Networked Smart Coin Collector

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Networked Smart Coin Collector

A dissertation submitted for the Degree of Master of Computer Science

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University of Colombo School of Computing
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Declaration

The thesis is my original work and has not been submitted previously for a degree at this or any other university/institute.

To the best of my knowledge it does not contain any material published or written by another person, except as acknowledged in the text.

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This is to certify that this thesis is based on the work of

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under my supervision. The thesis has been prepared according to the format stipulated and is of acceptable standard.

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Supervisor Name: Dr. Prasad Wimalaratne

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ABSTRACT

The study attempts to investigate an innovative solution for automating the small and medium cash transactions. The small cash transactions drive with coins all the time. The study focused on charitable donations which add up millions of coins each month. In many countries coin collecting, coin counting and coin processing are still done manually. The investigation has done to make this manual process automated and intelligence.

Two coin machines were selected from two different vendors. Coin machines were trained to identify and release a unique coin code per each coin. A system has implemented to make coin process more intelligence. Four modules have implemented to get work done. The device module has programmed to accept coins and send the unique code to the client application. The client application module has developed to convert coin code to its market value and updates backend server with the new value and then trigger a coin event to web socket server. Raspberry pi device has configured as the client application of the system. The backend server module has developed for user authentication, to interact with the database and send new updates to client web portal. The web socket server module has integrated to real-time update subscriber's web portal.

Sri Lanka's latest coin types were used to accomplish the objectives. Experiments were done to confirm that the coins are accurately identified by the machine. Coin data updated in real-time to the user dashboards with expected minimum latency of 200miliseconds. Alert notifications have triggered when the coin box exceed its limit of 75% and 100% in percentage. All Sri Lankan coin types were able to train to the coin machine for identification. Coin machine returned unique code for each coin. This coin code converted into its real value and then sent to the user dashboard within average 300miliseconds of time. The dashboard is generated from history coin data that are saved in the database server. This data is displayed in graphical formats by using graphs, charts, and tables. Alert notification successfully triggered to indicate coin box status by the back-end server after calculating fill status with the help of coin algorithm.

The first conclusion is that the coin machines can be used as IoT device in order to obtained benefits in various subject areas such as saving home wasted coins in a valuable manner, bus ticketing, smart vending machines etc. The second conclusion is that web socket data communication can be integrated with IoT devices to achieve real-time information sharing via TCP network connectivity. The third conclusion is that a coin algorithm could be used to identify the coin volume of a container object such as coin safes or coin boxes.

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I specially want to mention my parents and sisters who gave a big guidance for me from childhood to present. Big thank for you all.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF ABBREVIATIONS, DEFINITIONS

Term	Definition
API	Application Programming Interface
IoT	Internet Of Things

LIST OF FIGURES

APPENDICES

CHAPTER 1 INTRODUCTION

1.1 Motivation

There are still billions of coins are circulating around the world on day-to-day transactions. Coin collecting and counting process should be enhanced to become more intelligent. Proposed system enables automated coin identification and real-time counting process with a centralized system to view and process all collected data as required by the relevant business or other application processes. To achieve this, it is required to convert a normal coin collector machine into an Internet of things device.

The proposed system can have a variety of usages. One important aspect is this system as a home coin collector. A simple and small machine that has a coin insert point and a small display to show the total value of inserted coins. This machine will help householders to save some money from coins they received on their daily transactions as changed values and also get rid of the messy coin boxes/pots that they have to manually count and submit to banks for convert into cash.

The second usage is this machine could be used as Donation Collecting Machine. Donation collecting machines use for various social services. These machines will send its real-time data to a centralized system which will help authorities to view and assess total amounts and other related data.

The third usage is this system as a Bank ATM to collect Coins. People are not making transactions by coins at banks. t is a hard work for the Central Bank to collect coins that are rotating all over the country. If bank deposit machines are capable of collecting coins, then people will easily place/deposit their money on them.

The fourth usage can be highlighted as this system as a Ticketing and goods vending machines. Ticketing and good vending machines with central servers only use by few developed countries.

1.2 Problem Statement

Coins are used for small amount of transactions among the world. In Sri Lanka coin collecting, coin counting and coin processing are still done manually.

As an example, In donations, organizers keep small boxes in several places like temples, shops etc. At the end of donation, they collect those coin collecting boxes and count the total money which is a more time-consuming task and organizers have no idea about total money collected until counting completed at the end of the donation program.

Problems encountered from this manual approach are need human involvement from start to end of the coin collecting program and it is a very difficult task. The owners have to stay until the end to get the total coin value. Robbers can steal the coin boxes as there is no much security in small coin collecting processes. Therefore, coin identifications and counting mechanism required more intelligence.

My research proposed a new approach to overcome this issue which makes coin machine more intelligent by real-time processing coins which are inserted to the machine and update central servers which can access by authorized users and can have an idea about the total collection of the ongoing program.

This system proposed solutions to identify unauthorized access to coin machines and keep them more security.

1.3 Aims and Objectives

1.3.1 Aims

This research work aims to investigate an innovative solution for converting a stand-alone coin machine to an IoT device in order to automate coin collection processes more efficient and intelligent.

1.3.2 Objectives

1. Analyzing similar research papers on automated teller machines.
2. Training coin machines to identify local coins.
3. The client application will be developed to measure coin value, calculation and trigger coin event to the backend server.
4. Real-time data transferring method will be implemented using web sockets and SSL connection.
5. The backend server will be developed for User authentication and save coin data into the database.
6. The web portal will be developed to view real-time data by authenticated administrators of the system.
7. Graphs will be implemented to summarize all captured data for the analytical purpose.

1.4 Scope

The scope of the study is to analyze local currency coins and make an efficient process to

The scope is focused on,

Convert stand-alone coin machines into networked IoT device. This will be facilitated once donators inserted coins from any coin machine over the country that coins will be identified automatically and will be done a real-time counting process and update centralized system.

The main aspects looked into were the following capabilities,

1. Make coin machine an IOT device by gathering each separate coin machine data of a specific event into a centralized server.
2. The capability of real-time update a central server.
3. The capability of analyze big data set and calculate coins according to market value and output results as graphs.
4. Use coin filling algorithm to alert administrators on the status of the specific coin machine.

1.4.1 Assumptions

1. As it is hard to buy expensive coin machines one of the assumptions is that coin machine has physical security of the place it is located.
2. The administrator has already registered as an authorized person.

1.4.2 Limitations of the Study

1. The scope has limited only to investigate Sri Lankan currency coins.
2. The research study target on donations carries on in Sri Lankan temples.

1.4.3 Structure of the dissertation

From next chapter, this dissertation has organized to summarized the related research work done by other research groups and criticized the advantages and disadvantages of technologies used for related work along with Literature review chapter.

Methodology chapter has described related requirement analysis, functional and non-functional requirements of the networked smart coin collector. Overall architecture has explained the implemented system wisely. Detailed process flow diagram has explained sequence the process flow until getting input from the customer to serving output to the web portal in order to make coin machine more intelligence. Further methodology chapter has described algorithms that were used to calculate the volume of each coin box.

Implementation chapter has explained about technical information used such as programming languages, runtime environment, and frameworks used to implement the modules inside the system. Further, this chapter has explained details about software application modules that are back-end API, Client application, device connector application, web socket server and hardware modules that have used to make the system smart.

Evaluation and results chapter has described the designed experiments that have done and experimented with results that have obtained through the research work.

Finally, the conclusion chapter has summarized the conclusions that have obtained through this research project and discussed the limitations and future works that need to be done in near future.

CHAPTER 2 LITERATURE REVIEW

2.1 Related Work

Many researchers have involved in coin transactions based on vending machine systems. Experiments have done for making more intelligence coin transaction systems in the vending machine. As the same basic concepts will be used to develop this smart coin deposit machine a few of them are discussed here.

The research paper [1] criticized a vending machine controller with auto-billing features.

This research claims a new approach to vending machines by designing a multi-select machine using a finite state machine model with Auto billing features. Researchers developed this process using 4 states. The first state is user selection. The second state is waiting for money insertion. The third state is Product delivery. The fourth state is servicing.

When we talk about succeed states of this product, its productivity is in high level. And they have reduced development cost. This approach is well organized but the complexity of this system is very high. The system is easy to use by an ordinary person. The auto billing system is an important feature and reduces human involvement.

Also there are few drawbacks of this research. They haven't use any modern technologies to improve the intelligence of the machine. As when the year 2012 we can find new technologies rather than developing step by step processor using Finite State Machine which represents each output is a state and it will return a different set of states as the output. A state register keeps the current state and next state logic. Researchers have focused just to improve the interior functionality of the machine. The system lacking in certain areas, another drawback is machine has trained only to accept Rs. 10 and Rs. 20 notes which means people have some limitations of only they can request items when they have small notes. This is a stand-alone vending machine and researchers approached only to enhance the functionality of the vending machine by claiming new technology to vending machine workflow.

ANALYSED DATA ON FINITE STATE MACHINE BASED VENDING MACHINE CONTROLLER WITH AUTO-BILLING FEATURES			
1. Proposed Solution	Technologies	Strengths	Weaknesses
Improve vending machine to enhance productivity and simplicity	Modeled using 4 states which represent each output is a state. 1. First State - user selection 2. Second State - waiting for money insertion 3. Third State - Product delivery 4. Fourth State - servicing	1. Productivity is high 2. Reduce development cost. 3. Easy to use.	1. Only to accept Rs. 10 and Rs. 20 notes. 2. Doesn't use any modern technologies to improve the intelligence of the machine. Just improve the interior functionality of the machine.

Table 2.1: Illustrates the Analyzed Data of Reference [1]

In reference paper [2] presented a coin machine research done by North China Electric Power University, Baoding, 071003, China and researched system is an Intelligent bus coin box.

This research group has indicated that the present situation of the bus company which has received a large number of mixed coins and empowered a large amount of manpower to sort out this which makes low the efficiency. The solution for this is which function is to separate the coins and notes. Designed coin sort storage and the display shows the value of the received coins improve the efficiency of zero cash recycling, use simple mechanical principles for classification to become efficient, accurate and practical. This uses real-time sorting and real-time counting.

Researchers claim that there are several problems with other coin sorting machines. They are coin machines equipment manufacturing costs are high, large models are not suitable for all countries and Lack of paper money and coin separation function.

In this research work, Smart coin box main functionalities are a coin, note classification, and coin counting. Researchers designed intelligent coin box with 4 components.

1. Through the Coin
2. Banknote sorting chute

The Upper runner of the device handles mixed zero bills. At the bottom of the upper runner, a banknote - coin sorting tunnel is provided. Due to a certain thickness of coins and notes have a certain fluffy, tail in the slide to make a high degree of moderate tunnels so the coins free through fall into the lower slide. At the end of the lower slide openings, coins fall into a lower device.

3. Coin sorting device

Coins fall into a conveyor belt. The belt is slanting forward and sloping downward with a certain height difference. The difference in height giving the coin certain speed and has made different coins in a different radius of the falling position.

4. Coin counting device

After classification of coins falls into the box below the slide, an infrared sensor goes through the coins. The sensor receives the signal and feedback to the microcontroller. Data collection and processing display shows the total number of coins and total value.

As explained in this research paper its mechanical structure is simple and the equipment cost is low.

This research system reduced the cost of manpower. This research project has not explained more about the accuracy level of currency notes and coin identification. This is a standalone system and although it reduces sorting manpower, the bus companies have to count each individual machine to get the total count of each bus coin boxes. And bus companies have no idea of the profit until the last process which is manual counts each coin boxes to calculate total using manpower.

Contrast to research paper [1], the research paper [2] has used modern technologies to make the system more intelligent. And this bus coin box is functioned as a fully automated system.

The research team has not indicated any clear statement about accuracy level. And bus coin box is a stand-alone machine and this can be networked with other bus coin machines as a future work of the research.

ANALYSED DATA ON INTELLIGENT BUS COIN BOX			
2. Proposed Solution	Technologies	Strengths	Weaknesses
Proposed intelligent bus coin box to sort and count mixed coins.	1. Developed 3 hardware components. 1.1. Banknote sorting chute 1.2. Coin sorting device 1.3. Coin counting device 2. Used Sensors to count total.	1. The mechanical structure is simple. 2. Equipment cost is low. 3. More Intelligent. 4. Reduce the cost of manpower.	1. No clear statements about accuracy level. 2. Stand-alone device.

Table 2.2: Analyzed Data Summary of Reference [2]

The third research paper [3] argued about smart milk vending machine developed for the Indian market.

In the modern world, everything has computerized and automated and the need for the human was overcome by machines. But this research group has stated out still there are small-medium businesses and workflows have many areas to be enhanced. In India, the supply chain of milk normally owns one or two cows, deliver milk to the local collection points typically located at the village itself. And they are supplied to the milk dealers in the city.

In milk centers, there is a big queue to collect milk because milk has to be measured and has to receive cash. This is a very time-consuming task. Also for the distribution of milk and collecting money human involvement is needed.

In this research project, the research group has proposed a milk vending system which is cards are to be placed on the RFID reader for authentication and required milk will be dispensed according to the balance of customer's credit and GSM will provide and SMS on remaining balance in the account.

Here, Method of paying the bill in vending machines use two techniques. The first approach is coin-operated vending machines. And the second approach is notes operated vending machines.

Here, notes and coins can stick in machines. To avoid this, issue these researchers proposed a rechargeable prepaid card system.

To eliminate the human involvement a card system is used for vending or for dispensing the milk in milk centers. The card system included RFID card reader and RFID tags which helped customers in milk centers. With the help of a flow sensor, we can measure the flow of milk through a microcontroller.

In the proposed system, every single user provided with an RFID tag. By using this tag every customer can access and buy milk in milk centers. To vend the milk, the card must be inserted on to the RFID reader module which has a microcontroller with serial interfacing.

Microcontroller read the information and asks the number of liters want which will be shown on the LCD screen. Then the user is required to enter the liters he wants and microcontroller checks the required balance on the smart card. If it has enough balance machine will pump the

milk. This uses a sensor and whenever the milk level is going to finish it will send SMS to the manager of the vending machine.

The items used in the system are RFID Reader, RFID tags, Liquid Crystal Display (LCD), GSM Modem, Crystal Oscillator, Flow Sensor, Lactometer (To detect the quality of the milk).

When criticized about the importance of this proposed system, this research team make the machine more intelligent by using sensors to indicate whether it has sufficient milk to deliver or milk tank is empty. In addition, the proposed system has designed to fast serving and improve the efficiency of milk collection and distribution. But still, the research group has failed to reduce the complexity of the system as each and every user needed to be issued an RFID tag and need to recharge the RFID tag before vending milk.

ANALYSED DATA ON SMART MILK VENDING MACHINE			
3. Proposed Solution	Technologies	Strengths	Weaknesses
Smart milk vending machine has proposed to replace the human involvement to collect money and distribute milk to small-medium customers.	1. Used RFID reader for authentication 2. Issue RFID rechargeable tags. 3. Used sensors.	1. Has used authentication system before serving milk. 2. Designed to improve efficiency. 3. The system designed to keep more Intelligent by using sensors to indicate milk tank is full or empty	1. Complexity is high.

Table 2.3: Analyzed Data Summary of Reference [3]

The research paper [4] has indicated about a note to coin exchanger which developed by an Indian research group. This research team has argued about the importance of coins in the day-to-day transaction places and proposed a smart note to coin exchanger. They have developed a mechanical coin exchanging model to fulfill this requirement named their research as an intelligent note to coin exchanger with fake note detection.

The proposed machine accepts note to check whether the note is fake or real. Camera used to check the value of note inserted. Proposed counting machine has a display and prompt user to operate basic functionalities. The research team has used coin sorting machines to output relevant coins match with the note inserted. The research team has organized Note placing unit, Fake note detection unit, Microcontroller to generate the number of coins issue to match with note value, camera to get the image of notes, LCD to display whether enough coins have to issue or not.

ANALYSED DATA ON INTELLIGENT NOTE TO COIN EXCHANGER WITH FAKE NOTE DETECTION			
4. Proposed Solution	Technologies	Strengths	Weaknesses
A solution to immediately exchange notes to coins in shopping malls, bus stands, and railway stations.	1. MATLAB algorithm for image binarization to detect the value of the note. 2. MATLAB and feature extraction with HSV color space, other applications of image processing.	1. low production cost. 2. Provide fake note detection. 3. A good approach to provide coins in daily transactions.	1. Limited only to few notes Rs. 10, Rs. 20.

Table 2.4: Analyzed Data Summary of Reference [4]

COMPARISON OF REVIEWED RESEARCH PAPERS

	Functionality Improvements	Improve Intelligence	Weaknesses
Reference [1]	High	Very Low	Limited to identify only Rs. 10 and Rs. 20. No any concern about security.
Reference [2]	High	Medium -used sensors to count coins	No clear statement about accuracy level
Reference [3]	Very High	Very High	More complex
Reference [4]	Low	High	Limited to identify only Rs. 10 and 20, 100, 500, 1000

Table 2.5: Comparison summary of reviewed research papers

2.2 SUMMARY

This chapter criticized the concepts and theories of related research work in early inventions. In addition, this chapter discussed the current technologies used in vending machines in different research projects. Understanding literature reviews important to get an idea about the importance of current proposed research works and shortages of current systems in order to propose new research solution.

CHAPTER 3 METHODOLOGY

This chapter will give an overview for the complete system. Chapter will describe what functionality is available in this innovative system and what type of stakeholders will use the system.

3.1 Requirement Analysis

Proposed smart coin machine's purpose is to provide a smart and innovative solution for small and medium level coin collections. This will be implemented using IOT technologies which will reduce human involvement until end of the process. Main requirements have identified for the machine to make it more intelligence.

Collecting coin and process them is a hassle and time consuming task. Specially, in charity services people use coins to do donations. Then the organizers have to give an extra effort to collect, count and take those coins into a valuable thing.

There are lots of coins distributed among entire country by the central bank but most of them are not circulating properly due to heavy use of cashless transactions. Many people use credit cards, debit cards, check transactions etc. This solution should encourage people to use coins for small transactions in very attractive manner.

Functional Requirements

1. Collect coins from smart coin collecting device
2. Record coin data in a central database to analyze them in real-time
3. Prevent possible human mistakes and frauds that can happen while coin counting processes by automating the entire process
4. Provide summarized diagrams, charts and reports by analyzing coin data for business decision makers

Non-Functional Requirements

1. The system should be scalable to support all country wide coin collections
2. Coin collecting unit should be portable and easy to deploy in any place.
3. Coin machine and the back-end dashboard should be easy to operate by non-tech savvy personals

3.2 Process Flow

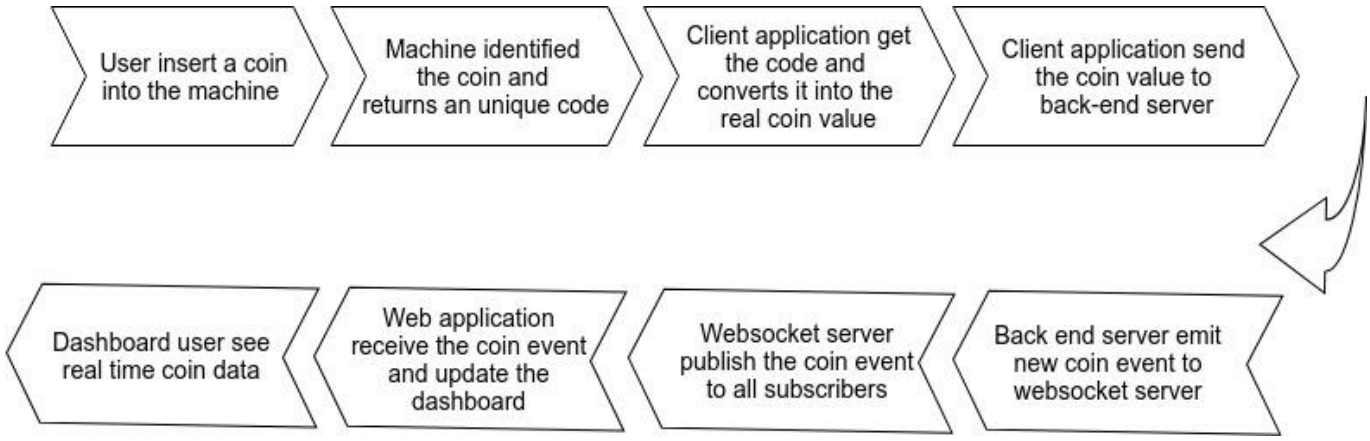

Figure 3.1: Process flow diagram

Step 01 - User insert a coin into the machine

Step 02 - Machine identified the coin and returns as unique code

Coin accepting machine has to be trained to identify all required coin types. Coin training process may differ according to the machine vendor

Step 03 - Client application gets the code and converts it into the real coin value

Step 04 - Client application send the coin value to back-end server

Step 05 - Back-end server emit new coin event to WebSocket server

Step 06 - Websocket server publish the coin event to all subscribers

Step 07 - Web application receives the coin event and then updates the dashboard

Step 08 - Dashboard user see real time coin data

3.3 design assumptions of prototype architecture,

1. Proper continues network connectivity should be there for real-time communications between coin machine and the back-sever.
2. Physical security of machine and collected coins has to be provided by outside of the design concept.

3.4 algorithmic design details

Calculating possible coin capacity of a given coin box

If the coin box will be filled with a single coin type then the total capacity equation will be as follows,

Method 1 - (less accurate)

- Number of coins that will fit into the box = Coin Capacity = C
- Volume of a coin = V
- Volume of the coin box = B

$$C = V \div B$$

Calculating V

Figure 3.2: Volume of a Coin

But this will only give a logical capacity of the coin box. Following method will be more accurate than the above calculation

Method -2

Assumptions -

- Coins will be stacked properly without any misalignments
- Only one coin type will be used for the calculation per time

Parameters -

- Diameter of the coin = D
- Height of the coin = h

Figure 3.3: Diameter of a Coin [10]

- Length of the coin box = L
- Width of the coin box = W
- Height of the coin box = H

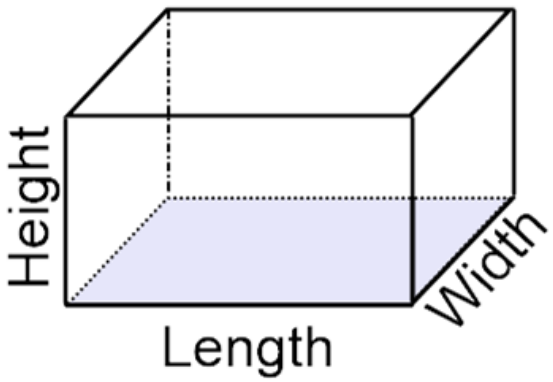

Figure 3.5 : Measure volume of Coin Box

Figure 3.4 : Height of a Coin [10]

Number of coins can stack for full width of the box = $W \div D = C_1$

Number of coins can stack for full length of the box = $L \div D = C_2$

Number of coins can stack on top of each other to fill the box = $H \div h = C_3$

Total Coins $C = C_1 \times C_2 \times C_3$

The stakeholder interacts with the system in 2 stages.

1. The user Insert data into coin machine
2. The Admin view total coin summaries via Web Portal.

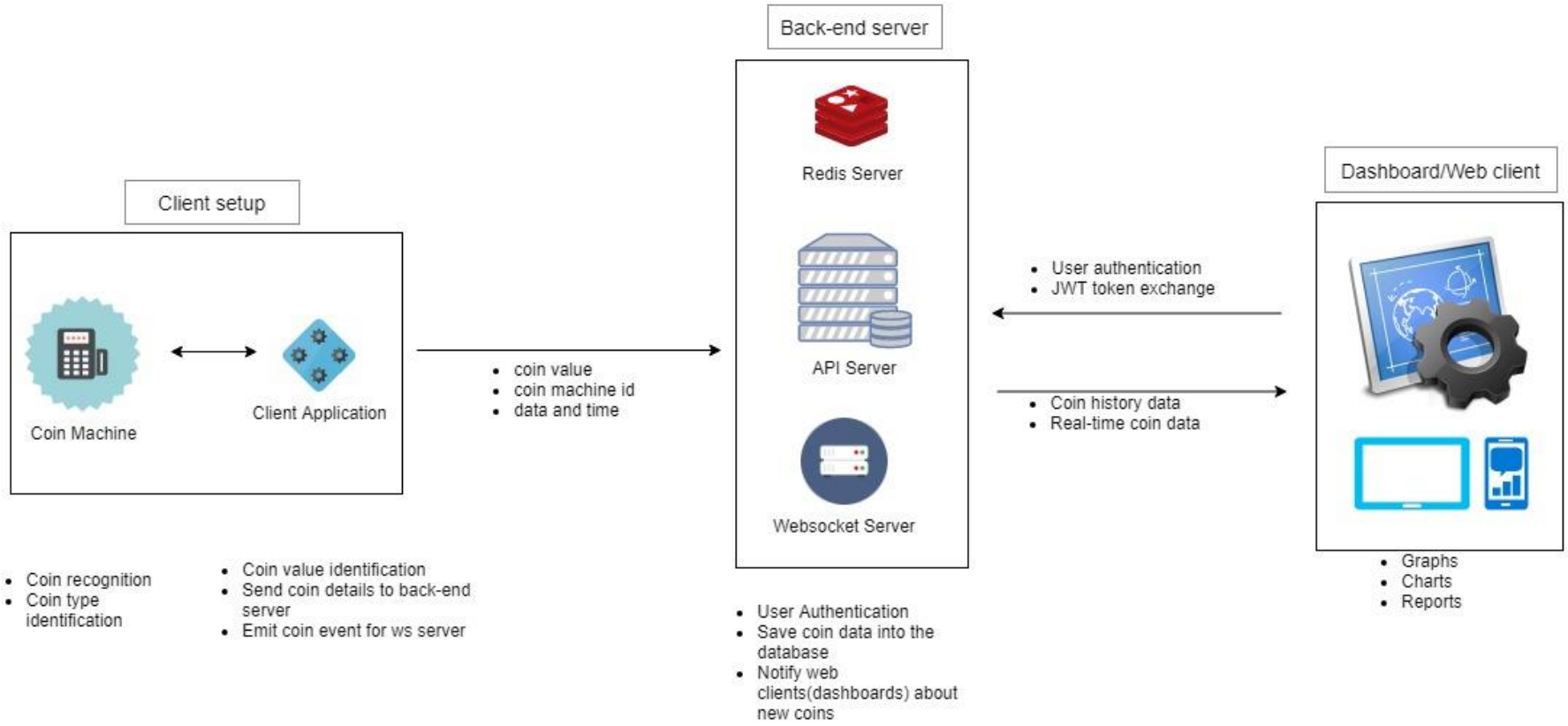

Figure 3.6 : Detailed Process Flow DIagram

3.5 Coin Machine Workflow

Step 01 - Receiving coins one by one and identification the coin value

1. Coin comes into the drawer.
2. Coin go through a magnetic field to identify its metal type and metal amount by the variation of the magnetic field strength
3. Coin pass through two Light emitters (with receivers).
4. Two light emitters will record coin dimensions by the light distraction happened on the above stage.
5. The machine will match data against previously collected (while coin training process) data and if match found then return the correct coin code else pass the coin to the rejected slot.
6. Machine output coin type signal code to its output port.

Step 02 - Client application (Running on small computer like raspberry pi) receive the coin information via serial port (or USB port connector).

Step 03 - Client application mapping coin data to its real market value (by a table which contains coin code against its market value) and send data to back-end server.

Step 04 - Client application sends coin data to the main server via Web Socket connection.

Step 05 - Server application will update all its subscribers(other client apps such as a mobile app, web dashboards, etc...)

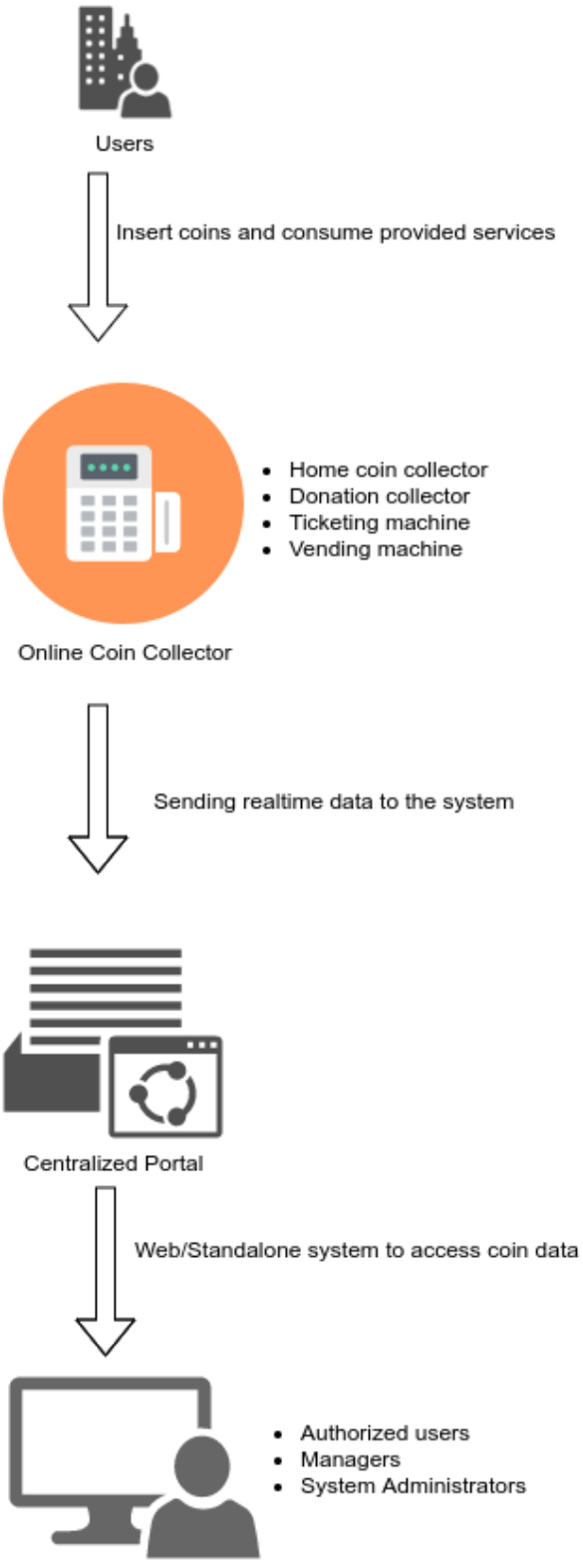

Figure 3.7: Overall solution Architecture

CHAPTER 4 IMPLEMENTATION

4.1 Technical Information

4.1.1 Programming language

Javascript - Javascript can be run on both client and server side environments. Since my solution contains multiple components including native application and web based application which is effective to use same programming language for all components

4.1.2 Runtime environment

Nodejs - Node.js is a JavaScript runtime built on Chrome's V8 JavaScript engine. Node.js uses an event-driven, non-blocking I/O model that makes it lightweight and efficient. I used nodejs to achieve followings

1. Support both client side and server side application execution
2. System has included the largest library ecosystem called npm which has almost any required libraries including following used for my applications,
    a. nodejs/websockets
    b. nodejs/axios
    c. nodejs/serialport

4.1.3 Frameworks

Loopback.io [5] - LoopBack is a highly-extensible, open-source Node.js framework designed for API developments. I used Loopback to generate back-end server APIs of my solution. Also for database modeling and database communication is controlling by the Loopback data models.

Vue.js [6]- Vue.js is an open-source progressive JavaScript framework for building user interfaces. I used vue.js for my client side web application to create more interactive single page solution.

4.2 Software Application Modules

4.2.1 Back-end API

This is a RESTful application interface to communicate with other software components. This API act as a central point control of the entire solution. Followings are the main features that are controlling and handling by the back-end API

1. User authentication and access control
2. User notifications (eg: email)
3. Accept and record coin transactions from multiple connected clients
4. Connect and communicate with websocket server to broadcast transaction information into web applications

4.2.2 Client application

This is a web based application that is for end-users to view real time transaction details that includes number of connected devices, details of each transaction, transaction reports and other custom reports. Followings are the main features and their sample screen of the client application

1. User Management
2. Device management
3. Dashboard
4. Transaction details
5. Reports

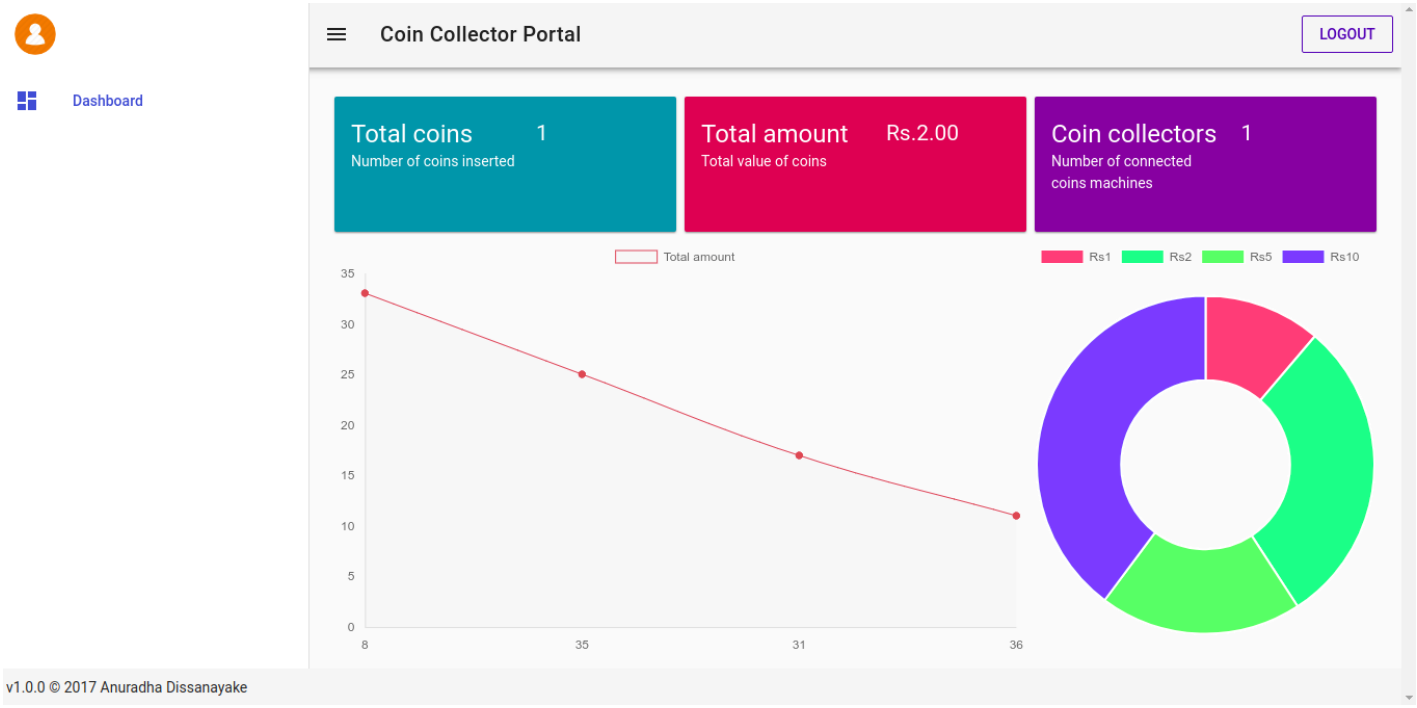

Figure 4.1: Web Portal Dashboard Screen

4.2.3 Device connector application

This is an offline native application which is running on a small PC (raspberry pi) to connect with portal coin acceptor hardware device. This application will collect coin data and communicate with back-end application via REST API. Followings are some technical information used for this application

1. Language: JavaScript
2. Runtime environment: NodeJs
3. Dependencies
   3.1. axios(version ^0.17.1) : Promise based HTTP client for the browser and node.js
   3.2. serialport(version ^6.0.4) : Node-Serialport provides a stream interface for the low-level serial port code necessary to control and communicate with hardware devices
   3.3. ws(version ^3.3.2) : ws is a simple to use, blazing fast, and thoroughly tested WebSocket client and server implementation.

4.2.4 Web Socket Server

- WebSockets are an advanced technology that makes it possible to open an interactive communication session between the user's browser and a server. With this websocket server implementation we can send messages to a server and receive event-driven responses without having to poll the server for a reply.This is how the real-time status update happens when a coin inserted in any of the connected coin machines.

4.3 Hardware Modules

4.3.1 Coin Acceptor - Type 1

Figure 4.2: PY616 multi-coin acceptor [7]

This is multi-coin acceptor model PY616.

This coin collector is accepting 6 types of separate coins. It uses 3 types of parameters to uniquely identify a coin. They are magnetic field, coin dimension and weight of a coin. This model has two physical buttons and a LED display which helps to train coins and make necessary configurations.

4.3.2 Coin Acceptor - Type 2

Figure 4.3: CX363-CA multi-coin acceptor [8]

This is model **CX363-**CA multi-coin acceptor which is more advance coin collector machine compared to PY616 multi-coin acceptor.

This coin collector machine can uniquely identify 8 separate coin types.

When user enters a coin, this machine releases a code which is unique to each type of coin. This code can be configured from the given configuration sequence. Also this unique code uses to identify coin type separately inside Raspberry-Pi device application.

4.3.3 Small Single-board Computer

Figure 4.4: Raspberry Pi 3 model B [9]

Raspberry Pi 3 model B used to run a node.js application which use to get the input from coin collector machine and send to backend API server.

This hardware model is the main device used to make stand-alone coin collector machine to be a portable, smart IOT coin collector device.

Device specification is as follows

1. Operating System - RASPBIAN STRETCH LITE(Kernel version 4.14)
2. CPU - Quad Core 1.2GHz Broadcom BCM2837 64bit
3. Memory - 1GB RAM

CHAPTER 5 EVALUATION AND RESULTS

5.1 Evaluation Protocol

Coin recognition and determining their market value is used as one of an evaluation method for the implemented proof of concept model. Multiple coin types were used for this evaluation as sample coins that had to train with coin acceptors. The first coin acceptor hardware is supported for 6 different coin types and the other acceptor hardware supports 8 different coin types.

The second evaluation protocol is to achieve real-time communication between coin acceptor device and web application dashboard. This is measured in milliseconds and that value calculated by using available network profiling tools such as web-browser developer console.

The third evaluation criterion is to determine how much of coins would be fit for the coin box. This amount is calculated based of several algorithms and used multiple coin types to achieve different evaluation results

5.2 Designed Experiments

Multiple coin machines were used to check the system compatibility with various hardware vendors. These all hardware modules are successfully integrated with the system to work simultaneously without any pre-defined conditions.

Several calculation algorithms were used to determine most accurate coin volume of a given container. For the most accurate result to be obtain the selected coin containers has to have very specific shapes that has direct volume calculation mechanisms. Best accurate results were gained by rectangular coin box or cube shaped box.

5.3 Evaluation Results

Coin Type	**Returned code by** **Device model 1(PY616)**	**Returned code by** **Device model 2(CX363-CA)**
Rs.1	Pulse count 1	+C:00001
Rs.2	Pulse count 2	+C:00002
Rs.5	Pulse count 3	+C:00003
Rs.10	Pulse count 4	+C:00004

Table 5.3.1: Coin type identification by multiple coin acceptors

5.3.2 Sample coin volume Calculations

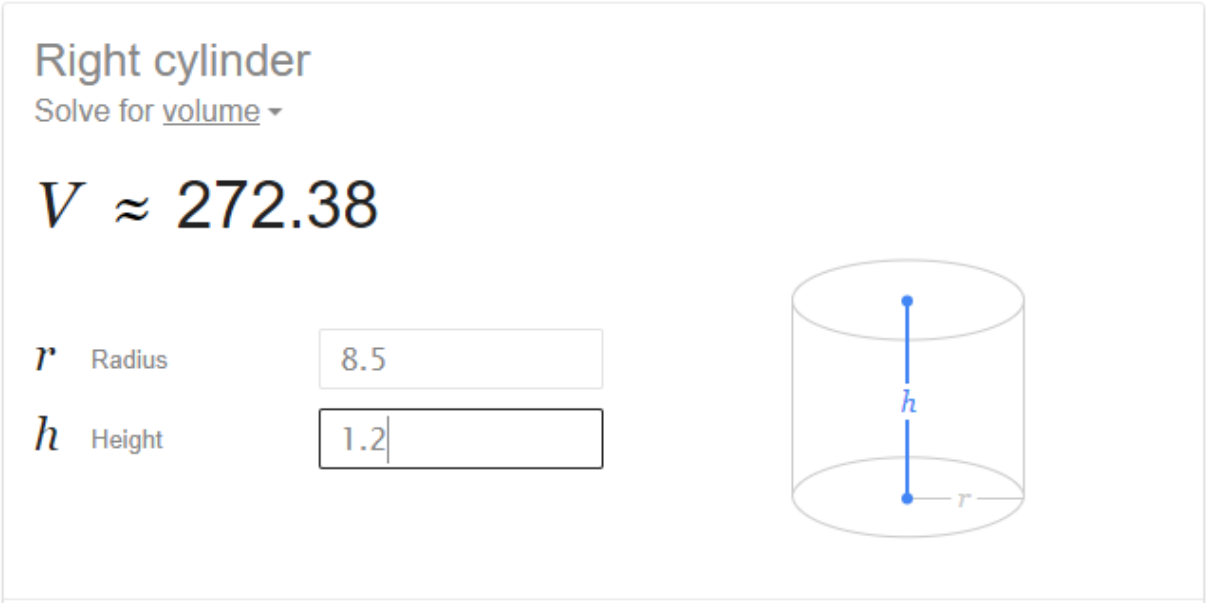

Figure 5.1: Sri Lankan Rupee 1(Rs.1) volume = 272.38mm^2

Figure 5.2: Sri Lankan Rupee 2(Rs.2) volume = 796.39mm^2

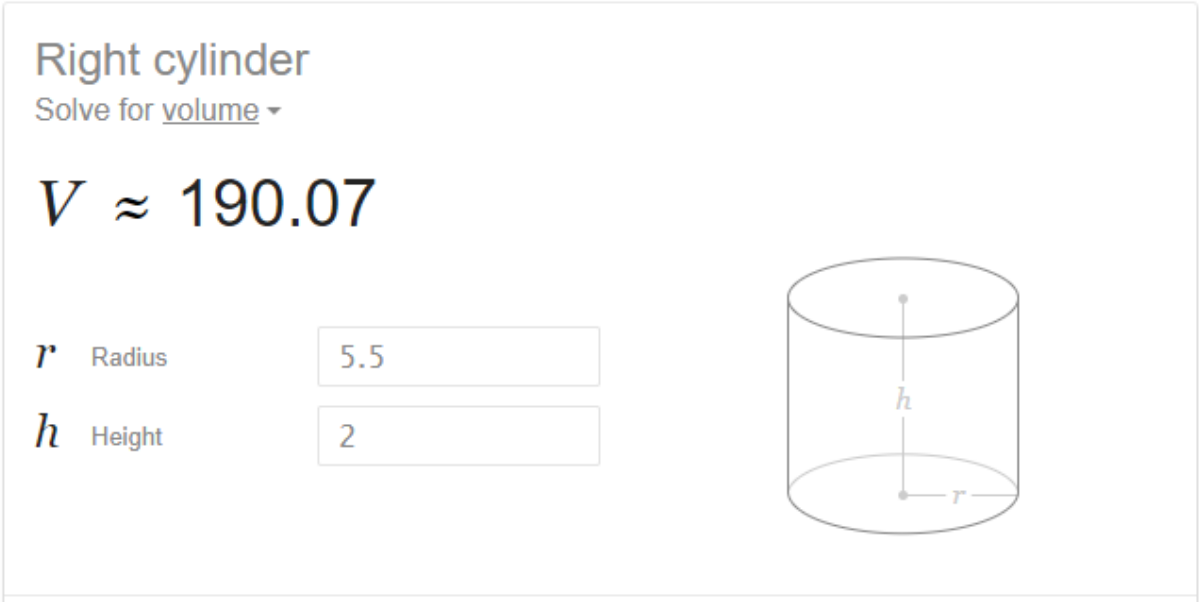

Figure 5.3: Sri Lankan Rupee 5(Rs.5) volume = 190.07mm^2

Figure 5.4: Sri Lankan Rupee 10(Rs.10) volume = 830.95mm^2

CHAPTER 6 CONCLUSION

The proposed system is designed to enhance the efficiency of small medium cash transactions that are based on coins. Several hardware and software modules are federated into a complete IoT solution to capture and store coin collection data into a central server for further processing.

Two hardware modules have used in two different occasions. One of the hardware devices is a coin acceptor which is capable of identifying coins and signaling the coin information to connected software module via serial port communication. This coin acceptor integrated with an application module to send coin code to the application server. Second hardware module is the Raspberry Pi device which used as minicomputer to process the data coming from coin acceptor. Four software modules have used to enhance the efficiency of the system. The first software component is the application module which converts coin code data into market value. The second module is the web socket server module which implemented to update real time data to all the connected clients of the web server application. The third component is backend-api module which has developed to authenticate authorized persons and save coin data into a backend database. The fourth module is a web portal which can be used by authorized users to view total coin summarization in graphical mode including charts and graphs. In addition, to enhance the intelligence of the developed system separate coin algorithm is experimented. The most accurate coin algorithm has chosen to measure the coin boxes fill status and send alert notification to authorized persons.

The first result obtained from the study is Websocket servers can be used for real time data transferring between event publishers and subscribers with minimum latency. When this solution implemented throughout the country then there will be thousands of data request coming to the central database system. This big data set can be used to analyze and identify various conceptual data models which could use for identifying data patterns and then predicting future data patterns which will helps for business decision making. Further the system can calculate coin box reaching the upper limit of the filling status using a coin algorithm. Once the system identified the coin box reaching its fill limit then system can send notification alerts to required authorities.

Limitations of the current work has identified when go through the research project. The coin machines that used to do experiment accept only eight different coins. To accept many coins, it is needed to use an advanced financial technology (fintech) grade coin machine.

The prototype does not have required physical security. This study assumes the coin machine will not be used for any frauds by physical access.

The future work of this networked coin collector is to enhance the physical security of the coin box by using sensors and other motion detectors in order to avoid any frauds and steal of coin machine. In addition, the big data can be analyzed and give many advanced predictions to make future decisions about coin related transactions within the entire country. Centralized coin collection solution will affect financial data processing of central bank of Sri Lanka which will lead to avoid coin wastages and coin related frauds.

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APPENDICES

Appendix A

Test Plan

To evaluate this research approach 2 sample coin machines are used.
Testing will be done in following steps.

1. Use 2 coin machines and test real time coin update process.
2. Use 3 or 4 devices phones, tablets and laptops to check real time update process in central server.
3. Test coin count accuracy and performance.

By inserting coins continuously test if alerts accurately send to authorized persons when coin machine filled with coins in 75% and 100%.

Appendix B

Test Cases

TC01 : User Login	
Authorized user should authenticate by the system and redirect to dashboard	
Preconditions	User enters a valid username and a valid password.
Assumptions	User has already registered as an authorized person.
Test Steps	1. User launch the smartcoin.tk app. 2. User enter valid username and valid password. 3. Click login button.
Expected Result	The user should logged in the application. The application should display the dashboard with the name of the user.

TC02 : Invalid User Login	
Authorized user should not authenticate by the system with invalid username or password	
Preconditions	User enter a invalid username and a invalid password.
Assumptions	User has already registered as an authorized person.
Test Steps	1. User enter invalid username and invalid password. 2. Click login button.
Expected Result	The user should not allowed to log in to the system. The application should display an error message and stay in the login page.

TC03 : Insert coin to coin acceptor	
Valid coin should accept and update central server	
Preconditions	Authorized user should logged into the system to view new updates for coin counts.
Assumptions	User has already registered as an authorized person.
Test Steps	1. Donator or client inserts a valid coin to coin machine.
Expected Result	Web application updates with new coin inserted. Centralized server updates with new value and every authorized persons real time update with new total value. Following records can view. 1. Total coin value collected in coin machine. 2. Number of coin machines connected to the coin network. 3. Display number of coins collected from each separate coin varieties Rs. 1, Rs 2, Rs. 5, Rs 10. 4. Coin summaries in graphs.

TC04 : Insert coins by two coin machines	
System should identify separate coin machines	
Preconditions	Administrator should logged into the system to view new updates for coin counts. User should use separate coin machines
Assumptions	Administrator has already registered as an authorized person.
Test Steps	1. Donator or client inserts a valid coin to first coin machine. 2. Donator or client inserts another coin to second coin machine
Expected Result	Web application should identify separate coin machines. Web application should individually updates 2 coin machines with new coins inserted. The user can view new total coin counts and summary graphs according to new coin inserted. Following records can view. 1. Admin can choose a coin machine to view summary details of each coin machine.

TC05 : Send notification to admin	
Admin should inform by an notification when coin machine exceed the coin limit.	
Preconditions	Administrator should logged into the system
Assumptions	Administrator has already registered as an authorized person.
Test Steps	1. Donators or clients insert a valid coins to coin machine continuously.
Expected Result	If coin machine is about to exceed the limit in 75% or 100% percentage then admin should be notify by an email about the current status.