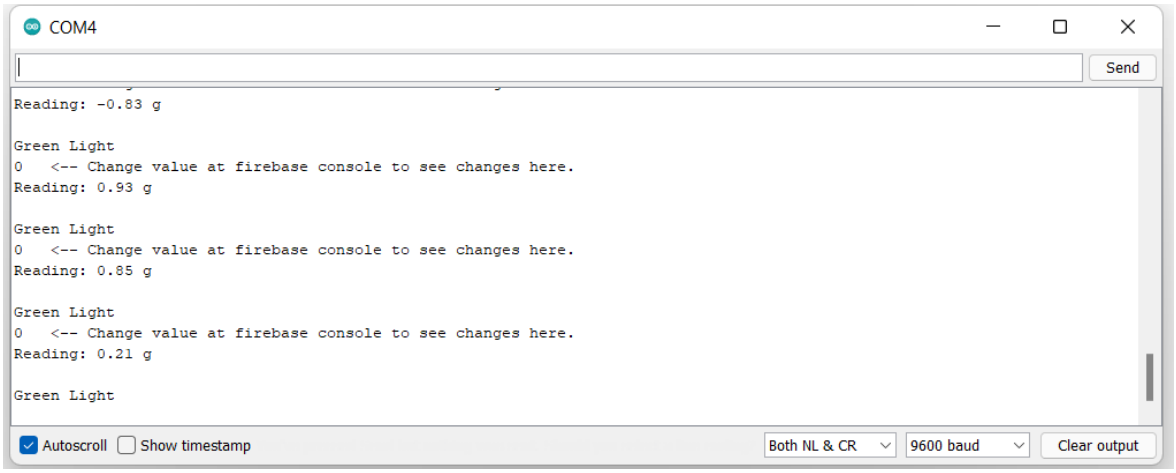
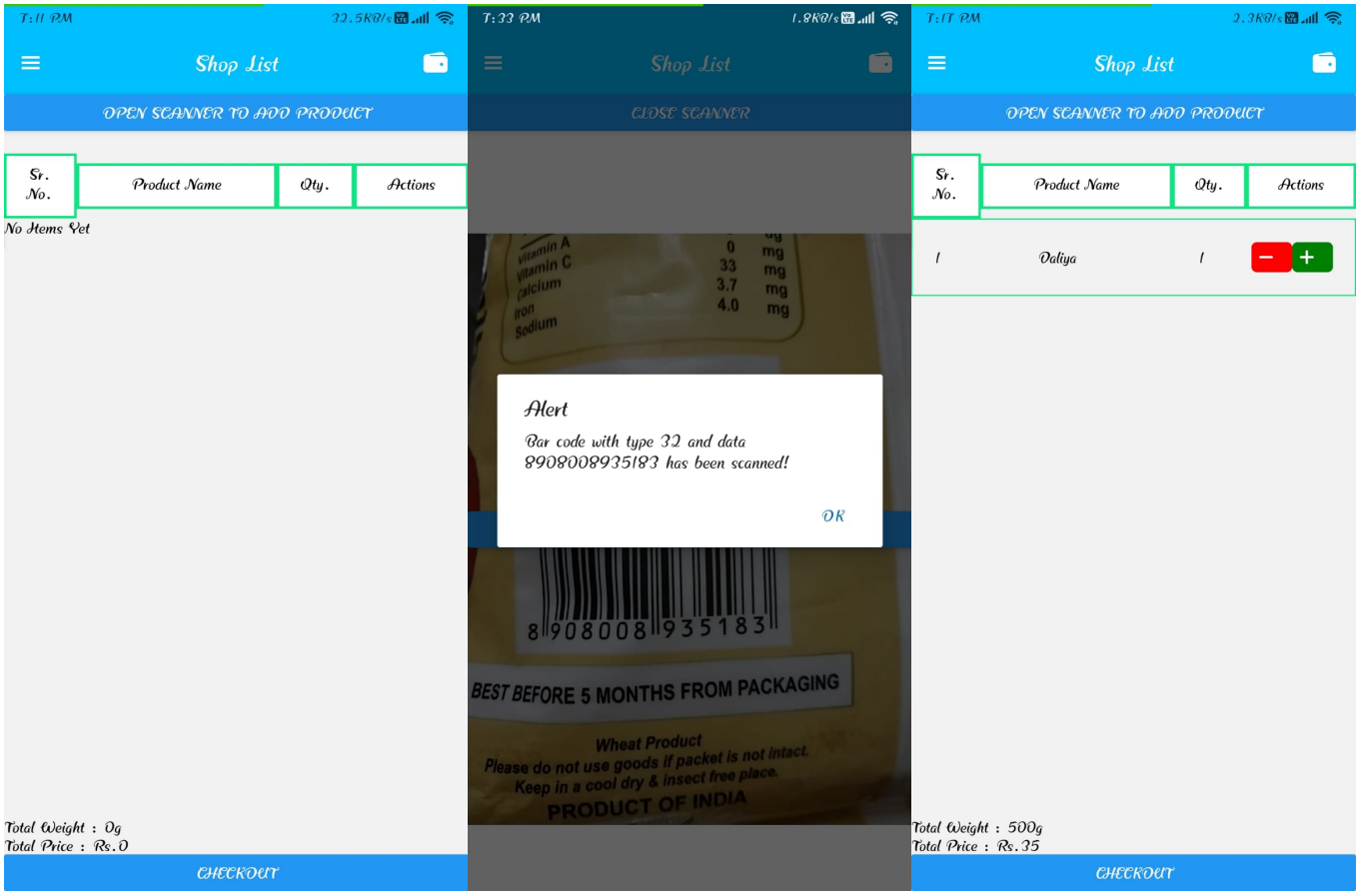


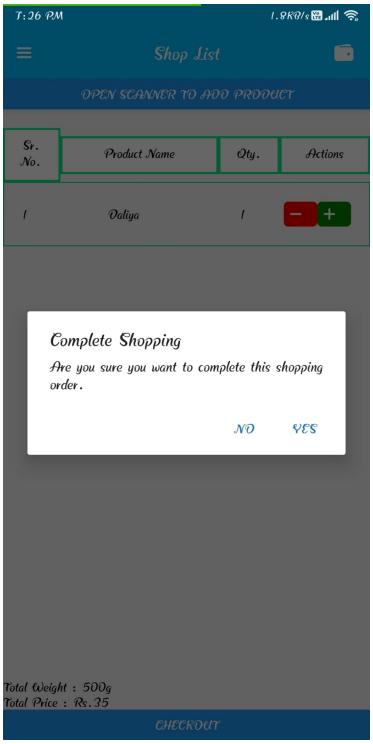
FIGURE 34: Test Case 2 Result

If the Admin wants to add a new product he just follows the simple steps first Click on Add new Product and a form will open. Just fill out the form and there is a button to scan Barcode just click it and the barcode will be scanned by the mobile camera. After submitting the form the new product will be added.

Result of Test Case 3 shown above :- (Successful)







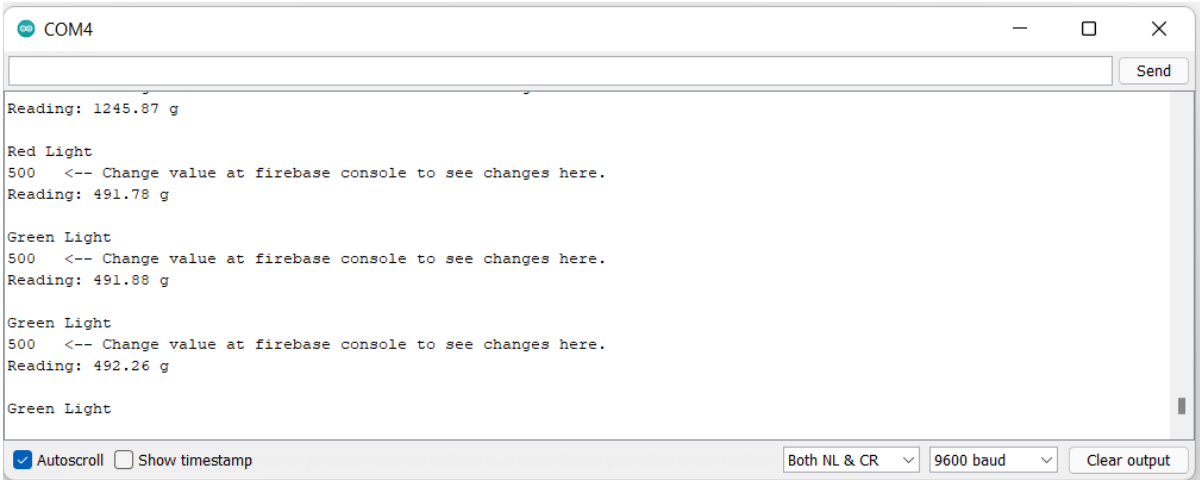


FIGURE 35: Test Case 3 Result

Users first login and then start shopping by adding items by clicking the open scanner to add items then just scan the barcode and the item will be displaced in the mobile after scanning and place the item on trolley and it will glow Green light when everything works fine. You can exit the shopping by clicking the checkout button and make a payment after that and empty the trolley.

Result of Test Case 4 shown above :- (Successful)

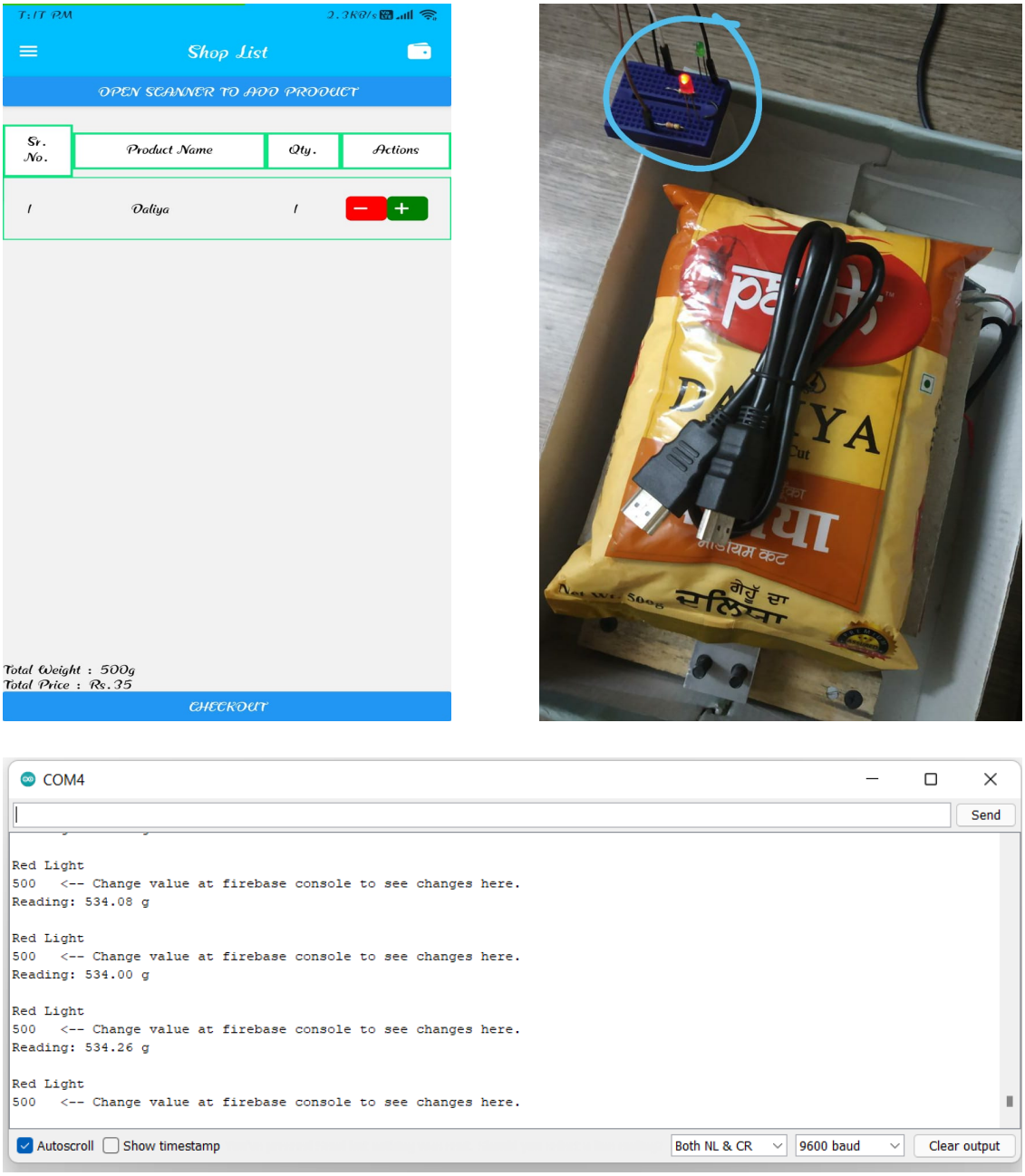


FIGURE 36: Test Case 4 Result

If a user tries to add an item without scanning it the trolley will glow Red light indicating that a fraud has occurred.

Result of Test Case 5 shown above :- (Successful)

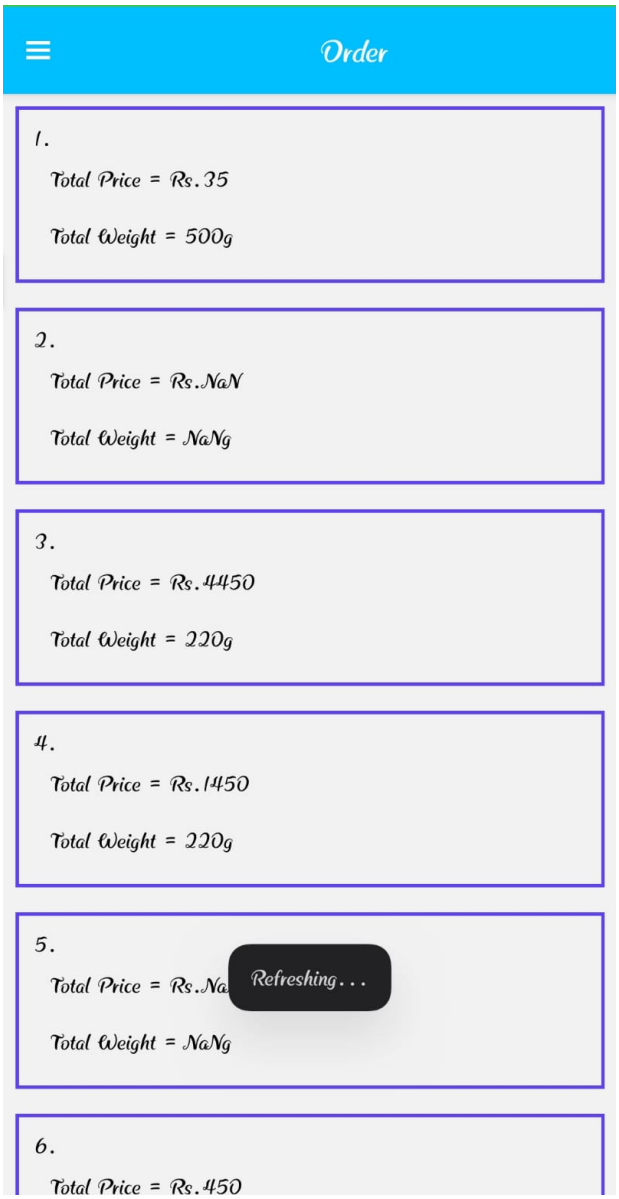


FIGURE 37 : Test Case 5 Result

All the previous orders by the user will be shown with full details after clicking that order.

5.5 Results and Discussions

After linking the application and hardware with Firebase, it was observed that 10g error margin is required for proper working of the project.

5.6 Validation of Objectives

S. No.	Objectives	Status
1	Real Time Bill Generation	Successful
2	Fraudulent Cases are handled by glowing red LED for fraud and green LED for correct working.	Successful
3	Database and the application are in sync.	Successful
4	Users can only add those products which are registered by admin.	Successful
5	Easy and simple mobile application for users to operate.	Successful

TABLE 6 : Validation of Objectives

CHAPTER 6 : CONCLUSIONS AND FUTURE SCOPE

6.1 Conclusions

At this stage, the admin can successfully add products to the database for users to scan. Users can scan the products' barcode with their mobile phones to add products into their list and the new updated total weight is updated to the database which is read by trolley to check fraudulent cases and such cases are shown with Red or Green LED light. Users can also check their previous orders in the orders section.

6.2 Economic/ Social Benefits

- Real time bill generation.
- Customers get full privacy and no judgment.
- Customers do not need to stand in long queues, thus saving time.
- Cost effective.
- Customers will have a good grip over the budget.

6.3 Reflections

- Despite the Covid-19 pandemic, the team successfully maintained integrity and teamwork, though the team worked remotely..
- Learned about various hardware components Like NodeMCU, which is really useful for connection with the internet.
- Learned about various libraries needed to combine all the hardware together.
- Learned how to create an android application from scratch using React Native.

6.4 Future Work Plan

- Proper payment interface can be integrated with a mobile application.
- Error margin for hardware can be further improved with improvement in hardware components.

- Discount algorithms may be deduced.
- User interface can be further improved for better user experience.
- Machine Learning can be used for understanding a user's shopping patterns and providing product suggestions.
- The problem of adding the same weight product could be rectified.
- The Product will be made on a large scale.
- Size of the trolley will be increased by enhancing the Load cell size for larger orders.

CHAPTER 7 : PROJECT METRICS

7.1 Challenges Faced

- **Hardware Related** - Testing the parts individually and then merging all takes a lot of time. But the toughest part is to select the best hardware component required for the project to optimize the Total cost of the project.
- **Software Related -** Debugging and testing of software and syncing the software with hardware was a bit tough. Connecting the hardware with the firebase took quite some time.
- **Team related -** Work from home was quite difficult but somehow the team managed to complete the work.
- **Project Related -** Making this project in the Covid times was a great challenge for the team as it required a good amount of hardware work.

7.2 Relevant Subjects

Subject code	Subject name	Description
UTA014	Engineering Design Project - II	In this Subject we learned how to program Arduino Ide while making a Buggy Project.
UEC001	Electronics Engineering	In this subject we learned how to connect hardware components.
UCS503	Software Engineering	In this subject we learned how to design the software and how to make proper documentation.
UCS310	Database Management System	We learned how to make tables to store data in the database for particular software.

TABLE 7 : Subject Code and Subject Name

7.3 Interdisciplinary Knowledge Sharing

During the event, members had time for different groups to discuss the feasibility and practicality of the idea. Sharing information between the workings of the human mind and practical ideas helped to develop the software as it is today. The principles of governance, as well as the ancient laws of stoicism, helped us to stick together as a group. Sharing information between Hardware and Database components makes the project much better. The steps shared in the development of the previous application helped bring life to the project and helped solve the problem. Information about limited weight transfers from hardware to firebase as well as downloading the right weight on site is shared with team members who fulfill all of our aspirations as an engineer and provide a lifelong project.

7.4 Peer Assessment Matrix

		Evaluation of			
		Ajat	Chaitanya	Bibek	Harshit
Evaluation by	Ajat	5	5	5	5
	Chaitanya	5	5	5	5
	Bibek	5	5	5	5
	Harshit	5	5	5	5

TABLE 8 : Matrix on 1 (min) to 5 (max) rating of contribution of each member

7.5 Role Playing and Work

1. Ajat Suneja : Hardware requirements studying, Hardware coding and Documentation

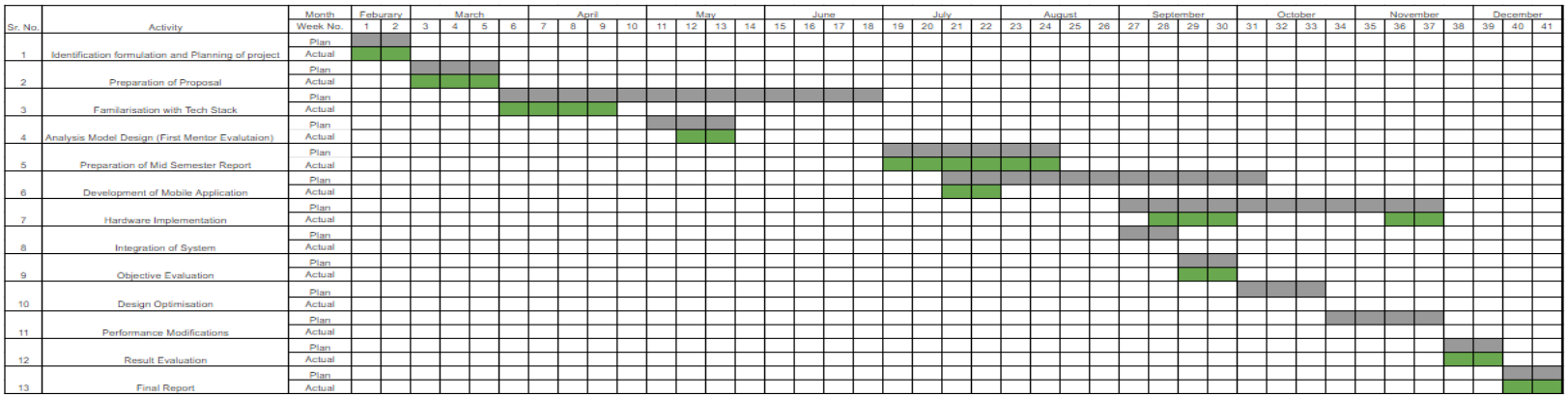


FIGURE 38: Ajat Suneja work plan

2. Chaitanya Kaushal : Mobile application development, Managing Firebase, implementing barcode scanning, Error management in mobile applications and Documentation.

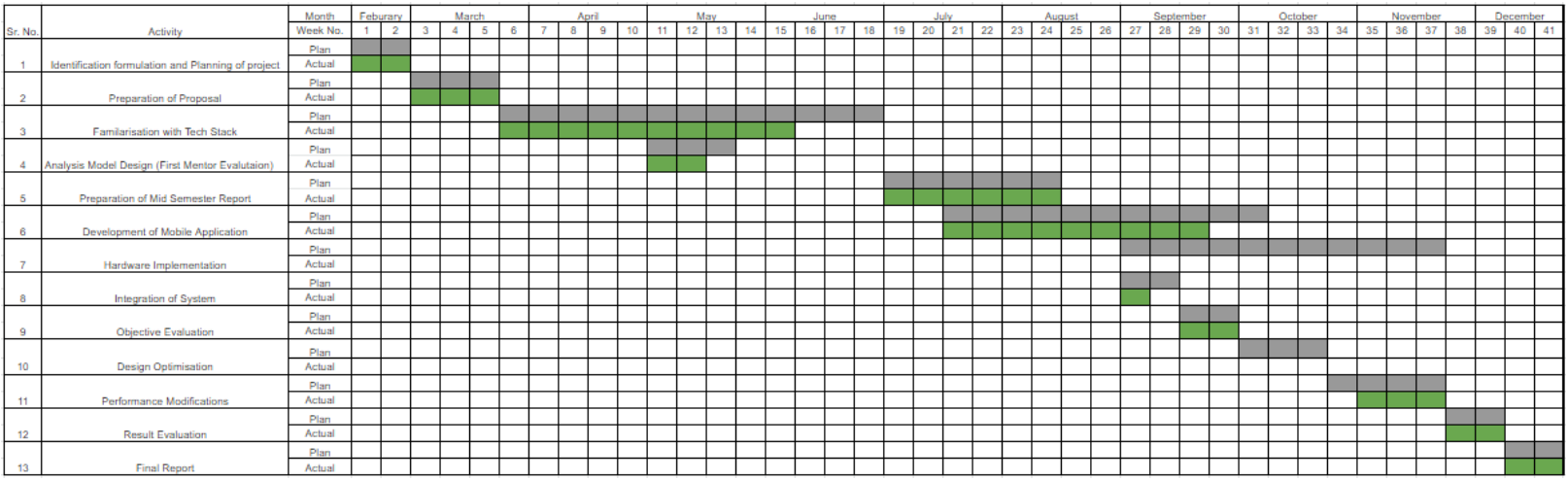


FIGURE 39: Chaitanya Kaushal Work Plan

3. Bibekpreet Singh : Mobile application development, Managing Firebase, implementing barcode scanning, Designing of the screens and managing state for products, algorithm development for fraud detection and Documentation.

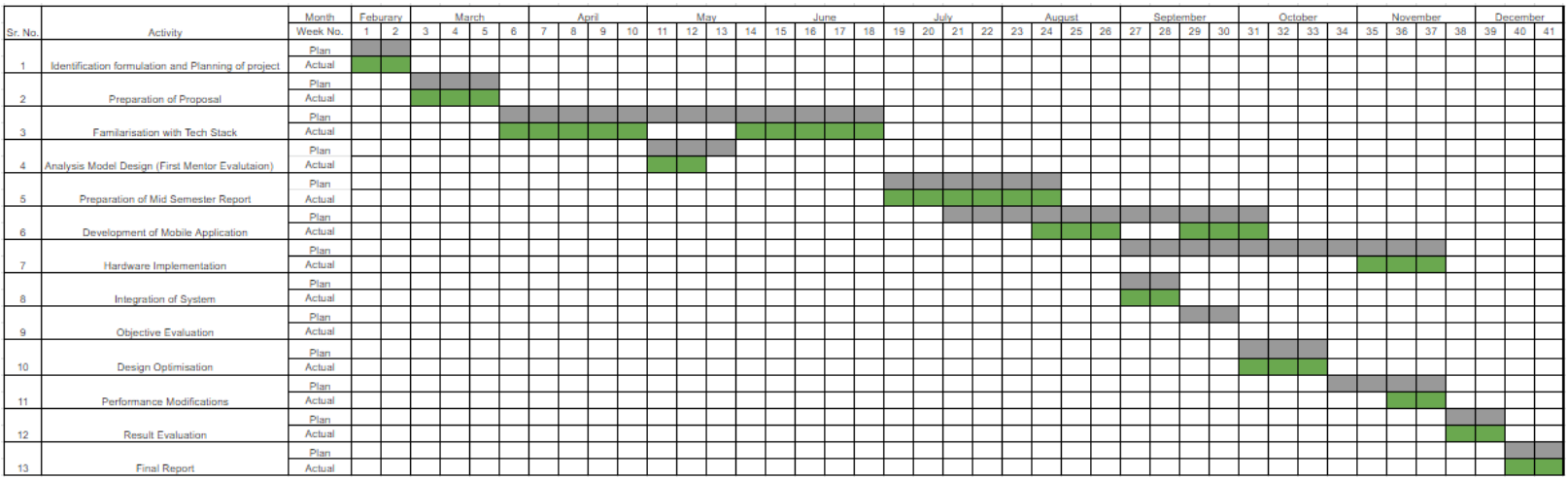


FIGURE 40 : Bibekpreet Singh Work Plan

4. Harshit Bansal : Hardware requirements studying, Hardware connections, Hardware coding and connecting it with firebase, Algorithm development for fraud detection, Maintaining Database, Hardware Testing and Documentation.

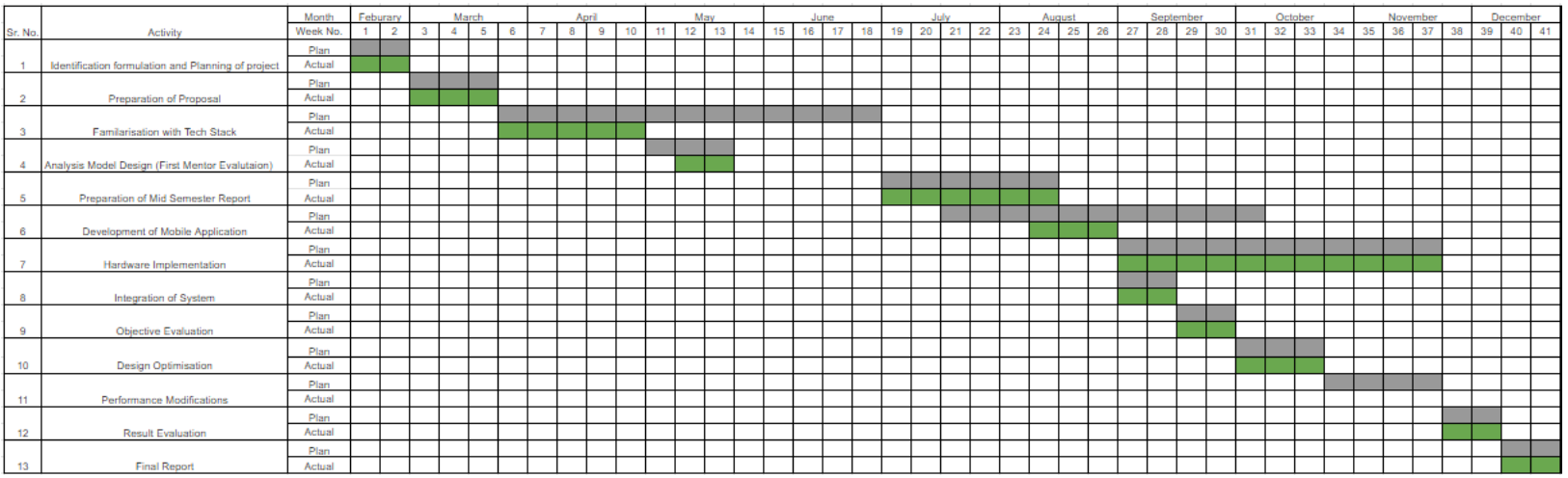


FIGURE 41 : Harshit Bansal Work Plan

7.6 Student Outcomes (A-K Mapping)

SO	SO Description	Outcome
1.1	Ability to identify and create computer-related problems	Identified the problem which almost everyone faced in our day to day lives, thus leading to devising a plan to remove queues during shopping.
1.2	Apply engineering, science, and mathematics to obtain analytical, numerical, and statistical solutions to solve engineering problems.	These concepts were also used to interpret and analyze the results.
2.1	Design computer systems to address the needs of different problem areas and build prototypes, simulations, conceptual proofs, wherever necessary, meeting design and application specifications.	Our major focus was on reducing the queues while shopping and real time bill generation and both have been solved by our project.
2.2	Ability to analyze economic transactions in computer systems.	Researched a lot of hardware components for our project and the trade-off to reducing the cost of hardware leading to choosing nodeMCU and arduino as major drivers.

3.1	Prepare and present a variety of documents such as project or laboratory reports depending on computer standards and processes.	Documentation is made with a variety of diagrams and screen shots of the working project in a proper format.
3.3	It is able to communicate effectively with peers in an orderly and logical way using sufficient technical knowledge to solve computer domain problems and problems.	Divided the team into Hardware and software according to the knowledge of teams and communicated through video calls for proper functioning.
4.1	Be aware of ethical and professional responsibilities while designing and implementing computer solutions and innovations.	Major concern was to reduce the cost of the project and be able to detect the fraudulent cases. Thus we devised our own algorithms for such.
4.3	Evaluate computer engineering solutions by considering environmental, social, and economic factors.	Real time bill generation. Customers get full privacy and no judgment. Saving time as there is no need to stand in long queues. Customers will have a good grip over the budget.
5.1	Participate in the development and selection of ideas to meet the stated goals and objectives.	The whole team participated in all the project related discussions.
5.2	Able to plan, share and execute work commitments effectively by creating a collaborative and participatory team environment.	Every member of the team was given a chance to express the part they wanted to contribute to the project.
6.1	Ability to perform tests and further analyze the results obtained.	Testing the small parts of a project individually and then combining it is the most difficult part and takes a lot of time.
6.2	Ability to analyze and interpret data, make necessary decisions and reach conclusions.	Deciding of the error margin was reduced by changing the calibration factor for weight measurement and studying the data at every factor.
7.1	You can test and use resources to improve your reading skills.	Everything in the project has been learned from scratch from every team member and everyone used a lot of resources to learn about their part in the project.

Table 9 : SO1-SO7 Mapping for the course 'UCS794- Capstone Project'

7.7 Brief Analytical Assessment

Q1. What resources has your team explored to come up with a list of potential project issues?

Ans: We researched about common problems that are faced by a lot of population and after considering some of the problems and comparing them to our technological knowledge we arrived at the Self checkout system and read reports for the same and tried to device our own thinking into those reports.

Q2. What analytical, computational and/or experimental methods did your project team use to obtain solutions to the problems in the project?

Ans: The major alternative to our approach was the RFID tag which was already used in some of the research papers, but the problem was its cost was much higher and we needed something economical for our project to be accepted at larger scales and thus we arrived at using barcodes along with user mobiles solve the problem.

Q3. Does the project require demonstrations of basic, scientific and / or engineering knowledge? If so, how did you apply?

Ans: In this project, knowledge of mobile application development, NodeMCU and arduino connectivity with all the sensors and Database management have been used. NodeMCU has been used for connecting to the database and arduino to read data of weight sensors.

Q4. How did your team share responsibility and communicate the information of schedule with others in a team to coordinate design and manufacturing dependencies?

Ans: We divided the project in two major categories of Hardware and Software and the team members were assigned to the categories according to their interests and we communicated with each other through online meets while everyone working from their own homes.

Q5. What resources did you use to learn new things that were not taught in class during the project?

Ans: We have taken various online tutorials, MOOCs (Massive Open Online Course) at sites like Coursera, Udemy, edX, Arduino for Arduino program and web application development especially for YouTube videos. The team read numerous papers and technical reports to learn the new features needed for a non-teaching classroom project.

Q6. Does the project make you aware of the need to solve real-life problems using engineering and can project development enable you to become more proficient in software development tools and environments?

Ans: Yes, the team worked very hard during all the phases of the development of the project, major reason being that our problem set was realized by every team member thus adding to the motivation to improve it. It helped us to understand the ways to divide work and the dependencies of various things on one another, as hardware could only be used after the mobile application was developed to a certain point. We all learned everything from scratch like React Native, Firebase and NodeMCU and arduino working with different sensors and connecting to Firebase.

APPENDIX A : REFERENCES

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APPENDIX B : PLAGIARISM REPORT

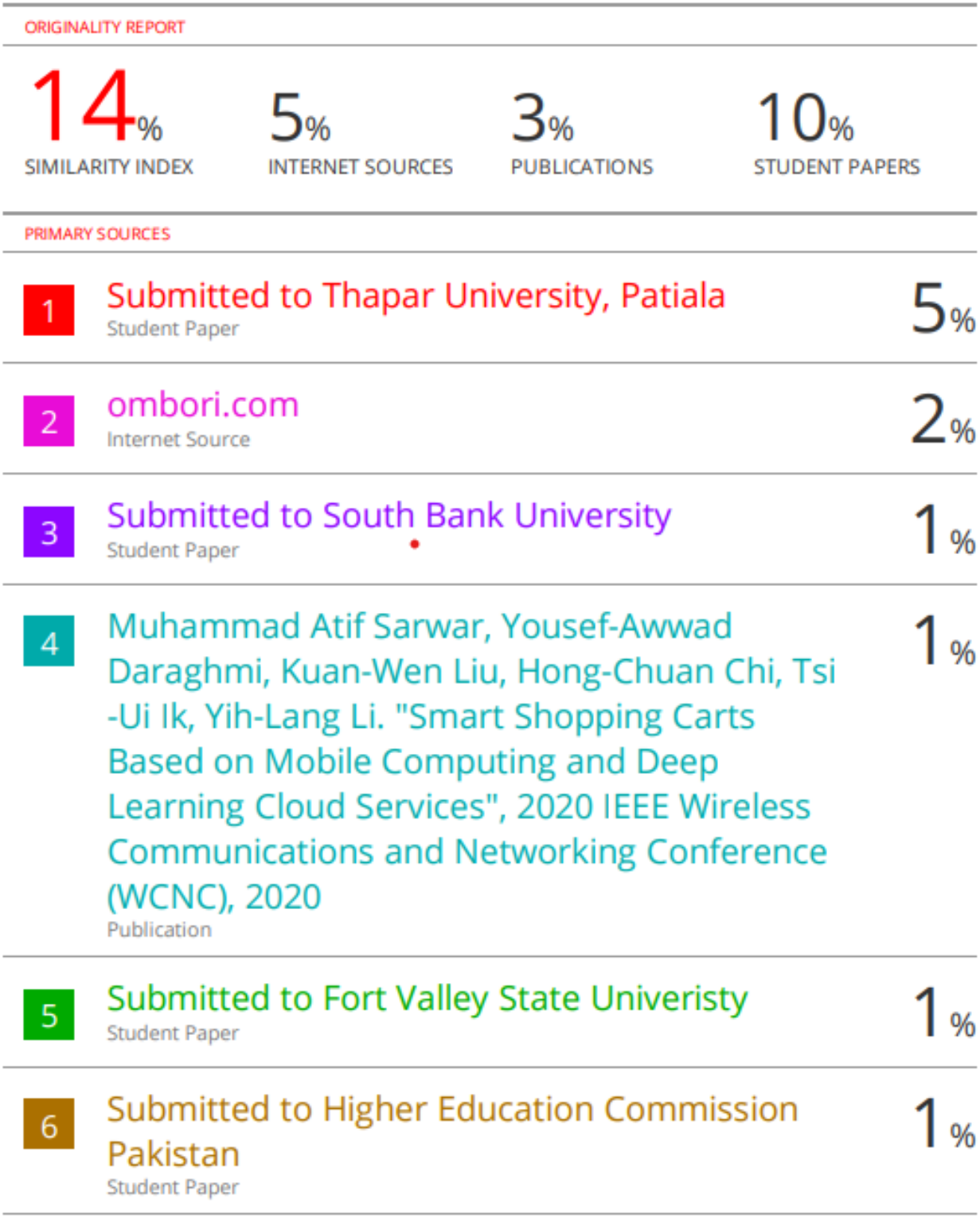

FIGURE 42 : Plagiarism Report