Shop Smart

Oct 19, 2015

Dr. Andrew Rawicz
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Re: ENSC 440/305 Functional Specification – Shop Smart

Dear Dr. Rawicz,

The following document contains the functional specifications for our Shop Smart project. This project aims to enhance the shopping experience of an everyday customer by creating an embedded system that can be attached to a shopping cart. This system will not only keep track of the items inside the cart, but will also cut down the time an average shopper spends in the store.

This document entails an overview of all aspects of the project, particularly focusing on our vision, design and technical specifications. The functional specifications give an overview of the design solution proposed by Shop Smart and its functionality. The purpose of this document is to specify the stages where the product goes from proof of concept to the final marketable product. The document also discusses the sustainability and the current constraints related to the device as well.

Shop Smart is composed of five highly motivated engineering students, coming from different backgrounds –Zargham Amer, Manpreet Singh, Yasamin Houshmand, Shaihryar Khan, and Jashan Dhaliwal. Our aim is to successfully complete this project with the highest possible quality and efficiency.

If you have any concerns or inquiries regarding this documentation, please do not hesitate to contact any of our team members.

Kindest Regards,

Zargham Amer
Chief Executive Officer
Shop Smart

Functional Specification for *Shop Smart*

'The Self-Checkout on Wheels'

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Executive Summary

Since time is money, the majority of people aim to complete their daily tasks as quickly as possible. Unfortunately when it comes to buying groceries on a weekly basis, not many of us can accomplish this task efficiently. One of the major hurdles that people face is the checkout wait times. For a large group of shoppers, waiting in line after spending so much time looking for a specific set of items becomes an obligation. To address this issue a group of engineers created Shop Smart. This technologically advanced shopping cart system consists of a GUI, where users can simply add or delete items to a shopping list, and an express checkout option, where shoppers can avoid the large checkout lines by simply tapping their card on the cart itself.

Our aim at Shop Smart is to save a shopper's time. We will particularly focus on the time spent on creating a shopping list, on finding items and most importantly, on waiting and paying at the checkout. In designing this product we need to constrain ourselves carefully to avoid breaking any engineering standards.

To do this, we have divided the development of this system into three phases:

First Phase

- Use the RFID reader to scan items and make sure the tags are read correctly
- Build a working prototype of the interaction between the hardware components and the GUI
- The RFID reader should validate and monitor each addition or removal of an item inside any area of the cart

Second Phase

- Ensure the hardware system reflects accurate information on the Graphical User Interface
- Add the payment feature to our hardware device so that a customer can tap his/her card directly on the cart without having to wait in the checkout lineups

Third Phase

- Have the device firmly in place on an actual shopping cart. It is critical to ensure that the cart does not become inconvenient for the shopper to move and that we are not attaching our device too close to the handles
- We will create a smartphone mobile application which can be used to import a list of items intended for purchase to the touchscreen device

For the final phase of this project, the system will be refined to incorporate an easy yet elegant GUI. For our final phase of production, we will test all features as to remove any glitches or errors so that the device could be ready for commercial use.

Here at Shop Smart we strive to make our device strictly in compliance with various standards of safety. This document enlists all of the device functionality, covering various aspects such as system reliability, sustainability, hardware and software components used, as well as an effective test plan. A working proof-of-concept will be delivered by December 10th, 2015.

Shop Smart

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Glossary

9600 Baud Rate	-	Standard baud rate (or more commonly used baud rate) [10]
Baud Rate	-	Rate at which data or information is transferred between communication channels. [10]
Cradle-to-Cradle Design	-	A design technique that has zero waste. This design method incorporates the reuse of all components and materials incorporated in the design of a product, eliminating all waste.
CVV	-	Card Verification Value. It is a 3 digit number to prevent fraud and authorize fair method of payment.
Flow Control	-	Control through which flow of data can be managed between computers or devices [10]
GUI	-	Graphical User Interface
IEEE	-	Institute of Electrical and Electronics Engineers
RFID	-	Radio Frequency Identification
RFID Tags	-	Tags with unique ids.
RX	-	Receiving (data/packets) into the interface [10]
Serial	-	Interface that streams its data at a rate of one single bit at a time [10].
TX	-	Transmitting of (data/packets) out of the interface [10]
UART	-	Universal asynchronous receiver/transmitter, responsible for implantation of serial communication [10]

1 Introduction

Shop Smart is a system which is designed to assist grocery shoppers with their daily shopping. It is a system which combines both hardware and software components in a way that users will be able to finish their shopping quickly. Shop Smart takes advantage of a GUI and smartphone app technology to enhance user's experience while shopping.

1.1 Scope

In this document all the functional requirements for both hardware and software components are clearly outlined. These functional requirements along with safety and engineering standards will serve as a blueprint for the proof-of-concept and will also assist us to deliver the final product successfully.

1.2 Audience

This document is intended to be used by the members of team Shop Smart to help with the overall development and design of the product. It shall also assist in creating a testing plan which will ensure that the delivered product meets the requirements.

1.3 Classification

The requirements outlined in the functional specification will follow the following convention:

[Rn-p]

where **R** denotes the functional requirement, **n** denotes the requirement number and **p** is to indicate the priority of the requirement according to the following scale:

A: Applies to proof-of-concept only
B: Applies to the prototype and proof-of-concept
C: Applies to the final product

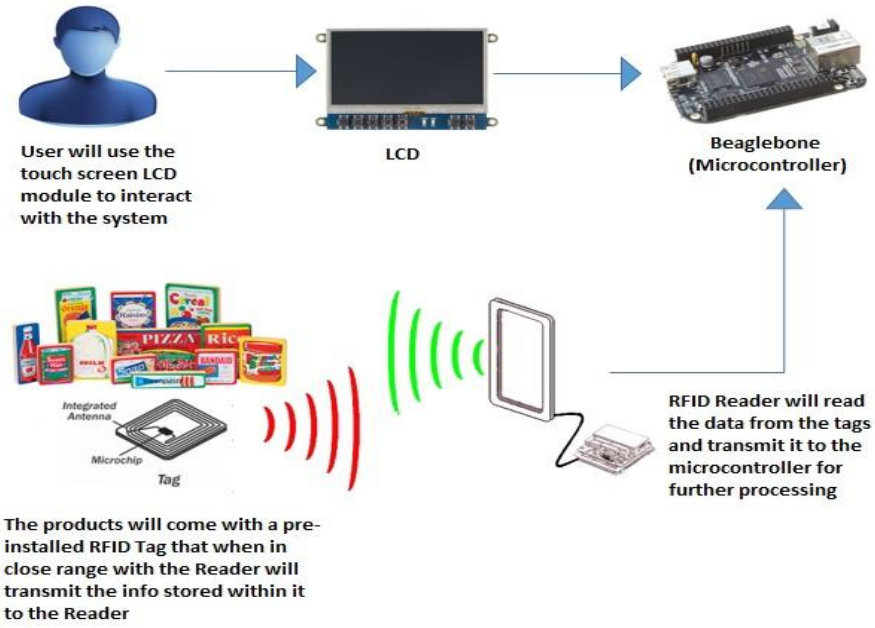

Figure 1 – High Level Diagram [6][7][8][9]

2 System Overview

The solution that Shop Smart team intends to introduce is a device that is user interactive and helps everyone save time in an era where time is one the most valuable things. Our goal is to make the entire shopping process time-efficient and cost effective. The device consists of a design that features a touch screen module, an RFID tracking system for scanning the items and an android cell phone application for planning. The system is comprised of three subsystems as shown in the Figure 2.

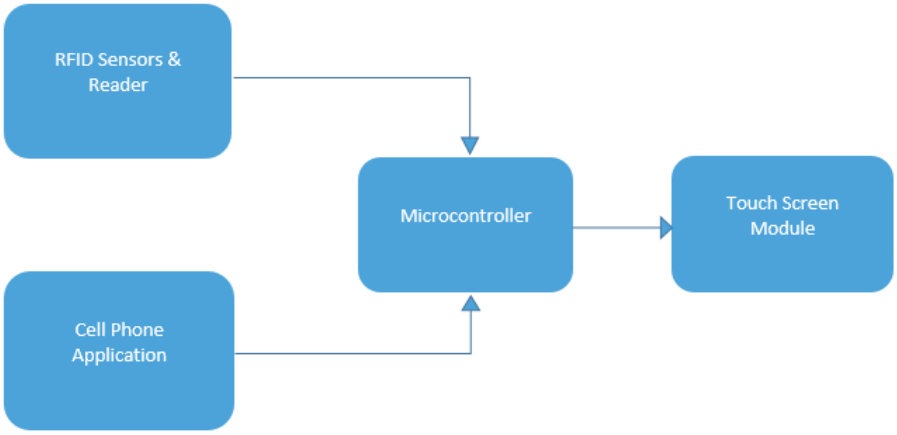

Figure 2 – Flowchart of the process

The following flowchart depicts the functioning of the overall system. The user can either use a smartphone app or just manually add items using the GUI.

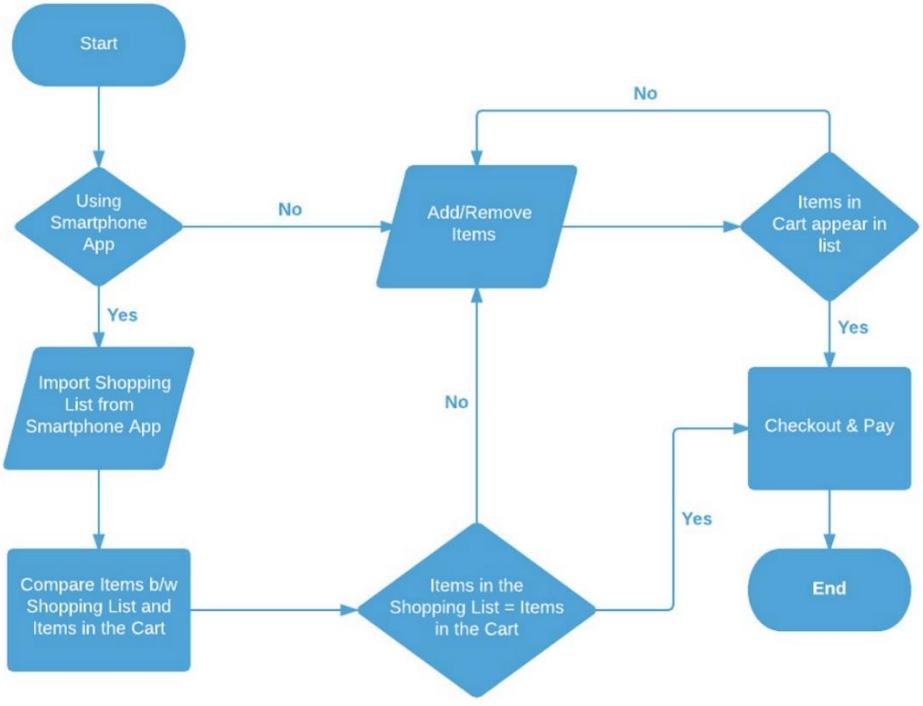

Figure 3 – Flowchart of Overall System

2.1 Software Component

Main focus of the software component is a GUI based application that runs on a microcontroller and displays relevant information on a touch screen module which is connected to the Beaglebone board. The GUI is a way to provide user with the feedback while shopping and keep them updated with the budget and the items acquired. Detailed functionality is as follows:

- An item locator option where a user can select from a list of items and the GUI will provide the shopper with the location of that item. For example, “This item is in Row 2 of Aisle-11 on the right side.”
- Ability to display the updated list of items that a user has added to the cart
- Provide a grand total along with the price of individual items sought for purchase
- An option to import the pre-created shopping list via cell phone application and as the user keeps on collecting the items, both the planner and the items in the cart list will update automatically
- A simple self-checkout option for the user when they have picked up all the items

Besides GUI there will be another piece of software running in the background that will automatically read the unique code from each tag and provide this information to the GUI in the form of file or a list. Since the process needs to be as fast as possible, there will be a polling period of less than one second where the updated list of codes will be provided to the GUI which then will be decoded and an updated item list will be displayed on the screen.

2.2 Hardware Component

For the hardware section there are two devices that completes the design as a device. The first one would be the microcontroller on the Beaglebone board which will have the software running on the Linux OS. The second component is a board that has an RFID reader attached to it. The idea behind using this component is to provide an option of scanning items on the go in a less traditional and time consuming way as compared to the regular barcode scanner. RFID technology provides more reliable functionality and ability to make this process hassle free. Since RFID reader that are generally used for prototyping purposes has a range of up to a maximum of 20 cm [1], therefore, the preliminary prototype design by Shop Smart uses the reader in such a where the reader is attached at the top corner of the cart and as the user picks up the items they can simply bring the item close to the reader or tap it and the item will be added to the list and the updated list and grand total will be displayed on the screen via GUI application. Once the project design goes towards mass production phase then the process of scanning the item will be changed in such a way that user would not have to tap the item anywhere. As the user adds the items in the cart it automatically gets updated to the shopping list on the GUI. This process can be performed with an extension to hardware components such as antenna and a high power signal booster where the tags can be read by the reader within a range of 40 cm [1].

2.3 Cell Phone App Component

Lastly the cell phone application that will be designed for android based devices as a prototype that will give users an option to simply create a list of item before they even begin shopping. Once the costumer reaches the store, they can simply import the list onto the device and the items to be bought will be displayed alongside. As the customer continues to add items from the list, it will automatically get added to the items on the shopping cart list. Once the device goes into production phase, the app can be used as a standalone component that will use its own RFID reader by accessing the cell phone's hardware and perform all the tasks of the GUI (Software component section) on the app itself. This would give stores an option of serving the customers who don't generally use the cart for quick trips to the store.

2.4 Current Constraints

The constraints we face currently involve two of the features, the self-checkout paying method and the automated scanning of the items while the items are being added to the shopping cart. The self checkout method for the prototype will allow the user to enter the credit/debit card number along with the security code (CVV) so that the payment can be processed. The device does not have any chip insert option or the magnetic stripe scanner at the moment but as the device goes under production phase the method for self payment can be more refined.

The other constraint of not being able to introduce the automated scanning of the items for the prototype is due to the antenna and the limited range of the RFID reader (maximum 20 cm). As the device goes into large scale production phase, Shop Smart can provide its user with a stronger and wide range antenna that can be installed at the boundary of the shopping cart. Introducing such an antenna may also cause tag collision which is a known issue with RFID technology but to get around it the scanning protocol will be re-designed such that the error can be avoided.

3 System Requirements

3.1 General Requirements

[R1-C] The cost of the system should be less than $150
[R2-C] Our solution should be easy to assemble on various types of shopping carts
[R3-B] Device should not obstruct user's convenience while holding the shopping cart's grip

3.2 Physical Requirements

[R4-B] Device dimension shall not exceed 4''x 4''
[R5-B] LCD dimension shall not exceed the size of Beaglebone black
[R6-C] RFID Reader's beep shall be of moderate volume
[R7-B] RFID Reader's module shall not be more than 12.4mm x 20.9 mm [1]
[R8-B] Device shall have a touch screen LCD
[R9-B] Device shall have enough room to be able to connect to RFID reader

3.3 Performance Requirements

[R10-C] System shall be able to withstand daily and frequent usage
[R11-B] RFID Reader shall be able to scan several items
[R12-B] RFID Reader shall be able to scan items well within the range of 20cm [1]
[R13-C] An antenna shall be able to increase the RFID's reader range up to 40 cm [1]
[R14-A] Battery shall be able to provide 12 hours of backup

3.4 Electrical Requirements

[R15-B] Any electrical component including wires shall not interfere with user's operating shopping cart
[R16-B] Portable battery shall be able to provide a voltage of 5V using lithium cells
[R17-B] Battery shall be easy to install and replace
[R18-B] RFID reader shall be compatible with tags of 125 kHz frequency [1]
[R19-C] RFID Reader's module Pin 3 shall be able to connect to antenna

4 Software Requirements

4.1 General Requirements

[R20-A] GUI's interface shall be interactive and user friendly
[R21-B] Communication between RFID Reader and GUI shall be quick and smooth

4.2 Database Requirements

[R22-A] Database file shall contain the store's list of items, item's price and aisle number
[R23-B] Database file shall be in a python script file

4.3 Functional Requirements

[R24-A] GUI shall be able to run programs written in Python
[R25-B] GUI shall have an option to add items, check item's price and aisle number

4.4 Performance Requirements

[R26-A] Smart phone app shall be compatible with android devices
[R27-B] User shall be able to see the list of items on the GUI after they tap their smart phone app

5 Microcontroller Requirements

For our device the microcontroller is the main hardware component that is used to run GUI application and also interact with the RFID module

5.1 General Requirements

[R28-C] The wires connected to microcontroller for the RFID reader shall be durable and secured
[R29-C] The touch module's cape to the microcontroller shall be firmly connected with a protective casing that is also water resistant

5.2 Functional Requirements

[R30-A] Updated signals from the RFID reader must be pulled onto the microcontroller every 0.5 seconds
[R31-B] Microcontroller must be able to process and parse the identification numbers coming in from the RFID reader and pass them on to the touch screen module
[R32-C] Power supply for the microcontroller board shall not exceed more than 10V and shall be provided via an external rechargeable battery source
[R33-A] The OS running on the microcontroller must be a LINUX operating system

5.3 Performance Requirements

[R33-A] Any soldering done on the board with the microcontroller shall be tested before plugging in the device
[R34-A] Microcontroller shall be able to process the data coming from the GUI with a minimum lag time of 1 second

6 RFID Requirements

RFID uses radio waves to detect the presence of an RFID Tag. The device introduced by Shop Smart uses passive tags for scanning the items, which uses the electromagnetic energy from the reader to get activated and then transmits the tag's unique serial number [2].

6.1 General Requirements

[R35-B] RFID module (ID-12LA) shall be firmly connected to the reader board

[R36-B] The serial port for the RFID module must be compatible with the serial connection from the RFID reader

[R37-X] The reader must be compatible with EM series of passive tags

6.2 Physical Requirements

[R38-C] The reader module must be easily accessible for replacement in case of breakage

[R39-C] All the connections on the RFID reader must be protected and contained in a box

[R40-A] The standard of communication used by the RFID reader shall follow the RS232 serial industry standard [3]

6.3 Functional Requirements

[R41-A] The embedded buzzer on the reader must be activated when it detects a card in the approximate range

[R42-A] The embedded LED shall light up when the serial number from the tag is read successfully

[R43-B] The USB to serial IC shall be able to transmit the tag ID over the USB to the microcontroller for data processing

[R44-A] The inputs/outputs to the RFID module form the reader board shall follow the data specified in the data sheet for the ID-2LA [1]

6.4 Performance Requirements

[R45-B] Reader shall be able to detect an RFID tag within a range of 20 cm [1]

[R46-A] The serial drivers shall come pre-installed onto the microcontroller to have no compatibility issues

[R47-A] The tag identification number shall be transmitted to the microcontroller as 16 bytes of hexadecimal numbers

[R48-A] The user shall be informed about scanning of items with a 0.5s lag to avoid tag collision

6.5 Electrical Requirements

[R49-A] Power supply to the RFID reader shall be provided from the microcontroller connection

[R50-C] For the implantation of external antenna on the production device, recommended inductance is of 1.337mH with the internal tuning capacitor of 1n2 [1]

[R51-B] The reader must not be provided with the power supply voltage higher than 5V or lower than 2.8V [1]

7 Touch Screen Module Requirements

7.1 General Requirements

[R52-B] The touch screen module shall be compatible with microcontroller board (Beaglebone)
[R53-B] The module shall have a size of 4.3" diagonal dimension.
[R54-A] The module shall be a third party plug and play device
[R55-C] The module shall be sheltered in a water resistant casing

7.2 Functional Requirements

[R56-A] The push buttons on the module shall be used to scroll through the list displayed on the GUI

7.3 Performance Requirements

[R57-A] Touch screen shall be calibrated upon installment for the most accurate touch use
[R58-A] The brightness of the screen shall be set for the most visible setting as per the data sheet [4]
[R59-A] The screen shall be able to operate with or without a stylus pen.

7.4 Electrical Requirements

[R60-A] All display signals and the power supply to the touch screen cape shall come from the microcontroller
[R61-B] Power supply to the touch screen module shall not exceed 5V

8 User Documentation

8.1 General Requirements

[R62-C] User documentation shall be a comprehensive technical guide written in English language explaining on how the device is to be operated
[R63-C] User documentation shall contain the company logo along with the company's contact information
[R64-C] User manual shall provide enough information for the store staff to be able to understand the functionality of the device
[R65-C] A detailed installation guide for the store owners shall be provided
[R66-C] User documentation shall be provided in multiple languages based on territorial adoption

9 Sustainability and Safety

Our device aims to have zero waste, as to comply with the cradle-to-cradle design principle. Using the principles of economy, ecology and equity [5] shown in Figure 1 below, we can discuss the cradle-to-cradle design of the Shop Smart device. Please note that the goal is not to balance economy, ecology and equity but to maximize and optimize all three. As such, the perfect cradle-to-cradle design will take all three aspects into account.

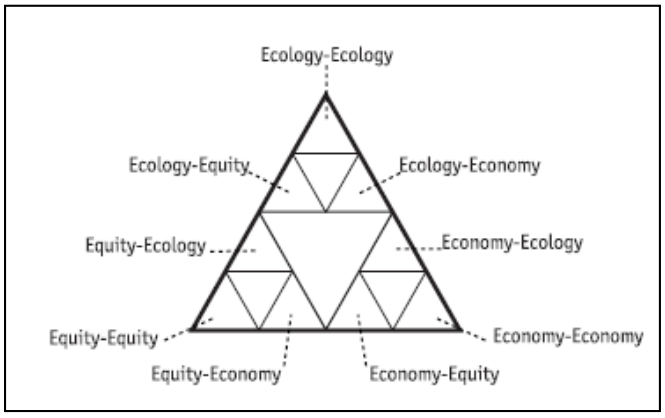

Figure 4 - Economy, Equity and Ecology Triangle for Cradle-to-Cradle Design [5]

Economically, the cradle-to-cradle design aims to make and sell a product at a profit, while contributing to the wider economic health of the community and providing fair benefits and wage practices [5]. Our team at Shop Smart aims to create a product that will not only be profitable, but will help people live a healthier life-style by spending less time shopping for groceries and more time elsewhere. In terms of benefits and wage practices, since Shop Smart will redesign the entire shopping industry by replacing menial jobs with ones that require more knowledgeable people, it will lead to better benefits and wages.

Equity relates to the quality of life and safety of all stakeholders, as well as the safety of the global communities and ecosystems [5]. The only aspect of our product that could potentially harm a global community and ecosystem is the manufacturing portion. In this aspect we would need to make sure that our manufacturing plant will be eco-friendly, will not cause any pollution or waste that can be harmful to the surrounding community, and will be able to decompose all components in the Shop Smart device in order to be reused and recycled.

In terms of ecology, the aim is to create a device that will promote a healthy habitat, and that effectively and efficiently uses resources [5]. In this respect, we will aim to only use components that can be recycled and decomposed. This method takes into account the cradle-to-cradle life cycle that is show in Figure 2 below.

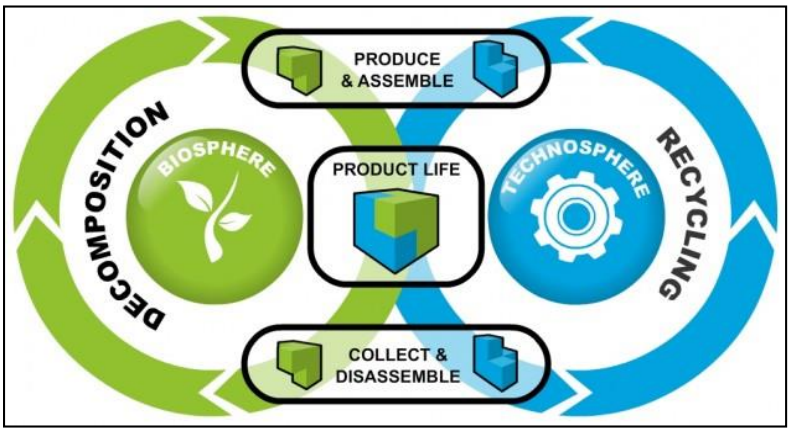

Figure 5 - Cradle to Cradle Life Cycle [6]

Keeping in mind the principles of the cradle-to-cradle life cycle, we were able to create Table 1 below that displays the materials used in the Shop Smart design.

Table 1 - Component Materials

Component	Material
Shopping Cart	Alloy, Nylon
Beaglebone Board	PCB, Silicone
RFID Reader	Alloy, Metal, PCB, Silicone
RFID Tags	IC, Metal, Plastic

As Table 1 displays, we will be using polymers and metals that can be broken down into smaller parts and recycled. Although the IC and PCB components may be tricky to decompose, there are already companies that have created a treatments [7] in order to stay within the cradle-to-cradle design frame. As stated in the RFID Journal, “Eventually, RFID tags could even help ensure that manufacturers comply with regulatory mandates for disposal of toxic substances” [8] by keeping track of various products during all stages of their life-cycle, and particularly during their disposal.

With regards to safety, our device will be designed to make sure the microcontroller board is securely placed inside an enclosure. The device will be fixed firmly onto the shopping cart to rule out any abuse to the electronic components enclosed within. Any faulty component is individually tested/replaced before it is integrated with the rest of the components in order to avoid any further damage. Furthermore, we are committed to making sure each component of our device is used in compliance with the safety guidelines as specified on their safety manuals.

10 Conclusion

This document has outlined the functional specifications of the Shop Smart device. It has discussed the system overview and requirements, software and hardware requirements, as well as sustainability and safety.

In the system overview section we presented the four main design areas of our device: RFID sensor and reader, microcontroller, touch screen module and the cell phone application.

Within the system, software and hardware requirements sections we further explained how each design feature is intended to work by specifying electrical, physical, functional and performance requirements.

We then went on to discuss how the user documentation would be created and used.

Finally, using the principles of ecology, economy and equity we were able to discuss the cradle-to-cradle design and the sustainability and safety of our device.

11 References

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