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Group 15

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SMIDGE

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1. Executive Summary

SMIDGE: the Smart Fridge System; an appliance that will offer an enhanced grocery shopping experience. It will aim to be the kitchen appliance that every home must have, offering the user the ability to implement smart shopping lists and recipes custom to their preference and list of already acquired items. SMIDGE interacts with the user and allows the use of today's peak technologies. From the private sector point of view, SMIDGE will simplify homes, simplify life and give people back all that time that is wasted on dealing with kitchen inventories, shopping lists and complex recipes. From the industrial point of view, the creation of a database that will be linked to several hardware and software components, from which the database can be accessed and modified, is definitely an idea that can be used in future applications.

The team decided to engage in a smart fridge project for the technology challenge it represents and how beneficial it can be in our everyday life. The project merges different technologies to come up with the final result. Phone application technologies, web servers, web applications and the hardware technology that involves connecting a fridge, printed circuit board, LCD display and a scanner were used. There have been some attempts at creating smart fridge systems but none have made a real breakthrough.

SMIDGE will address all the functions that regular refrigerators have, as well as add new features that make the system unique in its nature. Refrigerator technologies in the current market are very similar from one competitor to the other. They all have the same basic functionality; keep items cool and fresh with no outside or remote view of its inventory. Based on this fact, we trust that our system would fare well in the market. SMIDGE allows the user to remotely access the system. It can be accessed anywhere with an Android-based smart-phone or any computer with internet access. With a database that manages the items in the system, it will be able to store the recipes and the different shopping lists that are created. The system allows for optimal user interaction regarding items, shopping lists, and recipes. SMIDGE also handles multiuser situations for use in the common case of two or more people living in the same household with separate item inventories. By providing an account for each user to create, each will be able to manage its own item shopping lists and recipes as they wish. The idea of separate accounts arose from real life experience of the team members living with roommates and not having an effective system to manage their grocery shopping. In such scenario, every person buys their own food and handles their food items individually. In the case that these people share a common fridge, this becomes problematic. With separate users accounts each person gets to keep their own inventory and personal recipe list.

While there are several companies with smart fridge systems that have attempted to put forth their product in the market, most never fared well. These ideas are innovative in their own category, composed mainly of a screen placed on the refrigerator that displays television channels and handles the refrigerator's temperature. There are also smart fridge systems that attempt to create a more eco-friendly environment by reducing power and water consumption. The SMIDGE system's purpose does not attempt to get into these areas, it is geared more towards the customer experience. It simply allows the user to access valuable information regarding their grocery items and shopping lists in all places, at all times; setting it apart from any other product already existing in today's market.

2. Project Definition

2.1 Motivation

What can you make with two mangoes, some leftover chicken, an onion, coconut milk, lemon juice and some spices? Questions like this were what inspired our group to create an application that would be able to put together a delicious meal from what you have in your fridge. In addition instead of asking this question why not let the application know what you already have in stock at the moment of purchase or when you are running low of certain item, or if it is completely out of stock. Imagine this and some other features added to one of the most used appliances in any home the Refrigerator.

The motivation for "Smidge" was to incorporate one of the most used appliances in the household to the era of smart devices. The idea came up when the group made the suggestion of a project that will make life a little bit easier for users. With "Smidge" you would not have to worry about running out of a particular item, or searching through your shelves looking for items that you need to buy to put them on a shopping list. "Smidge" is linked to your cell phone through an Android application so you will have access to your fridge and pantry inventory twenty four hour a day, seven days a week. Smidge database is also going to be synchronized to a website to make it easier to replace items or make adjustment to the inventory.

As mentioned earlier Smidge will eliminate the question of "What meal can I make?" or "What ingredients do I need, in order to make this recipe?" Smidge will have a recipe database that creates a list of ingredients, the corresponding quantities, and step by step directions on how to make the recipe. The user will have different categories of food on the touch screen display, from which he/she can pick, like "Quick and Easy", "Mexican Food", "Spanish food", "Asian", and more. Smidge will prioritize the use of nearly expired items to reduce the waste of food and money.

Since you probably have not yet answer the question asked at the beginning of this section here is the answer that will be given by "Smidge":

Q: Two mangoes, some leftover chicken, an onion, coconut milk, lemon juice and some spices?
A: Name of the recipe "Chicken Mango", plus a list of all the ingredients needed the amount that you will need from each ingredient and the directions on how to mix them all and end up with a delicious homemade meal.

2.2 Goals and Objectives

There are several goals and objectives that must be taken into account when developing the design of this project. Many of these goals are specific to each component. The following are the different areas for which specific goals have been laid out. All these goals will be beneficial when listing all of the specifications of the different components in the project

Cost Efficiency - While the Smidge is not being limited to a specific cost limit, one of the main goals for the overall system development is to try to maintain the overall system cost effective. This does not mean that any of the functional requirements will be sacrificed. For the system to work, many parts will have to be compatible with each other. Having this in mind, when given the option between different types of possible architecture implementations, cost efficiency will be given priority over improved performance. If the difference is minimal however, the architecture which produces higher performance will be selected. The threshold determining whether to select performance over cost efficiency will be determined during parts selection.

Fridge Display - The fridge display will be the main interaction point between the user and the system. Therefore, it is crucial that this display is as user friendly as possible. Everyone has seen at some point a product which is extremely beneficial and highly functional but the interface makes the product difficult to use. As the developers of the Smidge, our main goal in creating the fridge display is to avoid this problem, and enhance user interaction. There are five different areas which have to be kept in mind when enhancing usability. These include the learning curve, efficiency, ability to memorize, errors, and satisfaction. The learning curve measures the degree of difficulty for which the user can accomplish the desired tasks in with the display for the first time. Once the user has learned how to perform these tasks with the display, efficiency is measured on how quickly these tasks can be performed. Memory is established how well the user remembers to use the display. That is, after not seeing the system for a long period of time, how long does it take the user to regain proficiency in completing the desired tasks. The last two steps are errors and satisfaction. The user is always expected to commit some errors when using the system. Improving the errors phase consists of reducing the number and severity of errors, and increasing the recovery from these errors. Satisfaction measures how much the user enjoys using the design. If all these steps are taken into account when developing the fridge display, the user should feel extremely comfortable interacting with this system.

Web Interface - The web interface will inherit the same goals of the fridge display and tackle on additional goals. Since the web interface is not restricted development under a language that is optimal for the hardware as is the case with the fridge display, there are several aspects that could be optimized by researching different modes of implementation. The web interface must still be user friendly. One of the additional goals within developing the web interface is increased aesthetics. The web interface is not limited in display size as are the fridge display and the mobile app interface. That leaves plenty of room for enhancing the graphical user interface in ways that are only possible in this platform. In essence, the web interface will be the superior interface of the three. Since it is not mobile or attached to the main device, the web interface must have some attributes for which the user can feel compelled to use it. This can be achieved by providing as much information to the user on the screen as possible.

Mobile App Interface - The mobile app interface will inherit the same goals mentioned for the fridge display. Additionally, one of the main goals of the mobile app is to make up for a small display size by providing the most useful information to the user while not near the device. In other words, only the basic and necessary information will be available on the mobile app interface. This might include a quick list of items in the fridge, shopping list and items of that nature. Another goal that is associated with the mobile app interface is continuity. Most mobile apps follow a design workflow that allows the application to be easily used from a mobile device. By following some of the mobile app standards the user will be able to use the mobile app with a very small learning curve.

Shopping List - Our main goal in creating the shopping list feature is to provide the user with the most useful information regarding groceries. Having data stored in our database regarding these items that the user buys allows the system to display this information when needed. The system can let the user know what items are currently on the fridge. Furthermore, the system should provide a way for the user to determine what items that are usually in the fridge are missing. One goal in producing a useful shopping list feature is to have information be exclusive to the current user using the device. That is, if several different people use the smidge, then the functionalities of the shopping list should reflect the information for that specific user. The detail of the information provided also needs to be a priority in developing this feature. The more information the user can get regarding each item the better. Such information could include price, image, amount, and places containing the item depending on the availability of that information to the system.

Recipe - The recipe is currently being looked at as a possible add-on to the Smidge. Having the information of what grocery items are already in the fridge, the goal of this functionality would be to provide the user with the recipes that are available to the user with the items in the fridge. Another goal of this recipe functionality would be to display recipes either created by the user or gathered from other database, that way allowing the user to view the recipes in its collection regardless of what items are currently in the fridge.

Bar Code Scanner - Adding a bar code scanner to the Smidge allows the system to attain and organize data regarding the grocery items. This is a crucial component of the project since it enhances the interaction between the user and the device. With the barcode in place the user does not have to enter specific information regarding each item. That would take a long time and the user would be hesitant to use the device frequently. The barcode allows the system to pull up all of the data needed by referencing the barcode value given by the scanner. The goals related to the scanner involve reliability, efficient, small in size, and cost efficient. The scanner must be reliable since it is placed in the Smidge for an every-day use. Efficiency plays a big role in making the Smidge user friendly. Should the scanner be slow and not responsive, the user would get frustrated when placing items inside the fridge. As mentioned, a third goal is to have a device that is small enough. This will aid in the mounting phase of the project. Although performance will be prioritized when selecting a scanner, our goal still remains to develop a finished product that is cost efficient.

Wireless Communication - One of the main goals in developing the project is to avoid wired connections to gain online access. If the server used to store the database is not hosted locally and an outside service is used to store the data, our goal is to be able to connect to it through the implementation of a Wi-Fi module. This follows that the board that is chosen should be able the developers to integrate a Wi-Fi module that is efficient and cost effective as specified in the previous section.

Power Implementation - Reducing the amount of time the hardware is developed requires simplification on the way the power source is developed. Many devices in the project could have their own power source requirements. Ideally, the user should only have to provide power to the main device and the rest of the components on this device would be powered. As consistent with the rest of the project, simplicity is our main goal regarding this area. If time allows, the power source implementation should be simplified to one main source for the entire device.

Database System - There are several goals that are always present when designing a database. Things that usually should be kept in mind during the design of a database include easiness of information retrieval, usefulness of information, and organization. Reducing redundancy and excluding inconsistencies is also very important. There are three main goals, however, that we have for our database development. We want the database design to be logically correct and complete, to retain relational integrity and retain data integrity. For a database to be logically correct and complete, the capture and maintenance of the data must be accurate and plentiful enough to solve the problem at hand. The second goal means that the relations between tables must be correctly linked with primary keys. The third goal pertains to the security of the database. This follows that each table will only allow data that is of the correct type for each field.

2.3 Scope of Work

Refrigerators are appliances developed for food freshness and storage. Due to this era of technology innovations and "smart items", new functions should be developed in order to satisfy consumer demands. Based on recent market studies, our team decided to build "Smidge", the first Smart Fridge System.

2.3.1 Objectives

Smidge, with its innovative technology, will turn a regular refrigerator into a new level of customer convenience. It will be designed to satisfy customers' needs. Smidge is a refrigerator system that will keep an inventory of the items inside the fridge, give feedback on nutrition and health, and provide a weekly grocery list. Smidge will have a small display monitor on which you can check the inventory in your refrigerator. It will have a mobile application that will run on Android phones, allowing the user to manage the content of their fridge and have access to their shopping lists and recipe creation. Smidge will have a bar code scanner that will be used to enter the items into the fridge electronic inventory. Every food item will be scanned before being entered into the fridge. Once the user has chosen to add the item to the list, the information will be stored in the inventory. When new items are scanned, and not found in the database, the user will have to manually enter the information regarding the product, then Smidge will save the new information in the database and have it for future reference. There will be a main database that will be stored remotely using a Google App Engine web application that will act as the main server. From here, we would be able to retrieve information to use in the fridge system, website and mobile application

2.3.2 Tasks

The table below shows all the Software Components that shall be part of the project and the group member in charge of it.

Tasks	**Member Group Responsible**
Server Configuration	Felipe Bernal
Database Structure	Felipe Bernal
Data Processing	Arian Caraballo
Display GUI	Isabel Virag
Display Programming	Isabel Virag
Mobile Apps+ Alerts	Daniela Zicavo

Table 1 Software Components Table

The table below shows all the Hardware Components that shall be part of the project and the group member in charge of it.

Tasks	**Member Group Responsible**
Barcode Scanner	Felipe Bernal
Display	Isabel Virag
Mounting	Arian Caraballo
Power	Daniela Zicavo

Table 2 Hardware Components

2.3.3 Schedule

The project shall take 4 months to be implemented, the duration of a school semester. We shall start on January 2011 and it should be completed by April 2011.

2.4 Significance

This project shall represent a jump in technology, adding another appliance to the so call "smart era". From a social point of view our project simplifies the everyday life of its users. Cooking, making shopping lists and taking care of provide our kitchen cabinets may seem a very easy thing to do and in fact it is, what is not easy is to find the time in our very busy lives to do this. This is one of the major reasons why smart phones and smart technology in general have been such a success in today's world, they make our lives easier, they help us make better use of our time so we can keep doing all those little things that make our everyday life. With this idea on mind we decided to create this project, the Smart Fridge.

There are several functions that our team will not be able to implement in our project. It is our desire and hope that these ideas shall be put in practice in future versions of our project. These functions will make the project of "green-implementation" nature. The new functions are related to the use of energy and power of SMIDGE. Future SMIDGE projects shall be able to regulate the fridges inside temperature in order to have less power consumption. With ideas like the prior one implemented into SMIDGE the fridge shall require low energy to work, which compare to the rest of refrigerators on the market will be a big difference.

From the technology point of view this project gives us the opportunity of integrating several hardware components all in one final task. After a lot of research and hours in the lab we shall end up with a system that work as a whole, integrating a refrigerator, a board, a scanner, a display and a cell phone. It sounds a little crazy to be able of putting all this items together but that is our goal. For our team and each of its integrants personally this project shall be the biggest learning experience of our lives as students.

2.5 Budget projection and financing

The entire project will be financed by the group members. We will split the cost equally between the four of us. We expect to spend at least six hundred dollars and no more than one thousand US dollars on our project.

Item	Quantity	Cost (in dollars)
PandaBoard	1	175
IMO pivot touch	1	170
HONEYWELL IS4225 SCANGLOVE	1	35
Refrigerator	1	0 – owned by member
Android application Development	-	-
Power management	1	20
Website with Google App Engine	1	0
Wi-Fi Module	1	0
Custom Board	1	160
USB Hub	1	20
5V power supply	1	20
Total	-	600

Table 3 Budget Projection

2.6 Specifications

2.6.1 Overall Specifications

The system shall have three main components: the physical system placed on the refrigerator with a development board, an LCD display, a user interface, and a barcode scanner; a mobile application that will allow the user to check their inventory on the go; and a website to accommodate for a simpler and faster user interaction. The physical touch interface will have access to the information posted on the website and mobile application through a remote server and vice versa.

- The physical system shall be placed securely on the refrigerator.
- The system shall be comprised of an LCD touchscreen, a development board with Android Operating System and wifi capabilities; and a Barcode scanner.
- The LCD touchscreen shall be placed on top of a small refrigerator or on the front a regular-sized refrigerator.
- The barcode scanner shall be placed on the side of the refrigerator such that there is no interference when the refrigerator door is open, for an easy scanning process.
- The system shall be powered by the same source cable that powers the refrigerator.
- The system shall be powered by no more than 5 volts through a regulator.
- The system shall have wifi capabilities to connect through the user’s network.
- The system shall be able to synchronize periodically with the remote server, and consequently handle the same inventory information available through the mobile application and website.
- The system shall have a similar interface on each one of the three segments: Refrigerator system, mobile application and website.
- The development board shall carry the Android Operating System that will drive the touch interface as well as the mobile application.
- The web interface shall be developed using Google App Engine which will allow for a simple user interface and ease of use.

- All hardware components shall be connected together in a compact manner around the refrigerator.

2.6.2 Barcode Scanner

The Barcode Scanner is in charge of reading the Universal Product Code located in any one of the products that will be placed inside the fridge, and delivering it as a sequence of numbers in the form of a keyboard input. This keyboard input will then be entered into a search for product recognition. The scanning system is responsible for linking this input read in by the scanner to the inventory API. The information is then retrieved and displayed in the LCD on the refrigerator system.

- The system shall be able to scan a Universal Product Code (UPC) from the products that provide one.
- The system shall translate barcodes from the reader into numbers.
- The system shall keep an updated list of barcodes with products they correspond to in an inventory stored in the local database.
- The Inventory API shall be able to read/write from the local database to keep track of the inventory items.
- The system shall frequently update the local database with the database on the remote server hosted on Google App Engine so that the webpage, mobile application and refrigerator system all have a synchronized inventory.
- The system shall use the inventory APIs incorporated into the software to find a matching product.
- The system shall be able to access the inventory API in order to locate the right product.
- The system shall be able to determine if an item is present in the database.
- The system shall be able to create a new item with user preferences in the database if it is not already present.

2.6.3 Touch Interface

The touch Interface is provided through an LCD touch screen placed on top of the small refrigerator for convenient access. With this, the user is able to easily enter and delete products from the inventory on the system. Through this system, the user will have the option to enter a product or a batch of products; remove a product from the inventory; change the size or weight of the product as it progresses through its use; add expiration dates if desired with the option to notify the user when the expiration date is reached; add and modify shopping lists and finally, view any recipes already in the system.

- The system shall be comprised of a touch screen for interaction with the user.
- The system shall have a login/activation screen for the user to input their account information they used on the website.
- The system shall have a list of options available at all times for the user to choose from.
- The system shall display a description of the current step on the screen for the user to be able to understand the application with ease.
- The system shall have four options for user interaction: Items, Recipes, Shopping Lists and Settings.

- The system shall have three main ‘item’ options for user interaction: Add Item, Modify Item, and Remove Item.
- When pressed, the Add Item option shall allow the user to scan any amount of products he desires, making it easy to enter one product, or a batch of products.
- The system shall provide the ability to enter the description of a product, if not found on the API database, and store it in the local database for later retrieval.
- The system shall provide the ability to enter a product’s expiration date based on the type of product and user preference.
- The system shall provide the ability to look at the current list inventory whenever the user is done adding, modifying or deleting items.
- The system shall provide the ability to modify the weight or amount of an item that is already in the inventory.
- The system shall provide the ability to remove an item or a set of items from the inventory.
- The system shall provide the ability to access shopping lists and be able to modify, add or remove items to the lists.
- The system shall provide the ability to access the recipes stored, the recipes that are available according to what is currently stored on the inventory, and be able to retrieve the list of ingredients needed for any of them.
- The system shall provide the ability to change or view settings in the user’s account and preferences.

2.6.4 Web Interface

The Web Interface resembles the touch interface very closely. It is responsible for offering yet another option for the user to check their current fridge inventory and make any changes; as well as create shopping lists, adjust shopping lists, create or delete recipes. The webpage plays a big part in the enhancement of user experience with the system and requires a personalized login account for complete privacy.

- The system shall provide access via a website.
- The system shall request the user to create an account in order to link the information used on the refrigerator system.
- The system shall provide access to a personalized account.
- The personal account shall be acquired by the user by providing an email and password.
- The system shall be divided into three sections: inventory, shopping lists and recipes.
- The system shall provide the ability to access the current fridge inventory.
- The system shall provide the ability to create shopping lists based on the current inventory and products bought in the past.
- The system shall provide the ability to add grocery items to a list.
- The system shall have a list of items that are and have been in the inventory in the past used for examination and adding items to the shopping list.
- The system shall provide the ability to modify the name and contents of a shopping list.
- The system shall provide the ability to add notifications for product expiration, products you are running out of, and when the refrigerator is reaching an undesirable temperature, through mobile app or email.

- The system shall provide the ability to modify the quantity, expiration date and notifications for a specific item on the inventory list.
- The system shall provide the ability to see shopping lists created in the past.
- The system shall provide the ability to delete shopping lists.
- The system shall provide the ability to access list of recipes.
- The system shall be able to provide the user with a form to fill out for recipe information.
- The system shall provide the ability to add customized recipes.
- The system shall be able to process the information keyed by the user to create a recipe.
- The system shall provide the ability to create new recipes with the items provided on both the current inventory and items used in the past.
- The system shall provide the ability to modify or delete customized recipes.
- The system shall provide a list of grocery items needed upon request, as a shopping list, using the list of items bought in the past to check which items are missing on the current inventory.
- The system shall provide a list of recipes on which all required ingredients are available.
- The system shall provide a list of recipes containing a specific ingredient or group of ingredients available on the inventory.

2.6.5 Mobile Application

The Mobile Application provides one of the main advantages of the system, being able to access the inventory at any time, any place. Having the ability to access, create, and modify shopping lists while at the grocery store makes all the hard work of keeping track of groceries worthwhile. The contents of the mobile application are very similar to those of the website. Through the mobile application, the user is also able to access, modify and create new recipes on the go as well as modify items on the current inventory available.

- The system shall provide access via a phone carrying the Android Operating System.
- The system shall have a login/activation screen for the user to input their account information they used on the website.
- The system shall be divided into three sections: inventory, shopping lists and recipes.
- The system shall provide the ability to access the current fridge inventory.
- The system shall provide the ability to create an automatic shopping list based on the current inventory and products bought in the past.
- The system shall provide the ability to add grocery items to a list.
- The system shall provide the ability to modify or delete the name and contents of a shopping list.
- The system shall provide the ability to add notifications for product expiration, products you are running out of, and when the refrigerator is reaching an undesirable temperature, through mobile app or email.
- The system shall provide the ability to modify the quantity, expiration date and notifications for a specific item on the inventory list.
- The system shall provide the ability to access list of recipes.
- The system shall provide the ability to add customized recipes.
- The system shall provide the ability to create new recipes with the items provided on both the current inventory and items used in the past.

- The system shall provide the ability to modify or delete customized recipes.
- The system shall provide a list of recipes on which all required ingredients are available for use.
- The system shall be able to provide the user with a form to fill out for recipe information.
- The system shall be able to identify the ingredients of a recipe as products in the inventory or check them as unavailable.
- The system shall be able to build lists of recipes available for use depending on the current items available on the inventory.
- The system shall allow the modification of description of products on the inventory.
- The system shall allow the modification of expiration date or size of an item on the inventory.

2.6.6 Shopping Lists

Shopping Lists are created by the user in order to have a list of items desired to be purchased in the future. They are available for creation, viewing, modification and deletion through the three interfaces: mobile application, refrigerator system and website. The user should be able to add his personal shopping lists with different names. Also, there should be a shopping list automatically created by the system that provides an up-to-date list of items the system has analyzed and concluded the user shall need. This list will be based on items bought in the past, items the user has already disposed of, or items whose expiration date is approaching. Based on user preferences, the shopping lists will have the ability to get sent through email or mobile application notifications.

- The system shall provide the ability to create one or several shopping lists through the mobile application, refrigerator application, and website.
- The system shall allow the user to modify available shopping lists.
- The system shall allow the user to delete shopping lists created in the past.
- The system shall create an automatic shopping list based on products that have been purchased before, and the products currently available on the inventory.
- The system shall be able to update the automatic shopping list periodically with the current inventory.
- The system shall be able to synchronize shopping lists to be used within the refrigerator system, mobile application and website.
- The items in a shopping list shall be automatically crossed out from a list whenever the user scans the item into the refrigerator after purchase.
- The system shall be able to perform a Universal Product Code search on the API to look for items that have never been purchased before to add to the shopping lists.

2.6.7 Recipe Creation

Recipes will be comprised of a list of ingredients and an itemized procedure divided into steps. The user will have to input these recipes into the system through the mobile application or website; however, the recipes should be viewable through all interfaces, including the refrigerator system. The system should be able to determine which recipes are available for creation based on the items currently available on the inventory. It should also be able to determine which items are missing in the inventory from a selected recipe.

- The system shall provide a database for holding recipes, their ingredients and itemized procedures.
- The system shall provide the ability to create recipes through the website interface or mobile application.
- The system shall provide access to a list of ingredients of a chosen recipe when requested on the refrigerator system.
- The system shall provide the ability to modify recipes amount, ingredients and procedures.
- The system shall provide the ability to delete recipes.
- The system shall provide a list of all recipes in the database when requested by the user interaction with the interface.
- Upon request, the system shall provide a list of recipes for which all items with their corresponding amounts are available on the current inventory.
- The system shall be able to synchronize recipes to be used within the refrigerator system, mobile application and website.
- The system shall let the user decide on the refrigerator system, whether to show the entire procedure for a recipe, or just the ingredients.
- The system shall be able to perform a Universal Product Code search on the API to look for items that have never been purchased before to add to the custom recipes.

2.6.8 Notification System

The notification system will be implemented to alert the user about items soon to reach their expiration date, items soon to be discarded, undesirable temperature readings, or shopping lists selected through user preferences. It can be implemented to use email or mobile application notifications in a mobile phone.

- The system shall be able to create a notification at the time specified by the user on the system preferences.
- The system shall be able to check when items are about to be expired at a time set by the user each day and create the necessary notification.
- The system shall be able to monitor the temperature readings for when they fall too low or rise too high.
- The system shall be able to check when a user is running low on an item at a time set by the user each day and create the necessary notification.
- The system shall be able to create a notification through email or mobile application notification according on user preferences.
- The user shall be able to set the preferences for the notification system through their mobile application or the website.

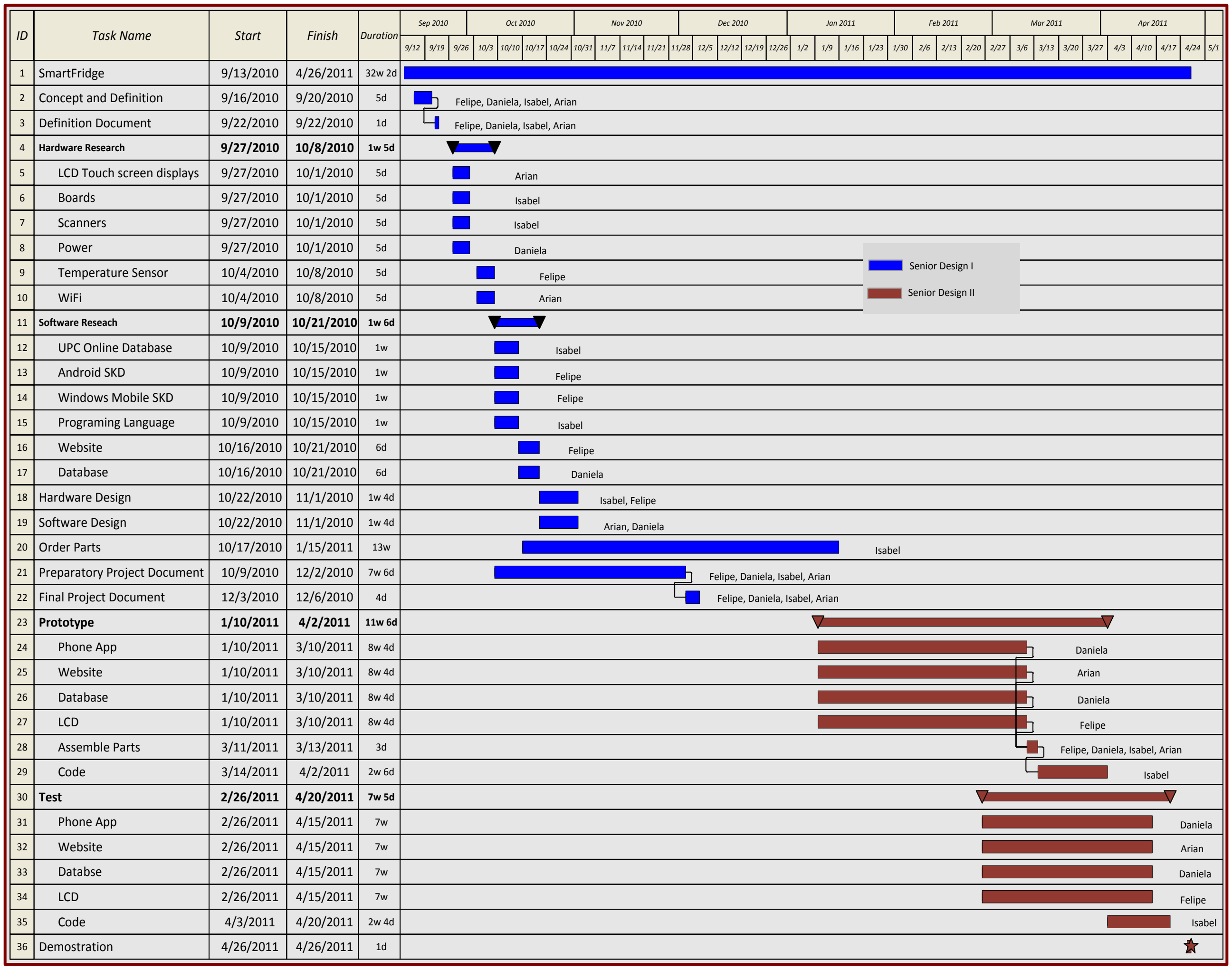
2.6.9 Temperature Sensor

Temperature sensors will be used simply to display the internal temperature of the refrigerator on the LCD panel at all times. It will serve the purpose of letting the user assess if the temperature reading is either too high or too low for the food that is in the refrigerator.

- The system shall be located inside the refrigerator, at a spot where the temperature readings are examined to be consistent and reliable.
- The system shall provide temperature readings from the location of the sensor.
- The system shall have a threshold of high and low limits set by the user.
- The system shall provide alerts when temperatures fall below or above the threshold.

2.7 Milestone Gantt chart

The chart on Table 4 is a time and activity bar chart that displays the project schedule in task sequence and by the task start and finish dates. Every activity that corresponds to the project's critical path, longest estimated time the project should take to be completed, is present in the left side of the chart under the column name Task Name. The chart shows the time duration for each activity as a horizontal blue axis for the activities corresponding to the first phase or Senior Design I and red for the ones corresponding to the second phase or Senior Design II. All the activities are list down and the top bar corresponding to Smart Fridge represents the total activity period between both phases. The lines connecting bars represent dependencies between activities. There are tasks that can only start after another task was completed.



ID	Task Name	Start	Finish	Duration
1	SmartFridge	9/13/2010	4/26/2011	32w 2d
2	Concept and Definition	9/16/2010	9/20/2010	5d
3	Definition Document	9/22/2010	9/22/2010	1d
4	**Hardware Research**	**9/27/2010**	**10/8/2010**	**1w 5d**
5	LCD Touch screen displays	9/27/2010	10/1/2010	5d
6	Boards	9/27/2010	10/1/2010	5d
7	Scanners	9/27/2010	10/1/2010	5d
8	Power	9/27/2010	10/1/2010	5d
9	Temperature Sensor	10/4/2010	10/8/2010	5d
10	WiFi	10/4/2010	10/8/2010	5d
11	**Software Reseach**	**10/9/2010**	**10/21/2010**	**1w 6d**
12	UPC Online Database	10/9/2010	10/15/2010	1w
13	Android SKD	10/9/2010	10/15/2010	1w
14	Windows Mobile SKD	10/9/2010	10/15/2010	1w
15	Programing Language	10/9/2010	10/15/2010	1w
16	Website	10/16/2010	10/21/2010	6d
17	Database	10/16/2010	10/21/2010	6d
18	Hardware Design	10/22/2010	11/1/2010	1w 4d
19	Software Design	10/22/2010	11/1/2010	1w 4d
20	Order Parts	10/17/2010	1/15/2011	13w
21	Preparatory Project Document	10/9/2010	12/2/2010	7w 6d
22	Final Project Document	12/3/2010	12/6/2010	4d
23	**Prototype**	**1/10/2011**	**4/2/2011**	**11w 6d**
24	Phone App	1/10/2011	3/10/2011	8w 4d
25	Website	1/10/2011	3/10/2011	8w 4d
26	Database	1/10/2011	3/10/2011	8w 4d
27	LCD	1/10/2011	3/10/2011	8w 4d
28	Assemble Parts	3/11/2011	3/13/2011	3d
29	Code	3/14/2011	4/2/2011	2w 6d
30	**Test**	**2/26/2011**	**4/20/2011**	**7w 5d**
31	Phone App	2/26/2011	4/15/2011	7w
32	Website	2/26/2011	4/15/2011	7w
33	Databse	2/26/2011	4/15/2011	7w
34	LCD	2/26/2011	4/15/2011	7w
35	Code	4/3/2011	4/20/2011	2w 4d
36	Demostration	4/26/2011	4/26/2011	1d

Table 4 Time-activity relation chart

Table 5

3. Research

3.1 Implementation Methodology

3.1.1 Project Management

Managing a project can be very troublesome and problematic if not done correctly. We feel that it was critical for the team to research this topic in order to organize the project in appropriate phases and steps. The foremost challenge of project management is to accomplish all of the engineering project goals and objectives. These goals have been defined in the Project Definition and are explicitly stated. These goals and objectives have to be met while keeping in mind the predetermined project constraints. These usually include scope of work, time, and budget.

Some approaches to project management put an emphasis on the head of the group. That is, the project manager is the vital component for a project to successfully run its course. Others however, describe a more structured, systematic way of managing projects. All of the members in the group have engaged in projects of different scales both job-related and academic.

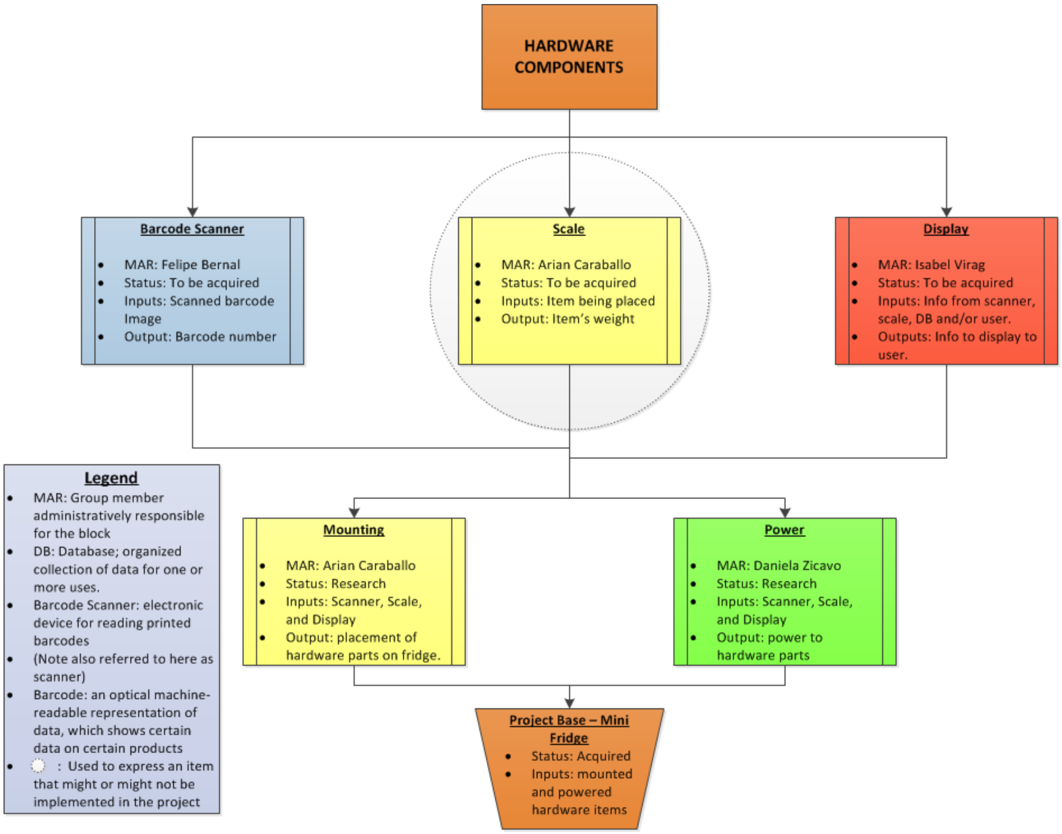

HARDWARE COMPONENTS
Barcode Scanner
MAR: Felipe Bernal
Status: To be acquired
Inputs: Scanned barcode Image
Output: Barcode number
Scale
MAR: Arian Caraballo
Status: To be acquired
Inputs: Item being placed
Output: Item's weight
Display
MAR: Isabel Virag
Status: To be acquired
Inputs: Info from scanner, scale, DB and/or user.
Outputs: Info to display to user.
Legend
MAR: Group member administratively responsible for the block
DB: Database; organized collection of data for one or more uses.
Barcode Scanner: electronic device for reading printed barcodes
(Note also referred to here as scanner)
Barcode: an optical machine-readable representation of data, which shows certain data on certain products
: Used to express an item that might or might not be implemented in the project
Mounting
MAR: Arian Caraballo
Status: Research
Inputs: Scanner, Scale, and Display
Output: placement of hardware parts on fridge.
Power
MAR: Daniela Zicavo
Status: Research
Inputs: Scanner, Scale, and Display
Output: power to hardware parts
Project Base – Mini Fridge
Status: Acquired
Inputs: mounted and powered hardware items

Figure 1: Hardware Components' Phases and division

We believe that to improve the dynamics of our team, we should refrain from selecting a project manager. Instead, we will use a well structured plan and ensure the team has a high level of communication to achieve all of the project goals.

Each member of the group has specialized knowledge in different technologies. The project will be broken down to different components and each member will be responsible for its assigned area. This does not mean that this person alone will develop this part of the project. Instead, this team member will in essence be the *leader* for that specific task. The tasks will be assigned according to the level of knowledge in that specific subject. The hardware related components can be seen on the diagram in Figure 1 while the software related components can be seen on the diagram in Figure 2.

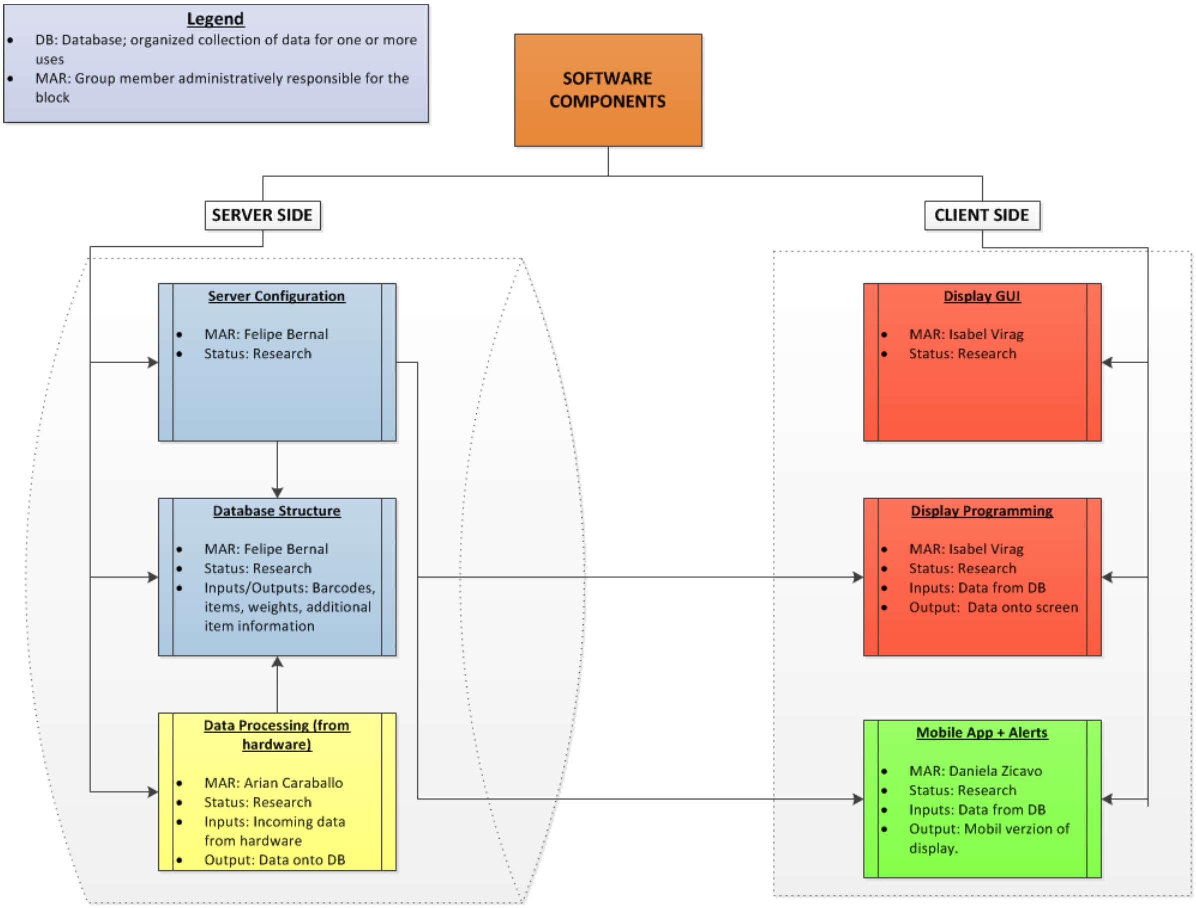


Figure 2: Software Components' Phases and division

To carry out the project in an organized and structured way, a common approach to managing projects will be implemented. This methodology contains the following phases: Analysis, Design, Build, Test, and Rollout. This methodology has been used by some of the team members in various projects both academic and non-academic. It is a system that has been proven to work and has allowed the members of the team that are working on the project to effectively make use of their time. No phase is more important than another as each of them is crucial to the success of the project. Some tasks from different phases can be parallelised and some tasks in different phases can be ongoing throughout the project. Such tasks include research of different technologies as the project progresses. In the analysis phase, the problem is discussed. This phase consists of describing all of the possible implementations, possible challenges, and so on. The design phase provides the conceptual design of the project and then the architectural design is defined. During the build phase, the team will use the design specifications developed to come up with a prototype. The test phase consists of thorough inspection of the system and testing according to the testing specifications described in this document. During the final phase, the rollout is performed. All required demos and presentations are given. Project functionality approval is attained during this phase.

3.1.2 Research Methodology

The team conducted a thorough research in all of the areas involved in the development of the project. The emphasis of the research was made on the hardware components since all of the team members are more software oriented. This procedure was broken down into several different components including LCD displays, development boards, barcode scanners, temperature sensors, and Wi-Fi modules. Although it was critical to gain useful information regarding all of the hardware parts, the software components of the project were not overlooked; an in depth analysis of possible software components was also researched. This included research in the fields of mobile app and web server applications, programming languages, web development languages, and communication systems. We felt it was crucial to have all of the required information and possible implementation options before any of the design was mapped out.

To improve the dynamic of the research stage, the topics were split evenly within each group member. Topics were assigned based on knowledge of the subject and also based on interest. Most of the information gathered was retrieved from websites or emails. After reviewing all the information gathered and comparing different product specifications, it was easier to make a decision on what products would work best for our desired functionality. This was especially true when comparing the development boards side to side.

3.1.3 Design Methodology

This phase of the project required numerous meetings to develop the design of all of the components of the project. Each member’s specific skill set was used to our advantage in leading the discussion of the design. The database structure, for example, was put together mostly by one of the members with previous experience with database systems, while the other members aided in brainstorming the different fields that would be necessary for the system to work properly. The design of the software was mostly done in stages. It was clear to the group from the research phase, that we would implement the interface in three different platforms. The design phase required us to create a design for the LCD display, a design for the website, and a design for the mobile app. Each of these was designed in different stages with the group meeting a couple of times. Most of the design efforts with these displays came from the workflow of the programs. That is, how were the programs going to interact with the user and what type of information would be available to the user in each platform. Numerous diagrams that pertain to software engineering were developed to aid the visualization of the software design for this project.

When developing a software product, it is often the case that the people developing might want to jump straight into developing the code for that product. After undergoing the design phase, it is clearer now that this step will facilitate and hopefully expedite the development process.

Team meetings were a huge aid in allowing each team member to provide their individual ideas and brainstorm together. Many ideas that will be implemented on the project could not have been possible if this phase would not have been performed correctly. The design methodology used should be kept in mind for future projects, in this or any other scope.

3.2 LCD Displays

Smidge will be equipped with an LCD touch screen display. Through the display the user will have some kind of tabbed interface from which he or she will have access to different options. One of the main reasons for the use of a touch screen is to make the user interact directly with what is on the screen, without having to rely on the use of a mouse or a keyboard. Second reason is that the interaction does not require the use of any intermediate device held in the hand. A third reason will be the likeability of this type of technology in the public. Now a day a touch screen display can be found almost in any application, from cell phones to ATM machines.

Smidge will be equipped with an LCD touch screen display and after doing some research we narrow our search to two choices, the ‘Innolux TFT LCD with touch panel’ attached, and the ‘IMO Pivot Touch’. They are both 7 inches in size, which is a relatively good size for our purpose, and they are both touch screen displays, which adds an element of speed and ease to the user experience when using the system.

3.2.1 Innolux TFT LCD with touch panel

This LCD panel shown in Figure 3 can be used with the OK6410 packet board. The drivers for this board are included with the system. The main advantage of this LCD panel is that it is the most affordable touch screen display in the market. Having the drivers readily available for use with Android is very important and saves us a lot of time when trying to create an interaction between all of our hardware and software components. The main issue with this screen is that there is little support offered online. There is not much evidence that this screen has been used before in these types of projects. The only help we could get is through emailing the manufacturer directly. The specifications for this model are shown on Table 5.

Item	Specification
Model	AT070TN83
Driver element	a-Si TFT active matrix
Resolution	800 X 480 (RBG)
Display model	Normally white, Transmissive
Dot pitch	0.0635 (W) X 0.1905 (H) mm
Active area	152.4 (W)X91.44 (H) mm
Module size	165 (W) X 104 (H) X 5.5 (D) mm
Surface treatment	Anti-Glare
Color arrangement	RGB-stripe
Contrast ratio	500 : 1
Interface	Digital(TTL)
Current consumption	500 mA

Power voltage	5 V
Backlight power consumption	2.500W (including the T-con Board power consumption)
Panel power consumption	0.825W (including LED Driver power consumption)
Weight	130g (Typ.)
Operation temp.	-20℃ ～ +70℃

Table 6 Innolux LCD Panel specification

3.2.2 **IMO Pivot Touch**

This LCD display is compatible with the PandaBoard or the BeagleBoard. It has generic drivers which might be a little harder to configure, but on the other hand it offers community support like forums IRC and many more. This LCD has a stand with a ball-and-joint system that offers full 360 degrees maneuverability for optimum view. The stand can be easily detached and used with a simple flip-out kick stand.

The main benefit of using this touch screen is that it has been proven to work with a variety of boards, making it somewhat easier to find a way to interface this lcd display with our own custom board. The price is not as accessible as the Innolux screen; however, there is more support and information found on the web for this model. This model's specifications are shown on Table 6. It is seven inches in size and it is also transmissive in type. The fact that it offers two different stand types to place the touch screen adds to its beauty; and the fact that it can be powered through USB cables makes it all the worthwhile as it can all be connected directly to our main board.

Item	Specification
LCD size	7.0 inch (Diagonal)
Resolution	800 X 480 (RBG)
Module size	190 (W) X 133.35 (H) X 12.7 (D) mm
Contrast ratio	400 : 1
Current consumption	100-240 V
Power voltage	24 V
Weight	544.31 g (with stand)

Table 7 IMO Pivot Touch

3.3 Development Boards

The main frame of the project will be based on a development board that can handle the operating system we choose to install and operate to create our smart fridge system. By looking at different options, we will be able to better assess our needs based on the level of performance, price, operating systems and availability of peripherals for each of the boards considered.

We started by looking at boards that would be able to port the Android System, as it is the operating system we are most interested in learning; however, each one of the boards we analyzed have other options when it comes to operating systems. Our second most important condition was to have the best price-performance ratio, and we came up with three very competitive boards to consider.

3.3.1 BeagleBoard

The first development board we are taking into consideration is the BeagleBoard. It is an OMAP3530 platform based board that caters to the open source community. It is priced at $149 and comes with U-Boot and X-Loader software flashed onto it but no peripherals or connection cables. However, it satisfies our need of being able to host the Android operating system at a reasonable level of performance, price and with plenty of room for development and expansion. It is also very popular, and plenty of information and help is provided in online forums, which translates as a big advantage when developing our senior design project.

The BeagleBoard is 3 by 3.1 inches in size. It uses the OMAP3530 DCBB72 720Mhz version processor that features over 1,200 Dhrystone MIPS using the superscalar ARM Cortex-A8 with highly accurate branch prediction and 256KB L2 cache running at up to 600MHz. It comes in a .4mm pitch pop package. POP is a technique where the memory, NAND and SDRAM are mounted on top of the processor. The memory used on the board is a Micron POP memory which has 2Gb NAND x 16 (256Mb) and 2Gb MDDR SDRAM. It is possible to add additional memory to the Beagleboard if needed by adding either an SD card, MMC or through the USB port. It offers OpenGL ES 2.0 2D/3D graphics accelerator capable of rendering 10 million polygons per second.

The BeagleBoard has a TPS65950 power module developed by Texas Instruments to provide power to the BeagleBoard; the 3.3V regulator in it is used to provide power to the DVI-D encoder and RS232 driver; and it also provides stereo audio out, stereo audio in, power on reset and power to the USB OTG port. This USB OTG port can be used as the primary source of power and communication for the board if connected to a computer USB port; therefore the Beagleboard requires a single minAB to USB A cable; a Y-Cable; or a 5V DC supply can also be used.

The board provides a single HS USB 2.0 Host Port, a Stereo Audio Output connector, a Stereo Audio Input connector, an S-Video output connection and a DVI-D connector. The USB Host port is provided via a USB Type A connector that provides power control on/off to the system. The 3.5mm standard Stereo Audio Output audio jack is used to access the stereo output of the onboard audio CODEC provided by the TPS65950. The Stereo Audio-In Connector is interfaced in the same manner. A 4 pin DIN connector is provided to access the S-Video Output that supports NTSC or PAL format to a standard TV. And finally, a DVI-D connector that has the ability drive an LCD panel equipped with a DVID-D digital input.

The BeagleBoard supports 24b color output, and it has a DDC2B (Display Data Channel) or EDID (Enhanced Display ID) support over 12C in order to identify the LCD monitor type and settings. The board comes with a DVI-D interface that uses an HDMI connector, which the user is able to implement by using an HDMI to DVI-D cable or adapter for the LCD monitor. A pair of 1.27mm pitch headers is provided to gain access to the LCD signals.

An SD/MMC 6 in 1 connector is available as a way to expand memory. It supports WiFi cards, cameras, Bluetooth cards, GPS modules, SD Memory Cards, MMC Memory Card, SDIO Cards, MMCMobile Cards, RS-MMC Cards and miniSD Cards.

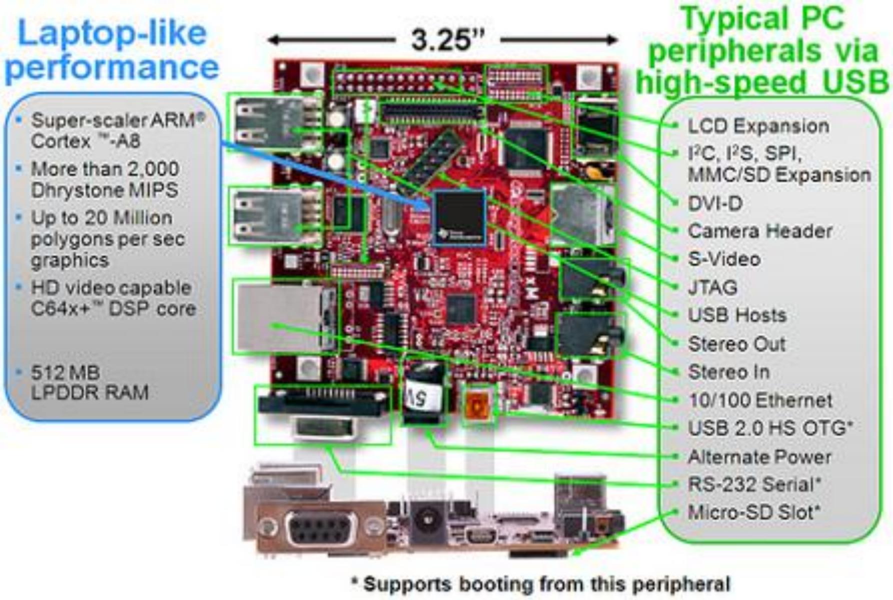

Laptop-like performance
• Super-scaler ARM® Cortex ™-A8
• More than 2,000 Dhrystone MIPS
• Up to 20 Million polygons per sec graphics
• HD video capable C64x+™ DSP core
• 512 MB LPDDR RAM
3.25"
Typical PC peripherals via high-speed USB
• LCD Expansion
• I^2C, I^2S, SPI, MMC/SD Expansion
• DVI-D
• Camera Header
• S-Video
• JTAG
• USB Hosts
• Stereo Out
• Stereo In
• 10/100 Ethernet
• USB 2.0 HS OTG*
• Alternate Power
• RS-232 Serial*
• Micro-SD Slot*
* Supports booting from this peripheral

Figure 3BeagleBoard Hardware architecture components.

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There is a reset button on the board, a User/Boot button and four LEDs on the board. The User/Boot button does one of two things: forces a change in the boot sequence of the processor, or is used as an application button for an implementation of the software used. It can also be used in combination with the reset button to cause changes in the order in which boot sources are checks as viable boot sources. There are three green LEDs on the BeagleBoard that are controlled by the user. One is controlled via the I2C interface while the other two are processor controlled via GPIO pins. The fourth LED indicates whether the board is on or off.

Finally, it provides a JTAG connector, an RS232 Header and an Expansion Header. The 14 pin JTAG header facilitates the software development and debugging of the boards by using JTAG emulators (Only 1.8V levels are supported). The RS232 Header is supported via UART3 by a pin header on the BeagleBoard. To access the port, you need an IDC to DB9 flat cable. The expansion header is a single 28 pin header provided to allow for the connection of expansion cards that could be developed by the user. All of the hardware components described are shown in Figure 4.

3.3.2 OK6410 package

Our second most comprehensive choice is the OK6410 package. It is a Single Board Computer based on the 667Mhz Samsung S3C6410 (ARM11) microcontroller. This board has plenty of built-in resources and powerful video processing capacity. It is priced at $110 and comes with Board Support Packages for Linux, Windows CE and Android, including some basic drivers for peripherals. As a package, it comes with the board, 1 serial port cable, 1 USB cable, 1 Ethernet cable, 1 JTAG wiggler with a JTAG cable, a 5V power supply and a DVD with help information.

This board clearly offers more than the BeagleBoard when it comes to hardware supplies and help provided with the system. However, it is not as popular in the open source community; which ultimately means there isn't as much help out there if we get stuck solving a problem when developing our project.

The OK6410 development board is split into two parts, a core board and a carrier board. The core board is the central controlling module, which includes the Samsung S3C6410 microcontroller based on the ARM 1176JZF-S core with a frequency of 533/667Mhz, a 128 Mb mobileDDR RAM, 1GB of NAND Flash, NOR Flash and 5V power supply adaptable. It can be connected to the carrier board via four 80 pin anti-oxidation connectors; or if programmed, It can be detached from the carrier board and used as an individual COM (Computer On Module) and inserted into test beds, prototypes, and production units.

The Samsung 1GB K9F8G08U0A NAND Flash chip is integrated for storing operating system kernels, applications, file systems and data. It supports 128 MB- 2GB NAND Flash chips. The mobile DDR RAM is 128 Mbytes consisting of two Samsung K4X51163PC chips and a frequency max of 266Mhz.

Carrier Board is in a 4 layer PCB that contains all the necessary useful components (other than memory or processor). The first important characteristic is an 8-bit toggle switch for selecting boot mode. The board supports booting from either NAND Flash or SD card and both 8 bit combinations are provided. The second would be that there are four serial ports on the board: one 5-wire RS232 and 3 3-wire RS232. Also, a USB Host interface that supports USB 1.1 protocol is provided that can be used to connect USB keyboard, USB hard disk a USB mouse, a USB memory stick or other USB powered devices of the manner. A USB OTG interface (Mini USB A/B port) that supports USB 2.0 protocol with a maximum speed up to 480 Mbps that can be used for downloading programs and binaries.

The carrier board also includes a JTAG interface, a Real Time Clock, an SD Card Slot or WIFI Connector, and an Ethernet Port. The JTAG interface is included to provide access to the ARM11 core and S3C6410 in-chip peripherals. The real time clock (RTC) is powered by a built-in button battery, which supplies the RTC when the power supply is detached from the board. The 4-wire high speed SD Card Slot provided supports both SD Memory 2.0 and SDIO 1.0 protocol. It supports up to 8 GB SD card and as an SDIO it can be used for a WIFI module or GPS module as needed. A DM9000AE Ethernet chip is used on the board to implement 100M Ethernet. It can be used to download WinCE binaries or mount a Network File System on Linux.

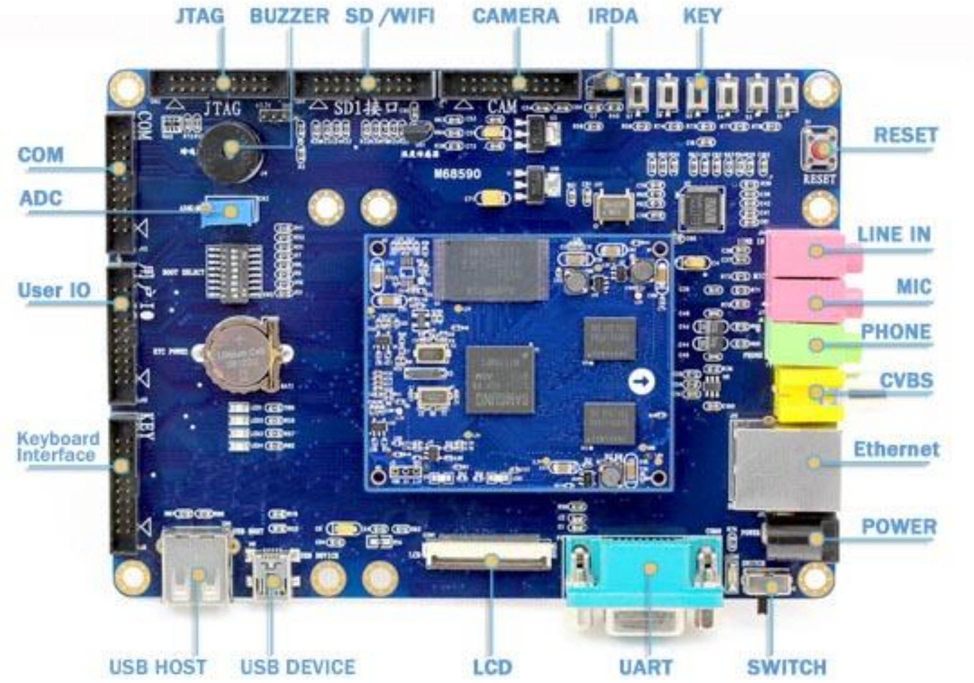

Figure 4 OK6410 Hardware architecture components.
Permission to use this material requested from Arm9Board.net

Finally, the OK6410 provides an LCD Touch screen Interface through a 50 pin 2.0mm pitch connector to which we can connect any of a 3.5”, 4.3”, 5.6”, 7”, 8” TFT LCDs; a TV out interface implemented as a 2 pin standard TV interface; Stereo I/O sockets; One CVBS output interface that accepts PAL/NTSC; one CMOS camera connector that supports ITU-BT 601/656 8bit mode, and a maximum of 4096x4096 megapixels; a digital temperature sensor; a HS0038B infrared receiver; 2x10pin IO pins reserved for user interactions and one reset button implemented with reset chip; four user LEDs, one buzzer and three 2x10pin expansion interfaces to carry out the camera signals. All of the hardware components described are shown in Figure 5.

3.3.3 PandaBoard

Our third and last development board considered is the PandaBoard, a new platform sponsored by Texas Instruments. It provides a Dual-core ARM® Cortex™-A9 MPCore with Symmetric Multiprocessing (SMP) at 1Ghz each. Allows for 150% performance increase over previous ARM Cortex-A8 cores and it is relatively new to the market. Features include Full HD (1080p) multi-standard video encode/decode; Imagination Technologies’ POWERVR™ SGX540 graphics core supporting all major API's including OpenGL® ES v2.0, OpenGL ES v1.1, OpenVG v1.1 and EGL v1.3 and Low power audio (up to 140+ hr CD-quality audio playback). This board is intended to be used as a platform for mobile software development which becomes an interesting point being that we are trying to develop a system that will be mostly based on a mobile environment.

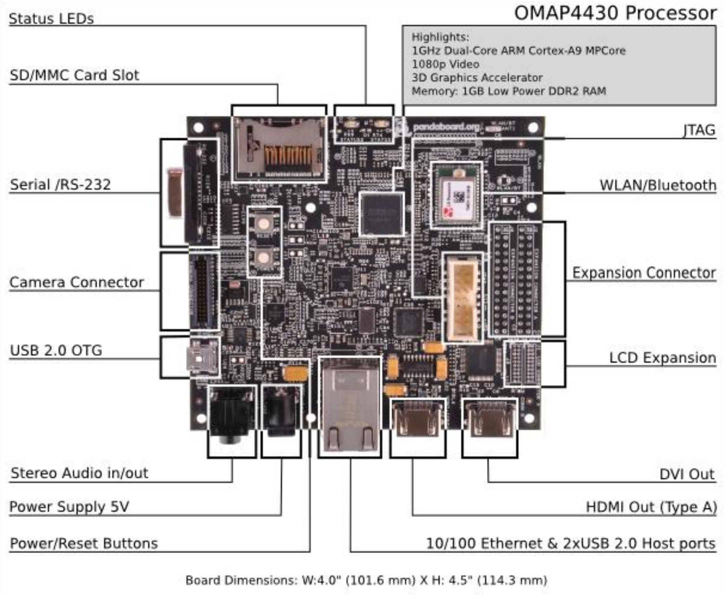

Figure 5 PandaBoard Architecture.

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The board is priced at $179, which makes it the most expensive development board compared to our other options; however, it is still at a reasonable and affordable price considering what it has to offer. At initial launch, PandaBoard supports Android, Angstrom minimal filesystem and Ubuntu. Just like in the case of the BeagleBoard, different operating systems have been ported to the PandaBoard by the open source community and they all have sources and binaries available ready to run on the PandaBoard . It is based on an OMAP4430 applications processor developed by Texas Instruments; and includes memory consisting of a 1GB low power DDR2 RAM and a full size SD/MMC card cage with support for High-Speed & High-Capacity SD cards.

The PandaBoard has several options when it comes to display; we already have seen these in the other two choices. It includes an HDMI v1.3 Connector (Type A) to drive HD displays; and a DVI-D connector similar to the one on the Beagleboard that can drive a second display or simultaneous displays but requires an HDMI to DVI-D adapter. Audio consists of a 3.5” audio in jack and audio out jack, also as we have seen in the other boards; as well as an HDMI Audio Out for the HDMI connector. Connectivity consists of a 10/100 Ethernet port on the board and it also offers wireless connectivity through an 802.11 b/g/n (based on WiLink 6.0) and *Bluetooth* v2.1 + EDR also based on WiLink 6.0. It includes one USB 2.0 High-Speed on the go port, 2 USB 2.0 high speed host ports; a general purpose expansion header that could accommodate an I2C, GPMC, USB, MMC, DSS or ETM and a Camera expansion header. Finally, it holds a JTAG wiggler for debugging purposes, as well as UART/RS232 connection; 2 status LEDs configurable by the user; and one GPIO Button.

3.4 Scanners

One of the most important components of our Smart Fridge System is the UPC barcode scanner that we will use to identify all the grocery items that will be placed in or taken out of the mini fridge. There are different types of barcodes; grocery items usually contain a Universal Product

Code, most commonly known as UPC. The basic UPC code and the one most commonly used for groceries, referred to as Type A, is composed of twelve digits. These twelve digits are broken up into four groups. First, the Number System Character (NSC), the first number represents the "number system' of the code, then the next five digits are the 'Manufacturer Code' given out by the Uniform Code Council (UCC), followed by 5 digits of the product code and the last digit is used to check the integrity of the other digits in the number.

The most significant and driving concern when it comes to this project and barcodes is which type of scanner to use, we have a choice of either a laser scanner, like the ones used in grocery stores, or a camera-based reader, like the ones recently seen implemented in smartphones.

Laser scanners consist of a laser beam used as a light source and employ either a reciprocating mirror or a rotating prism to scan the laser beam back and forth across the bar code. To read a bar code, the photodiode measures the intensity of the light reflected back from the light source and generates a waveform that is used to measure the widths of the bars and spaces in the bar code. It is a fairly fast process taking less than a second to scan all numbers and write them into a text field.

Camera-based readers, in contrast, are two-dimensional imaging scanners that use a camera and image processing techniques to decode the bar code. They are usually small video cameras or regular cameras with CCD technology that has hundred of rows of sensors arranged in a two-dimensional array so that they can generate an image.

For our purposes, we need something that will read the UPC barcode with no problems, have a fairly reasonable price, and be user friendly. Therefore, after taking a look at these two options, the differences are fairly obvious. A camera based reader is somewhat more complex, the placement of the camera towards the product may affect the reading; also, cameras tend to be a lot more fragile and present with more problems than regular laser scanners and the price of buying a camera capable of performing this action with no technical difficulties is a little more than a simple one line barcode reader. The other very important factor is that a camera takes about twice as long to decode the barcode than a laser scanner since it needs to snap a picture of it, analyze it and come up with the number sequence. This can take up to two seconds more than the barcode scanner; and even though it is not a huge difference, it does add up when trying to enhance user experience. The last thing would be that hardware-wise, a barcode scanner is much easier to implement since there are plenty of them offered on the market that are simply read in as a keyboard input, hence, no drivers are needed for the software used; while a camera-based reader will need drivers for any type of camera used.

Seeing that we established that laser scanners would be a better choice for our project, we looked at three different choices that compete against each other when it comes to price, size, and input mode. We looked at the Metrologic ScanGlove IS4225, the ROV scanner, and the LS2208 Handheld Barcode Scanner from Symbol'. The first one is a simple small version, while the other two are the typical handheld device found at grocery stores. The main points to look at when comparing these, is the overall size, price, connection type and types of barcodes that it can read.

3.4.1 Metrologic ScanGlove IS4225

MetroLogic's Scanglove is featured as durable, lightweight, wearable automatic-single line 1D bar code scanner that improves productivity as it increases scanning flexibility. It can be used as a back of hand scanner or a stationary desktop scanner or also as a compact, fixed mount presentation scanner. Its most important aspect is that as soon as it is plugged into a PC, and the barcode is presented to the scanner, the numbers are automatically entered into the computer, similar to a keyboard input; no special drivers are needed to be able to use the device. However, if needed, the user is still able to use this scanner with other interfaces such as RS232, a keyboard wedge, stand alone keyboard, light pen emulation or USB.

Interface	RS232, Light Pen Emulation, PC Keyboard Wedge, Stand Alone Keyboard, USB (low speed)
Size	Length: 70 mm (2.75") Width: 49 mm (1.94") Height: 24 mm (0.94")
Barcodes Supported	ITF , UPC , UPC-E , Code 93 , UPC-A , Code 11 , Matrix 2 of 5 , Code 39 Full ASCII , Interleaved 2 of 5 , Code 128 , Codabar , Bookland , MSI-Plessey , Code 39

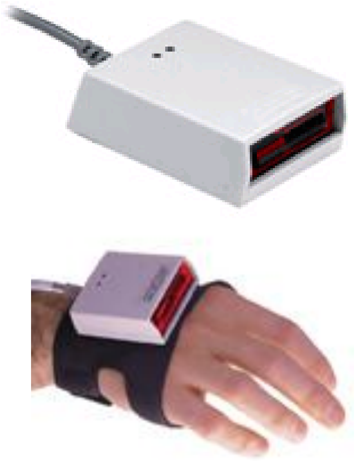

Figure 6 Metrologic ScanGlove

Permission acquired to reprint from Metrologic Instruments, Inc

The ScanGlove can read up to 80 data characters and has a visible laser diode of 650mm. It has three indicators: if the LED is red, the laser is on and ready to scan. If it is green, it means it just read a barcode successfully. When it comes to power, the ScanGlove comes with its own USB power cord attached and gets power as well as outputs the code through this same cable. The unit also features an infrared sensor (IR), if a specified time has elapsed without any scanning, the unit will enter a "standby" mode. The unit reactivates automatically when it detects an object in front of the IR sensor. The last feature is that the scanner can be programmed to emit three beeps when a timeout occurs between the host and the scanner.

This scanner is very expensive if it were to be bought off the shelf. It runs from $5250-$500 on the market even though it has already been a few years since it was created (2007). However, we would be able to find one of these devices that has already been used for about $30-$50 online.

3.4.2 ROV Scanner

The second option is the ROV Scanner by Microvision. It is a handheld, 1D laser barcode scanner that utilizes Microvision's MEMS technology which helps enable a reliable, low cost barcode scanner. It is also very small in size and is priced at around $160.

It features one button operation to trigger the barcode scanning and scans into virtually any software application on Windows or Mac. It can store up to 4000 UPC-A barcodes in non-volatile memory, which is a feature that is not seen in the Metrologic scanner and the most important benefit is that it is battery-operated so that it can be used wirelessly; or also with a USB cable to be used a s a keyboard input and no software required.

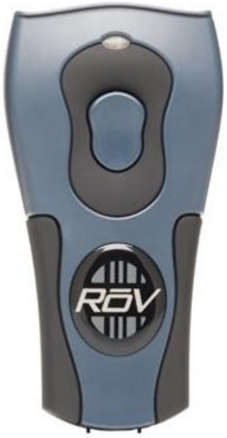

Figure 7 Microvision's ROV scanner.

Interface	Serial,USB
Size	*Length: 4.5 in (11.4cm); Width: 2in (5cm), Height: 1in (2.5cm)*
Barcodes Supported	*UPC/EAN/JAN, Code 39, Code 128, RSS, Interleaved 2 of 5, Codabar/NW-7*
Platforms supported	Symbian Windows Mobile Palm BlackBerry Windows

Permission acquired to reprint from from Microvision,Inc.

3.4.3 LS2208 Handheld Barcode Scanner from Symbol

The LS2208 handheld scanner from Motorola features high performance at a moderate price around $130. It provides fast, reliable scanning in a durable, lightweight form. It has aggressive scanning capabilities and a wide working range. It is easy to deploy and use because it features a plug-and-play installation and intuitive, user-friendly design. Its design reduces user fatigue to maximize user comfort. The unit has been tested to withstand multiple 5 ft drops to concrete and work continuously all day long. It also features something we have not seen in our other two choices, it has ADF, Advanced Data Formatting, which enables users to modify data prior to sending to host computer, reducing costly modifications to the host software. It is powered by USB just as the ScanGlove through the host power and it is a bidirectional scanner and decodes UPC/EAN, UCC/EAN as well as an extensive list of other types of codes. It also supports RS232, Keyboard wedge, Wand, IBM 468X/9X, Synapse and un-decoded interfaces.

Interface	IBM, Keyboard wedge, RS-232, Synapse, USB, Wand
Size	*Length: 3.34 in (8.4 cm); Width: 2.5 in (6.3 cm), Height: 6 in (15.2 cm)*
Barcodes Supported	UPC/EAN, UCC/EAN 128, Code 39, Code 39 Full ASCII, Code 39 TriOptic, Code 128, Code 128, Full ASCII, Codabar, Interleaved 2 aus 5, Diskret 2 aus 5, Code 93, MSI, Code 11, IATA, RSS-Varianten

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3.5 Wi-Fi modules vs. Wired

One of the main reasons for Smidge to use a wireless network will be the high mobility that this type of network offers. By using a Wi-Fi Smidge can be easily incorporated to an existing network, without having to worry about hanging wires all over the house or placing your refrigerator inside a bedroom or studio.

Belkin Wireless G USB Network Adapter F5D7050 - It can be used with the BeagleBoard or the OK6410 board. The adapter has generic drivers that might be hard to configure. The Belkin Wireless G USB, as the name says, can connect to the board via USB and offers 802.11g wireless capability, which provides 3 times the wireless range of the 802.11a adapter, and backward-compatibility with all 802.11b network devices. It also features wireless 64-bit and 128-bit WEP encryption.

Item	Specification
Network Standards	IEEE 802.11g
Range	Up to 400ft
Security	WPA, WPA2, 64-bit/128-bit encryption
Specification interface	USB 1.0, 1.1, 2.0
Operating Voltage	5 V

Table 8 Belkin Wireless G

TiWi-R1 Module – It comes integrated into the PandaBoard. The price of this module is included in the price of the board and it also comes with drivers. The TiWi-R1 Module offers two key features, low cost embedded 802.11b/g/n and Bluetooth. The TiWi-R1 offers a compact module with U.FL connector with approved antennas.

Item	Specification	
Network Standards	IEEE 802.11b/g/n	
Security	64-bit, 128-bit, 256-bit WEP, TKIP or AES Keys	
Operating Voltage	3.0 V to 4.8 V	
WLAN Features	**Output Power**	14.5 dBm, 802.11 g, 54 Mbps, -25 dB EVM
	RF Sensitivity	-76 dBm, 802.11 g, 54 Mbps
Bluetooth Features	**Output Power**	9.5 dBm, Class 1.5
	RF Sensitivity	-92 dBm, GFSK, BER=0.1%

Table 9 Tiwi R1 Module

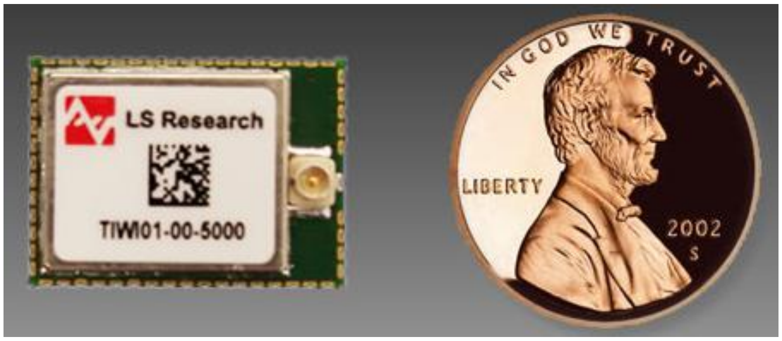

Figure 8 TiWI- R1 Module.
Permission acquired to reprint from from LS Research, LLC

3.6 Universal Product Code and Price Lookup Code Databases

The main goal of this project is to be able to keep track of the grocery items available in your refrigerator. To be able to achieve this, we have already researched the UPC barcode scanners available and relevant to our project. However, the scanner simply translates a UPC located in a product into a sequence of numbers. The number acquired represents the specific product, however, we need a way to search for this UPC and obtain the product's name, description, size and image.

For this purpose, we must research the different ways of obtaining this information. We have found several databases that allow you to search for a product via their UPC code through a webpage; however, most of these databases are not directly available offline or for personal use without paying large amounts of money for them. The other option to obtain this information is through an API (Application Programming Interface) offered by some of these web pages.

Another important detail is that most of the databases don't carry images or image links for products on them; and we are set on providing product images along with a product description on our system. Therefore, we decided that after using an API, we could grab the item's name and perform a search using Google Image Search API to obtain an accurate product image.

The last aspect to look at when researching the UPC databases, is to be able to perform keyword searches on the API. This would allow searching for a specific product only by specifying a common name for it. For example: 'Lays Stax' would return a list of all items found under this name with their corresponding UPCs for the user to choose from. This will be helpful when trying to add an item to a shopping list or recipe that the system has never seen or recorded before on the local database; meaning, it is not present in neither past nor present inventories.

Fruits and vegetables are a whole other matter to look into seeing that they do not carry Universal Product Codes. They have their own indexing system called the PLU (Price Lookup) code. This code is usually printed on a sticker stuck to the fruit or vegetable and it is usually four digits long (except for organic produce that is prefixed with the number 9). These PLUs are not scanned in the same way that UPCs are scanned, since they do not provide a barcode for these four simple digits. Therefore, we must search for a database of PLUs to store locally and give the user the option to input the four digit code, or search by name and image.

A description of the APIs, databases and Google Image Search API found follows.

3.6.1 UPC grocery (upcgrocery.com)

UPC Grocery Search is advertised as a resource for detailed information of more than 80,000 grocery products. It offers the option of purchasing the entire database searchable by UPC, product name, manufacturer, size, unit or category. This database is offered mainly to store owners that need a UPC lookup for the items sold at their store. Therefore, the price is very high at exactly $3000. We acquired this information through email exchange with the owner of the webpage; and after letting him know that we are in need of a UPC database for our senior design project, he gave us two options: the first one was a discount of $1500 for the use of the database if we agreed to non-commercial use. The second option was to have it for free if we agreed on creating an API for their database. This would be a great option for us; however, it will take a lot of time and effort.

3.6.2 UPC Database (upcdatabase.com)

The second database we looked into was upcdatabase.com. This webpage seems to be one of the most popular for online UPC lookup. It offers about 1.3 million generic item entries (contributed mostly by users of the webpage) and their corresponding descriptions. It provides the UPC-A, EAN, description, issuing country, and size/weight for every item found. If an item is not found, the website allows you to add the UPC and description for that certain item once you acquire an account. This website also offers an API that allows the user to interact with their database without the need to have a local database. This is done by charging a small price based on UPC lookup use.

On the website, you must first create an account to be able to use the API. Then, you can put money into your account to use the API without having to go through their website. Money buys you what they call ‘credits’, for example, $5 buy you five credits. With these credits, you accrue a free amount of lookups per day. They have an accrual rate of 20 lookups per day and a maximum of 150 free lookups on one same day. Apart from free lookups, they charge .002 credit (dollars) per query when looking up a UPC or EAN and .01 when performing a text search in conjunction with a .002 charge per result found.

To be able to use this database, they offer libraries in Perl, PHP and Python. However, the API is written as an XML-RPC Web Service, which is easily accessible using almost any programming language.

3.6.3 IFPS PLU Database (plucodes.com)

IFPS stands for the International Federation for Produce Standards. This group offers an international forum for standardization of produce sectors. On their webpage, they offer a free downloadable excel sheet that contains every PLU code with the corresponding fruit or vegetable, variety, size, restrictions and botanical name.

This comes in handy for us since we are trying to make the system offer two options to the user: input the 4 digit code into the LCD, from which it would be easy to look it up in the local database; or perform a search by keyword from which we could simply organize the entries in the database into an indexed table with their corresponding pictures for a simple user experience.

3.7 Google Image Search API

The Google Image Search API is valuable when you want to obtain the results of a search query as if it was done on an online Google search. This will be very advantageous to our project since through the use of this API, we will be able to attach an image link to every entry, and make it possible for every item to be accompanied by an image when scanned, modified or looked at by the user. The other great aspect of this API is that it offers a library written in javascript and additionally offers a JSON interface that is easily accessible using almost any programming language. In the website, there are examples using flash, java, php, python and perl. From these options, we would most likely choose to use Java to access the database.

3.8 Temperature Sensors

A temperature sensor is a component that will be used to measure the interior temperature of the refrigerator and display it on the LCD at all times. This will serve as information for the user to assess whether the temperature inside the refrigerator is too high, or too low depending on the type and amount of food currently present in the inventory.

Temperature sensors are classified into two major types. There are contact and non-contact temperature sensors. Contact temperature sensors measure their own temperature. For example, a thermometer used in medicine is a contact temperature sensor as it attempts to measure the temperature of the surface it is in contact with (temperature propagates between touching elements). On the other hand, non-contact temperature sensors attempt to measure the temperature of the environment they are in.

For this project, we are interested in looking for non-contact temperature sensors to be able to measure the environment temperature of the refrigerator. For this, we have several options. We could choose a simple temperature sensor that costs about $4 to $5. These can then be placed in a small breadboard that can then be connected to our main development board. This option is simple and somewhat inexpensive. We wouldn’t need any drivers to be able to interface them with the software used because we can simply take its reading. The only problem with this option is that it wouldn’t be aesthetically pleasant.

The second option would be to have a temperature sensor connected through USB. This sensor would enable the option to have a longer cable and eliminate the need for a breadboard. This option is a little more expensive than the previous one, although not for by much. It would cost about $15 for the sensor and it would aesthetically be much more concealed and hidden than having a breadboard in the refrigerator. However, the down side about this option is that we would most likely have to write custom drivers for use with the PandaBoard which can prove to be a little tricky.

For the first option, we would choose a temperature sensor such as the DS18B20, which is a digital temperature sensor with a serial 3-pin to 92 (1-wire) connection. This would be directly connected into the breadboard. It would cost $3.00 for the sensor and about $5 for the breadboard. For the second option, we would choose a USB connection temperature sensor such as the CV193SI temperature sensor, which has a 1 meter cable length and dimensions of 50x17x8 mm.

3.9 Power source implementation

Power supply is a device that supplies electrical energy to one or more electric loads. The term is most commonly applied to devices that convert one form of electrical energy to another, though it may also refer to devices that convert another form of energy to electrical energy. A regulated power supply is one that controls the output voltage or current to a specific value; the controlled value is held nearly constant despite variations in either load current or the voltage supplied by the power supply's energy source.

Every power supply must obtain the energy it supplies to its load, as well as any energy it consumes while performing that task, from an energy source.

A power supply may be implemented as a discrete, stand-alone device or as an integral device that is hardwired to its load. In the latter case, for example, low voltage DC power supplies are commonly integrated with their loads in devices such as computers and household electronics.

Constraints that commonly affect power supplies include: the amount of voltage and current they can supply; how long they can supply energy without needing some kind of refueling or recharging (applies to power supplies that employ portable energy sources); how stable their output voltage or current is under varying load conditions and whether they provide continuous or pulsed energy.

In our project we decided to use the PandaBoard which allows a 5V power supply adaptable.

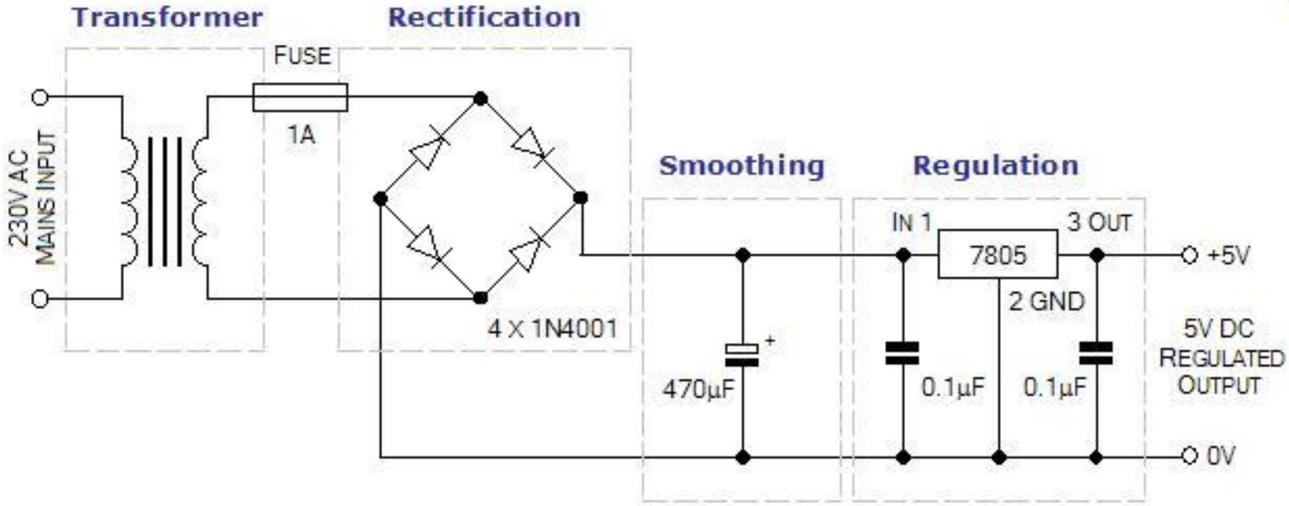

Figure 9 5V DC regulated supply system
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The fridge that will be use in our project is the model Sanyo SR-3770S Counter-High Refrigerator that has a rated voltage of 115 volts. The standard refrigerator is equipped with an eight foot power cord that requires a 115 Volt, 60 Cycle, 1 Phase properly grounded electrical receptacle. The power cord comes with a 3 prong plug for grounding purposes. The circuit must be protected with a 15 or 20 ampere fuse or breaker. The unit must be isolated on a circuit and not plugged into an extension cord.

To implement our project, we are left with two choices when it comes to power implementation. The first choice would be to join the two power cables together. This would mean we would splice the cables. This is done in five steps. First, we would look at the refrigerator cable, seeing that it has two or three separations, we could figure out which is the positive, negative and ground section (by looking at the higher end of the plug, we can spot the positive). This is also done on the power supply cable of the board, we should make sure to keep in mind or write down which is which. Now, the second step is to cut the cable coming from the power supply of the board and strip some of the coating of, so that the naked wires are showing while being careful that they don't touch each other. The next step is to peel off some of the coating present in the refrigerator cable, right at the point where the splicing will take place. The final step would be to wrap the board's corresponding wire to each side and coat it with electrical type. Again, the fact that they don't touch each other is very important in this case.

Being able to splice the cables in this case is somewhat simple. The fact that the power supply and the refrigerator's cable already have plugs to the wall means they both limit the amount of power needed to go into their respective systems. This simplifies the idea of having to regulate the power to each of them. However, this solution seems a bit unsafe. Dealing with 120Volts coming from the wall can be potentially very harmful. Not to mention, if either one of our refrigerator or board were to be damaged by this power source implementation, we would be making a huge dent in out budget to deal with this.

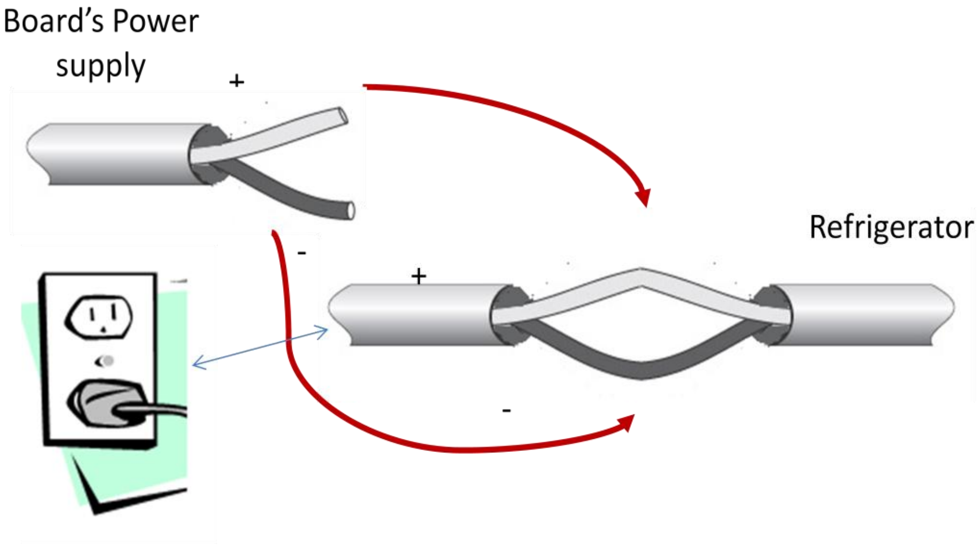


Figure 10: First choice for power implementation

Our second choice to avoid any harmful results to neither us nor the equipment due to handling power sources ourselves, is to simply find a power cable extension for two inputs that would accommodate both the power supply of the development board and the power plug of the refrigerator. The end of this extension cord would be where the two cables are to be plugged in, and we would use Velcro to discretely place it on the back of the refrigerator. This would allow for our main purpose of ultimately needing only one cable to be plugged in the wall to be fulfilled, and it would be a much cleaner, simpler and less risky solution to the problem.

Figure _ shows a generic extension cord for four inputs, two on each side. With this type of extension cord, we would be able to plug the two systems on either side and apply Velcro to the side of the extension cord so that it stays put on the back of the refrigerator, ultimately being out of sight and providing the whole fridge-system interaction a cleaner look and better user experience.

The pros and cons of each one of these two choices is clear. The first choice allows for a deeper understanding and involvement with electrical engineering. Having to cut, strip and connect wires together does not seem that hard to accomplish, but having the right cable where it needs to be is where the complications begin. If we attempt this solution, we might not be able to successfully connect it the first time. This means, we would probably need a testing procedure in order to make sure none of our group members get hurt, nor the equipment be damaged. We would need a power source that is not as harmful as 120V and a system that could be powered by the 5V power supply. However, the refrigerator still runs a big risk if we don't do things the right way, the first time.

The benefit of the second solution, as said earlier, is that it is a cleaner, simpler solution to our problem. It brings no power supply hazards. However, it lacks creativity and design when it comes to hardware design and electrical knowledge. Anyone can create this configuration without actually having to design anything. The decision will be made based on the importance of the power implementation in the overall system to add an electrical aspect to our research and design. If we find other more important electrical features to work on, the second choice might be the choice to go with.

3.10 Software Components

3.10.1 Mobile App & Website

Android SDK - Android is a software stack for mobile devices that includes an operating system, middleware, and key applications. The Android SDK provides the tools and libraries necessary to begin developing applications that run on Android-powered devices.

Android is a mobile operating system. It is based upon a modified version of the Linux kernel. Android relies on Linux for core system services such as security, memory management, process management, network stack, and driver model. The kernel also acts as an abstraction layer between the hardware and the rest of the software stack. Our team decided to use Android operating system since its open source. Due to its open source nature a lot of information and code examples can be found.

Android delivers a complete set of software for mobile devices: an operating system, middleware and key mobile applications. The Android SDK provides the tools and APIs necessary to develop applications on the Android platform using Java programming language.

Android will ship with a set of core applications including an email client, SMS program, calendar, maps, browser, contacts, and others. All applications are written using the Java programming language.

iOS SDK - iOS comprises the operating system and technologies that you use to run applications natively on devices, such as iPad, iPhone, and iPod touch. Although it shares a common heritage and many underlying technologies with Mac OS X, iOS was designed to meet the needs of a mobile environment, where users' needs are slightly different. If you have previously developed applications for Mac OS X, you will find many familiar technologies, but you'll also find

technologies that are available only on iOS, such as the Multi-Touch interface and accelerometer support.
The iOS SDK contains the code, information, and tools you need to develop, test, run, debug, and tune applications for iOS. The Xcode tools provide the basic editing, compilation, and debugging environment for your code. Xcode also provides the launching point for testing your applications on an iOS device, and in iPhone Simulator—a platform that mimics the basic iOS environment but runs on your local Macintosh computer.

Windows Mobile SDK - Windows Mobile lets you reuse your existing Visual Studio and .NET development skills and server infrastructure to extend your applications to mobile devices and give users new experiences and solve new business problems.

Windows Mobile is a mobile operating system developed by Microsoft that was for use in smartphones and mobile devices, but is being phased out to specialized markets.
Windows Mobile is based on the Windows CE 5.2 kernel, and features a suite of basic applications developed using the Microsoft Windows API. It is designed to be somewhat similar to desktop versions of Windows, feature-wise and aesthetically. Additionally, third-party software development is available for Windows Mobile. It is the 5th most popular smartphone operating system, with a 5% share of the worldwide smartphone market (after Symbian, BlackBerry OS, Android and iPhone). In the United States, it is the 3rd most popular smartphone operating system for business use (after BlackBerry OS and iPhone).

Operating Systems	**Windows Phone 7**	**Adroid 2.2**	**iOS 4.1**
Touch Screen Support	Yes	Yes	Yes
Multi-touch	Yes	Yes	Yes
Multitasking	No	Yes	Yes
Copy-Paste	No	Yes	Yes
App Store	Windows Marketplace	Android Market	App Store
Dedicated Game Center	Xbox Live	No	Game Center
Music/Video Player	Yes	Yes	Yes
Default Browser	IE based WP7 Browser	Android Browser	iPhone Safari
Default Search Engine	Bing	Google	Google
Maps	Bing Maps	Google Maps	Google Maps
Flash Support	No	Yes	No
Office Mobile App	Yes	Yes	No
Dedicated Books Apps	No	No	Yes
Messaging	Yes	Yes	Yes
SDK	Yes	Yes	Yes
Firmware Updates	Yes	Yes	Yes
Advertising Platform	Yes	Yes	Yes
No. of Apps Available	N/A	70, 000+	250, 000+
Supported Platforms	XNA, Silverlight, ARM, x86	ARM, MIPS, x86	ARM
Java Support	No	Yes	No

Table 10 SDK Comparison Table

Website - Google App Engine is a platform for developing and hosting web applications in Google-managed data centers. It was first released as a beta version in April 2008. After an extensive research our team decided to use Google App Engine for the “Smidge” project since it is free up to a certain level of used resources. Fees are charged for additional storage, bandwidth, or CPU cycles required by the application. Google App Engine lets you run your web applications on Google's infrastructure. App Engine applications are easy to build, easy to maintain, and easy to scale as your traffic and data storage needs grow. With App Engine, there are no servers to maintain: You just upload your application, and it's ready to serve your users. You can serve your app from your own domain name using Google Apps. Google App Engine supports apps written in several programming languages. With App Engine, you only pay for what you use. There are no set-up costs and no recurring fees. App Engine allows you to control the maximum amounts of resources your app can consume, so it will stay within our budget. Google App Engine makes it easy to build an application that runs reliably, even under heavy load and with large amounts of data. App Engine includes dynamic web serving, with full support for common web technologies; persistent storage with queries, sorting and transactions; automatic scaling and load balancing; APIs for authenticating users and sending email using Google Accounts; a fully featured local development environment that simulates Google App Engine on your computer; task queues for performing work outside of the scope of a web request; scheduled tasks for triggering events at specified times and regular intervals.
Your application can run in one of two runtime environments: the Java environment, and the Python environment. Each environment provides standard protocols and common technologies for web application development.

3.10.2 Programming Languages

With App Engine's Java runtime environment, you can build your app using standard Java technologies, including the JVM, Java servlets, and the Java programming language, or any other language using a JVM-based interpreter or compiler, such as JavaScript or Ruby. App Engine also features a dedicated Python runtime environment, which includes a fast Python interpreter and the Python standard library. The Java and Python runtime environments are built to ensure that your application runs quickly, securely, and without interference from other apps on the system.

Phyton - Python is a general-purpose high-level programming language that emphasizes code readability. Python’s standard library is large and comprehensive. Its use of indentation for block delimiters is unusual among popular programming languages. Python supports multiple programming paradigms, primarily but not limited to object oriented, imperative and, to a lesser extent, functional programming styles. Python is often used as a scripting language.

The reference implementation of Python (CPython) is free and open source software and has a community-based development model, as do all or nearly all of its alternative implementations. CPython is managed by the non-profit Python Software Foundation. Python can interpret and process information from the barcode scanners and the user at the same time.

Java - Java is a programming language originally developed by James Gosling at Sun Microsystems (which is now a subsidiary of Oracle Corporation) and released in 1995 as a core component of Sun Microsystems' Java platform. The language derives much of its syntax from Cand C++ but has a simpler object model and fewer low-level facilities. Java applications are typically compiled to bytecode (class file) that can run on any Java Virtual Machine (JVM) regardless of computer architecture. Java is a general-purpose, concurrent, class-based, object-oriented language that is specifically designed to have as few implementation dependencies as possible. It is intended to let application developers "write once, run anywhere". Java is currently one of the most popular programming languages in use, and is widely used from application software to web applications.

C - C is a general-purpose computer programming language developed in 1972 by Dennis Ritchie at the Bell Telephone Laboratories for use with the UNIX operating system. C was designed for implementing system software, but it is also widely used for developing portable application software. C is one of the most popular programming languages. It is widely used on many different software platforms, and there are few computer architectures for which a C compiler does not exist which makes it very useful in a product like ours.

C has greatly influenced many other popular programming languages, most notably C++, which originally began as an extension to C.

C++ -The language was developed at Bell Labs as an enhancement to the C language. It is one of the most popular programming languages as it is extensively use in the software industry. C++ is a general purpose programming language with a bias towards systems programming that support data abstraction, support object-oriented programming and generic programming. C its regarded as a middle level language since its compose by both high level and low level language features. C++ expands the functionality of the C language to include classes, data encapsulation, stronger type checking, inheritance, templating, exception handling, namespaces, and many other features.

C# - C# is a simple, modern, object-oriented, and type-safe programming language. C# combines the high productivity of Rapid Application Development (RAD) languages and the power of C++. Visual C# .NET is Microsoft's C# development tool. It includes an interactive development environment, visual designers for building Windows and Web applications, a compiler, and a debugger. Visual C# .NET is part of a suite of products, called Visual Studio .NET, that also includes Visual Basic .NET, Visual C++ .NET, and the JScript scripting language. All of these languages provide access to the Microsoft .NET Framework, which includes a common execution engine and a rich class library. Even though C# is a new language, it has complete access to the same rich class libraries that are used by experienced tools such as Visual Basic .NET and Visual C++ .NET. (Using any of the previous mentioned languages would require extensive knowledge by any of the members of the group to be able to program our system to follow our preferences).

3.10.3 Web Development Languages and Platforms

A large portion of the project will involve developing code for the system in web development languages. There are numerous languages available that must be researched to be able to develop the project in the one that best fits the needs of the system. Furthermore, there are several platforms that also need to be taken into account as possible options of implementation. This section will discuss some options the team has investigated as possible web development languages of implementation. One of these languages will eventually be selected as the preferred choice and will be used during the build phase of the project.

ASP.NET - Asp.net is a software framework that is designed to support the development of dynamic websites and web applications. This framework was developed and released by Microsoft following its predecessor ASP. The purpose of this framework is to try to relieve the overhead that comes along with most of the common activities that are executed in web development. Particularly, and in relation to the Smidge, database access and data retrieval are performed in a simpler and more efficient way. This framework aids in such regards by providing libraries that are available to the developer. Furthermore, Asp.net allows programmers to write Asp.net code using any language in the .Net Framework. These include C# and VB.Net.

Pages in Asp.Net are called web forms. These forms are one of two main characteristics of this framework, and are the main building blocks for the application. Forms are placed in files with an .aspx extension. These forms basically lay out the page that it represents. It contains static components as well as dynamic components. Dynamic components run on the server and the code for these components can be placed in the form with what is called an in line technique. This can be thought of as mixing front-end website components with back-end programming. Such practice is usually not encouraged since most of the back-end code can and should be placed in a back-end file.

Another main characteristic of Asp.net is the code-behind model. This model places the code for the dynamic components of the web application in a separate file. This file is called the code-behind file and contains an additional extension in the file name. For example, if the code behind is being implemented in C#, a code-behind file might be "*Index.aspx.cs*". Consequently, if the code behind is being implemented in Vb.Net, the code behind for that file would instead be *"Index.aspx.vb"*. This file is linked to its fron-end .aspx page by specifying the CodeFile (code-behind file) in the form. If an asp item in a form requires dynamic programming, it can be specified to run at the server and then the code can be placed in the code behind file.

Overall this is a viable option as a web developing platform for the Smidge. It helps separate static and dynamic components while increasing performance. It is also widely used in industry for mid to large-scale projects.

PHP - PHP stands for PHP: Hypertext Preprocessor. It is a general-purpose scripting language that was designed for the development of dynamic web pages. An interpreter application is used to process PHP code. This application performs desired operating system operations and produces a program output through its standard output channel stream. Since its main purpose is to produce dynamic web pages, its code is embedded with the html content and then interpreted by the server. PHP is open source and can be deployed on most web servers with PHP installed in them.

PHP is a dynamically typed language. Dataflow variables are not assigned a type such as int, string, etc, but rather used as common variables that can be bound to any type of value. This makes the language less restrictive and allows the developer to produce solutions faster. The PHP manual is available to all and it is free. This contains tutorials on every different functionality and trait of the language.

PHP presents itself as a possible option when implementing the website for the Smidge. It is perfect for the scale of this project and allows the producers of the Smidge who may not have experience developing code in this language to become well acquainted with it in a short amount of time. Furthermore, with the increasing popularity of the LAMP and WAMP architecture, which use, Linux or Windows as an operating system, Apache, and MySQL, PHP can be used as the P with other options being Perl and Python. PHP, however is the most popular of the three.

TCL - TCL is commonly used for scripted applications, graphical user interfaces and testing. Language structures are written in prefix notation and all operations in the language are commands. Although the language was originally a functional programming language, it now supports object-oriented syntax provided by extension packages. In TCL, everything can be dynamically redefined and overridden. One of the main advantages of TCL is that it is independent of any platform and runs on any modern operating system such as Unix, MacOs, and Windows. A great advantage to the developer is its extensibility with other languages. It can be interfaced with C, C++, and Java to extend TCL with these languages or vice versa. Most of this functionality becomes useful during testing.

Ruby – Ruby on Rails - Ruby on Rails is an open source framework for web-based applications used to implement the programming language Ruby. Ruby is a dynamically typed, general purpose object oriented programming language. It was designed for increased programmer productivity while following the principles of good user interface design. Ruby on rails is widely used in the web development industry for rapid development. Like PHP, Ruby on Rails is commonly integrated with a database server such as MySQL and a web server such as Apache. It is also known for its extensive use of JavaScript libraries. While it stands as a possible language of implementation. The main goals described by the Smidge developers do not include a rapid development of a web-application but rather one that is well-structured and efficient. Ruby on Rails would be better suited for other occasions.

3.10.4 Communication Systems

Researching different types of communications is key in determining which technologies will be used in delivering information wirelessly to the user. The main purpose of conducting this portion of the research is to become more informed on several different types of communication systems that can aid the project in achieving what has been specified in the project definition. This section covers three different types of communications, one of which will be used in the implementation of the project during the build phase.

Bluetooth - Bluetooth technology was originally developed as a wireless alternative to data cables RS-232. It was created in 1994 as an open wireless technology and is the standard for exchanging data over short distances. It uses short wavelength radio transmissions from fixed and mobile devices with a high level of security. As the use of personal devices such as cell phones, cameras, laptops, etc, has increased over the last few years, so has the use of Bluetooth to enhance user experience. A Wireless user group created by a master Bluetooth device can communicate with up to seven clients. Data can be transferred seamlessly between the master and the other devices.

This technology is primarily designed for short range and low power consumption. Since the devices communicate with radio communication systems, they do not need to be in the line of sight of each other to communicate.

The power-class dependencies are classified in three main classes. The third class (referred to as Class 3) permits a maximum power of 1 milliwatts and has a range of about 1 meter. This class would probably not be useful should we need to implement Bluetooth in our project. The second class, Class 2, uses more power at about 2.5 milliwatts allowed, and has an approximate range of 10 meters. This class would be more fitting for our purposes but perhaps not a perfect match. The first class, class 1, has a maximum permitted power of 100 milliwatts and has a range of about 100 meters. Class 3 in this case would be the best option since it has a longer range with a reasonable amount of power.

SMS - In order to provide the user with alerts, SMS was researched as a possible option. Short Message Service uses a standard communications protocol that enables the exchange of short text messages. It is the most widely used data application in the world serving as the text communication component of phone, web or mobile communication systems. The Global Service for Mobile communications defines a series of standards with SMS to connect to several devices. For the scope of this project, messages would have to be delivered through the internet to a mobile phone. To do this, an SMS gateway provider would have to be used. The drawback however, is that due to the limited bandwidth capability, the brevity of the messages could be troublesome. Furthermore, should the networks experience congestion, the message would not be delivered in a timely manner. This is a cause for concern and alternate options should be considered.

Email - Another option for sending automated alerts to the user is email. This method would allow the system to provide all of the information needed without the limitations experienced by SMS. These messages can have a variety of text and visuals creating a superior look and feel for the user. Furthermore, the client will be based on a smart phone since the scope of this project should include a mobile application. This means that the phone should have no problem receiving these email alerts. Email alerts can be easily created using a PHP script through an Apache server.

3.11 Database

A database consists of a collection of data that has been organized for one or more uses. These are found usually in digital form and are managed by a database management system. Database Management Systems, sometimes referred to as DBMS, are computer programs that control the creation and maintenance of a database, as well as common use operations. In order to have data that can communicate with the system and enhance the functionality of the Smidge, a database system has to be in place. There are several database management systems available that should be researched.

SQLite - SQLite is a database management system contained in a relatively small programming library. This library is written in C and can be compatible with a system using this language. One advantage of SQLite is that it is in the public domain and its source code is available to anyone. It was developed in the summer of 2000 and was created to work with cross-platform operating systems.

Most database management systems use a client-server model. SQLite however, does not have standalone procedures that the application program communicates with. Rather, SQLite is embedded, and it works as an internal procedure within the application program. There are several aspects that make SQLite advantageous. It can be called dynamically through simple function calls reducing the time between data request and delivery when accessing the database. SQLite stores the entire database in a host machine as a single cross-platform. Furthermore, it has bindings for a large amount of programming languages which include PHP, C#, Java, and Python, all referred to in this document.

PostgreSQL - PostgreSQL is another database management system that uses cross-platform operating system. It is written in C as an object-relational system and it has open source software. It's latest version, 9.0, was released September 20, 2010, and included the additions of named parameters, password rules, and anonymous code blocks. One way to manage this systems in the front end is by using phpPgAdmin. This is a web-based administration tool based on phpMyAdmin interface that was built originally for MySQL administration which we'll discuss later. It was written in PHP specifically for PostgreSQL.

Besides the vast majority of SQL standards that are supported by PostgreSQL, many other features are included in this database management system. Some of them include foreign keys, triggers, complex queries, and transactional integrity. One advantage is the readability of the database by supporting user-defined data types, access methods, functions and operators. PostgreSQL also ensures that if the database crashes, a record is available with the transactions made, and it allows the user to revert to a previous point. Once the user reverts to this point, it can proceed with the operations without having lost any data. This can be extremely helpful especially during testing. If a faulty query is executed, without this feature some valuable data could be lost. This database management system could be a viable option.

SQL Server - SQL Server is a relational model database server whose primary query languages consist of T-SQL and ANSI SQL. It is used extensively in industry and some of the group members have used it at work and are familiar with it so it should be kept as an option. SQL Server is written in C, C++, and C# and operates in Microsoft Windows. SQL Server includes all of the primary types for data storage including Integer, float, decimal, char, varchar, binary among others. One of the advantages of Microsoft SQL Server is that it allows user-defined composite types. These can be defined and used just like primary data types. Most database management systems allow database to contain mostly just tables. SQL Server allows the database to contain constrains, transaction logs, indexes, stored procedures, views among other objects. ".mdf" is the extension used to store primary data files which are used to store data in the database.

There are several tools that come in handy when using SQL Server as the database management system. The first one is SQLCMD. This feature exposes the management features of SQL Server. It is a command line application included with Microsoft SQL Server. Its main functionality is that it can execute SQL queries from the command line in a quick and easy fashion. This is useful when trying to test table relations or data retrieval in an unstructured way. SQLCMD can also act as a scripting language used for management of databases or database schema creation during the deployment phase. Another widely used tool is Visual Studio. It includes extensive support for data programming allowing the developer to construct queries using front-end code. The third tool to keep in mind is the SQL Server Management Studio. This tool provides both graphical tools and scripting editors that work with features of the server. Server Management Studio is now the primary graphical user interface used in which you can create a new database, analyze performance or alter any existing database schema.

MySQL - MySQL is a relational database management system. It is written in C and C++ and it runs as a server providing multi-user-access to various databases. Most free-software projects which include a full-featured database management system use MySQL. Large-scale world wide web products such as Wikipedia and facebook also use MySQL. It is widely used and it is very reliable. It is a popular choice for web application developers. It is a main component in the LAMP architecture which contains a Linux operating system, Apache, MySQL, and PHP. Should we choose to implement our website using PHP, MySQL would be very easy to implement developing PHP code for the front end functionality. One of the main advantages of MySQL is that it works in many different platforms. These include, Linux, Mac OS X, Solaris, SunOS, and mostly any Microsoft Windows operating system. Most of its libraries and the server are implemented in ANSI C/ANSI C++. MySQL has some distinguishable features that other relational database management systems may not have such as multiple storage engines. This allows the user to choose that which is more effective according to each table being processed in the application. It also uses commit grouping which increases the number of commits per second by getting together multiple transactions in multiple connections.

3.12 Previous Works

3.12.1 Existing products

There are currently few promising concepts of smart fridge. Some of these concepts do not follow the main idea of Smidge, like the *Siemens CoolMedia fridge freezer*, which does not include any smart features other than a built in 15" LCD TV with integrate DVD, or cable input and a remote control. In 2007 Kim Otto of Denmark's Innovation Lab hacked one of Siemens's CoolMedia fridge into a futuristic smart fridge. He included a new touch screen interface, with an embedded processor, internet connection, and a modified RFID reader. The RFID tags, short for radio frequency identification tags, communicate via electromagnetic waves to exchange data between a terminal and an object. Now the fridge is not only able to tell what items have inside, but also communicate with the user and let him know what he/she needs to buy in order to make a recipe; the system is also able to sent alerts if it is out of stock in certain items.

Another type of early smart appliance will be the *LG TV refrigerator*. It has the same features as the *Siemens* CoolMedia fridge plus FM radio, a 4" Weather Plus LCD display, that keeps track of the weather base on the user's location, a calendar with alarm, a database to store pictures to create a digital photo album and eight categories recipes with one hundred preloaded recipes. This last feature it will be one of the main attributes of Smidge. The *LG TV refrigerator* also has a child lock function, room temperature display, digital user manual, and product control.

The *Electrolux screenfridge* is other system that has some functions in which Smidge is going to be based on, like its ability to connect to a network wireless. Same as *Electrolux*, Smidge is going to be able to print out an up-date inventory list and a shopping list. Similarly Smidge's users will be able to access to its data base remotely. The *Electrolux* allows users that have multimedia messaging service on their mobile phone remotely take a picture of their fridge's interior. The refrigerator has built in Web cameras to take images of all the items inside the fridge. The system also offers the option of swiping near empty products across the fridge, and orders the new items through the internet.

3.12.2 Existing Projects

The Kitchen Master System project incorporates a lot of ideas of existing products and also their own. The system has a database of all the products inside the fridge, it is also able to tell the user if there is need to buy an item, eliminates products that are out of stock, and does not allow to purchase a duplicate. The system is aware of expiration dates, and also knowing how many days a leftover food has been in the fridge. The system can alert the user if an ingredient is necessary for a particular recipe. It also alert if there is a left over ingredient from a previews recipe, in this case the Kitchen Master will recommend the use of this ingredient before it goes to waste.

Kitchen Master System uses custom Debian kernel mounted on an Xbox as the web server backend and as the database backend. The interaction with the system was through a custom website. The system also uses a barcode scanner to easily add, track usage, or remove items to the database. One of the new ideas incorporate by Kitchen Master was the use of a smart trashcan system. The trashcan system interacts wirelessly with the fridge. It also divides the waste items into different categories and opens the appropriate lid either for recycle or waste.

Smidge system will share some similarities with the Kitchen Master System, but one of the main differences it is the way users will interact with the system. This interaction will be through a 7 inch LCD touch screen display, a website, or a mobile application for Android system.

4. Design

4.1 Rationale for Hardware Component Selection

Refrigerator - The Sanyo SR-3770S Counter-High Refrigerator is a small fridge that stands out from its competitors due to its affordable price. After comparing prices of several fridges in the market our team decided that this small fridge shall be the best option for our project.

The Sanyo SR-3770S Counter-High Refrigerator is a 3-2/3-cubic-foot counter-high refrigerator with stainless-steel reversible door. With a great design this fridge is packed with top of the line features that made us choose the Sanyo SR-3770S. It is equipped with adjustable thermostat, manual defrost, full-width freezer with ice compartment, vertical can dispenser, clear spill-proof shelves, and door storage for beverages.

The fridge has stainless steel door with an acrylic coat that eliminates fingerprints and keeps the fridge looking clean and sparkling. It also has a durable countertop that shall hold a 12 ounce liquid spill without overflowing. The Sanyo SR-3770S Counter-High Refrigerator measures are 18-5/8 by 33-1/2 by 19-7/8 inches. This fridge is a perfect choice for small spaces as this compact refrigerator can be placed in any bar or kitchen countertop.

Board with ARM-based processor - For our project we have chosen to use the PandaBoard. With an OMAP4430 processor, PandaBoard is intended to use as a platform for mobile software development and OMAP 4 processors are intended for manufacturers of Smartphones and other mobile devices.

The table below resumes the PandaBoard Technical Specifications:

Core Logic	OMAP 4430 applications processor
Memory	-1 GB low power DDR2 RAM - Full size SD/MMC card cage with support for High-Speed and High-Capacity SD cards
Connectivity	Onboard 10/100 Ethernet
Expansion	-1x USB 2.0 High-Speed On-the-go port -2x USB 2.0 High-Speed host ports -General purpose expansion header(I2C, GPMC, USB, MMC, DSS, ETM) -Camera expansion header
Dimensions	Height: 4.5"(114.3 mm), Width: 4.0"(101.6 mm), Weight: 2.6 oz (74 grams)
Display	-HDMI v1.3 Connector (Type A) to drive HD displays -DVI-D Connector (can drive a second display, simultaneous display, requires HDMI to DVI-D adapter) -LCD expansion header
Wireless Connectivity	-802.11 b/g/n (based on WiLink 6.0) -Bluetooth v2.1 + EDR
Debug	-JTAG -UART/RS-232 -2 status LEDs (configurable) -1 GPIO Button

Table 11 PandaBoard Technical Specifications

Wifi module - We decided to use the TiWi-R1 Module which is a Multi-standard module with support for WLAN (802.11 b/g/n) and Bluetooth using TI's WiLink™6.0 solution. This Wifi module is low cost embedded 802.11 b/g/n and bluetooth compact module with U.FL connector with approved antennas. As of hardware support the TiWi-R1 Module supports interface board compatible with OMAP35xx dev kit.

Wifi module Technical Specifications

- Hardware-Based Encryption/Decryption Using 64-, 128-, and 256-Bit WEP, TKIP or AES Keys
- Operating Voltage: 3.0 V to 4.8 V
- FCC/IC, CE, ETSI Certified (pending)
- Integral TXCO, Fast Clock
- Power Consumption: 185 mA in Transmit, 100 mA in Receive, 802.11 g, 54 Mbps

Barcode Scanner - HONEYWELL IS4225 SCANGLOVE Wearable Scanner (RS232 and Light Pen Interface)

Honeywell's IS4225 automatic wearable single-line laser scanner increases productivity by providing a flexible solution to a variety of 1D bar-code scanning applications. Lightweight and durable, IS4225 can be used as a back-of-hand scanner for increased mobility or a stationary presentation scanner. It provides simple and easy data capture with automatic scanning.

The HONEYWELL Scanner features are: mountable on back of hand, frees operator's hands while scanning; Automatic Scanning which facilitates speedy operation by eliminating the need for repeated button presses; small footprint, fits comfortably and prevents operational fatigue;

Break-away cable that allows operators to quickly break away from tethered host system should a hazard occur when scanning; alternate fixed-mount, mounts to virtually any device, without taking up much space.

Touchscreen LCD - The iMo Pivot Touch is a touchscreen, USB powered, 7'' monitor. This LCD compatible with the PandaBoard and the one we choose to use in our project. It is a touchscreen version of the iMo Pivot. This LCD features a pivoting head and a removable screen. The iMo Pivot Touch offers full touchscreen capabilities with amazing functionality. Its accessible price makes it the best option in the market for our project. The monitor can be positioned vertically or horizontally depending on preferences.

The iMo Pivot Touch has a small size touchscreen that makes it perfect for the user interaction with our Smart Fridge project. With a resolution of 800x480 this 7" screen fits perfectly in our project. The screen shall display the necessary information and the touchscreen feature shall allow the user to choose the option desired just by pointing the items on the screen.

The monitor comes with a stand, a small kickstand for portable use, and USB cables for power. It has a lot of adjustable mounting options, from the pivoting stand for your desk, to the kickstand for travel.

4.2 Software Design

4.2.1 Software Structure

4.2.1.1 Fridge Display Design

The following is a description of the design that was created for the display to be developed and outputted through the LCD display. This will be the main interaction point between the user and the device. It is important to remember that this display must interface more functionalities than the other displays since this display will be used when the user is scanning the items. Some functionalities that will be discussed in other sections however, will not be implemented in this display. This display is comprised of four main components. These are Items, Recipes, Shopping List, and Settings. These four components can be accessed from the main page of this display, with each of them having their own access button as shown in Figure 13. They are described in the following paragraph.

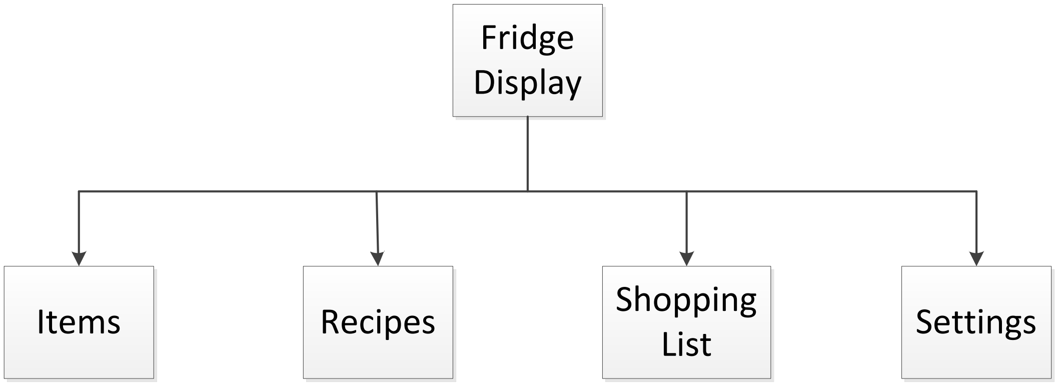


Figure 11: Fridge Display Breakdown

Items - The Items functionality is the main function in this display. It allows the system to receive information regarding items for the future providing the bulk of the data used in this device. After the user selects the Items button from the home screen, the user can either add one or more items, modify one or more items, or remove one or more items. Each of these functions will have their own button so that the user can access them. That is, the Items page will be comprised of three main buttons that will give the user access to these three functionalities. The workflow of this portion of the display is discussed in this section and is illustrated in Figure 14.

First, let's discuss one of the main functions 'add one or more items'. This function is used by the user when he or she has bought groceries and wishes to place them inside the fridge. By using this function, they will be providing the system with valuable information regarding the items that form the base of the overall functionality regarding the system. When the user selects this button it will take the user to a separate page. This page will instruct the user to start scanning the items. In the middle of the screen, there will be a list of items that have been scanned. At this point, the user can take the items, scan them one at a time, and place them inside the fridge. As the user scans each item, the list of items being scanned is updated. Depending on the information available and the speed at which this information can be gathered, we would like to include the name, weight, and a picture of the item being placed. When the user is finished scanning the items and placing them inside the fridge, the list will have all of the items that were scanned. There will be a button, whose location will be determined during the development of the prototype, which will give the user the option to stop scanning. This button will most likely read 'Done'. This button will redirect the user to a page with a list with the items that have just been scanned. Each item will have a button next to it to edit the item. This will allow the user to add the expiration date if he or she chooses to do so. The amount can also be modified here. On the other side of the item we will also include a button to allow the user to remove that item from the list. There will be a button on the list, at a place to also be determined during the development of the prototype. This button will read 'Store'. Once the user selects this option, all the information will be stored in the database. The expiration date will be defaulted to unknown since it probably won't be available by barcode scan. The quantity is defaulted to full since it is assumed the user is using this function to add new items. He or she will now be redirected to the home page where the original four functions are available.

The second function under the Items category is the 'modify one or more items' function. This function is used by the user when he or she needs to modify any of the information regarding an item. This information can be the expiration date or the amount remaining of the product being modified. Any other information is not being considered at the time but this might be subject to change. When the user selects this button, a separate page will come up. Since we wanted to give our users the option of modifying one quick item or a large number of items we decided to add two options in this page.

The first one will be a scan option which will have its own button in this page. The second is a list option and will also have its own button for the user to access this page. When the user selects the scan button it will take them to a separate page. This page will prompt the user to scan one item to be modified. After the user scans the item, it will be displayed on the screen as well as its information. Here the user will be able to change the expiration date or the amount left. The precise implementation is subject to change. Currently, the page will contain two buttons, one for each data field that can be modified. When the information is modified, the user can click on a button that will read 'Done', which will update the information in the database and redirect the user back to the main page.

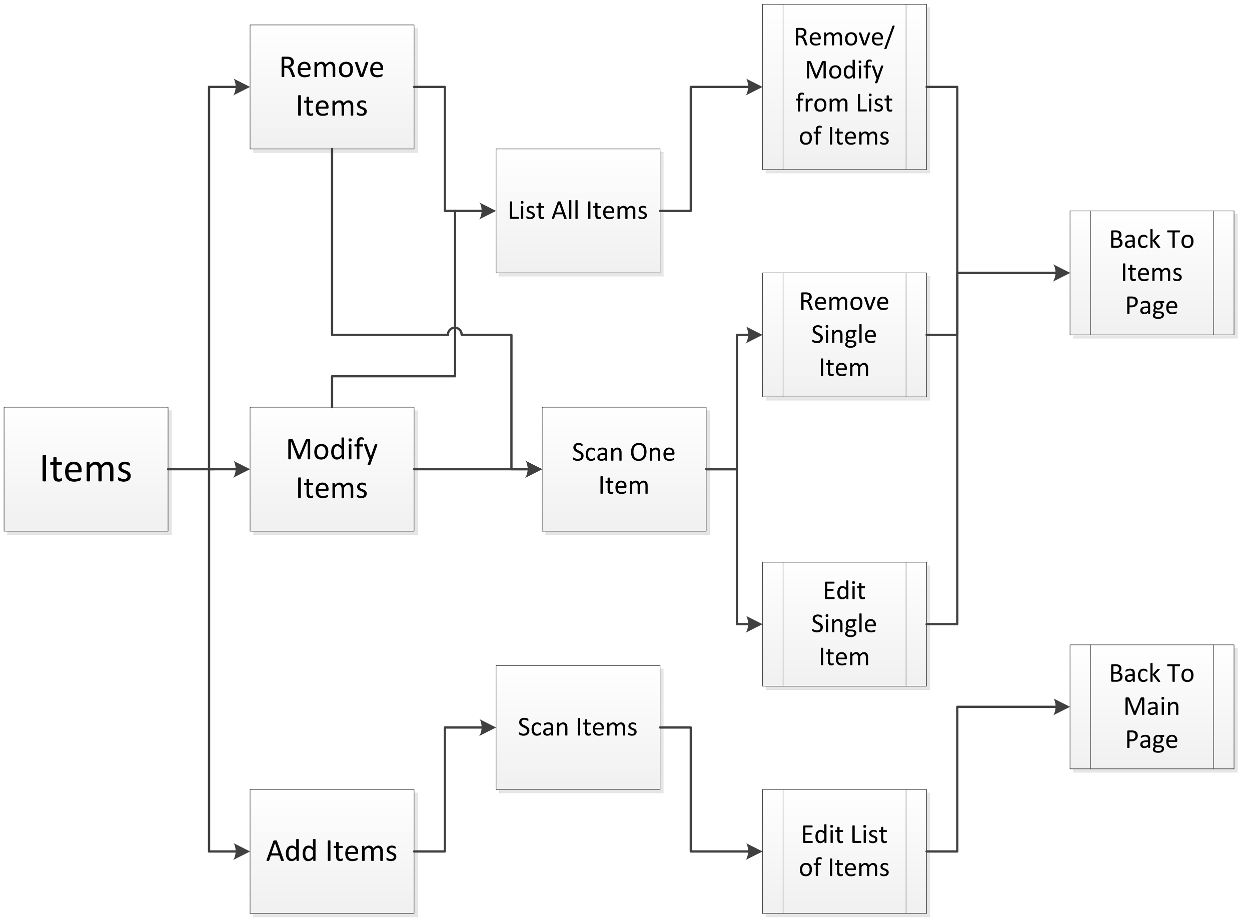


Figure 12 Items Menu Breakdown

The second option for modifying an item is to list all of the items. This option too will be accessed with a button that will be placed next to the scan button on the modify items page. When the user selects the list option, he or she is redirected to a separate page. This page will load all of the items that are currently stored in the fridge and display them. This page will have the same functionality as the list that is displayed when the user adds new items to the fridge. The difference is that in that list the items being displayed are the new items that have just been scanned. Here, the items being displayed are all the items stored. As with the other list, the list will have all the items with an edit button next to it. When the user hits the edit button for an item, it will take them to the same page discussed for modifying one item with a scan. The difference however, is that when the user accesses this page through the list, when the user is done editing the information and clicks on ‘Done’, he or she will be redirected back to the list in case there are other items to be modified. There will be a button on this list that allows the user to tell the system that he or she is done editing. This button will most likely read ‘Done’. When the user selects this button he or she will be redirected to the main page.

The third option under the Items category is the ‘remove one or more items’ category. Like the previous function, this will give the user the option to scan an item or list all the items. If the user selects list all the items, he or she will be redirected to a different page. In this page, all of the items inside the fridge will be displayed. This list however, instead of having edit buttons, will contain remove buttons that allows the user to remove the items they see fit. There will also be a button that allows the user to delete all of the items in the fridge. This will be beneficial in the case that the user decides to empty out the fridge. The other option from the remove page for the user is the scan option. Once the user selects this option, he or she is redirected to another page. This page, just like in the modify function, will ask the user to scan the item it wishes to remove. After the user has scanned the item, it will be displayed on the screen. There will be a button that will allow the user to remove this item. Once the user removes the item the page will redirect to the main menu.

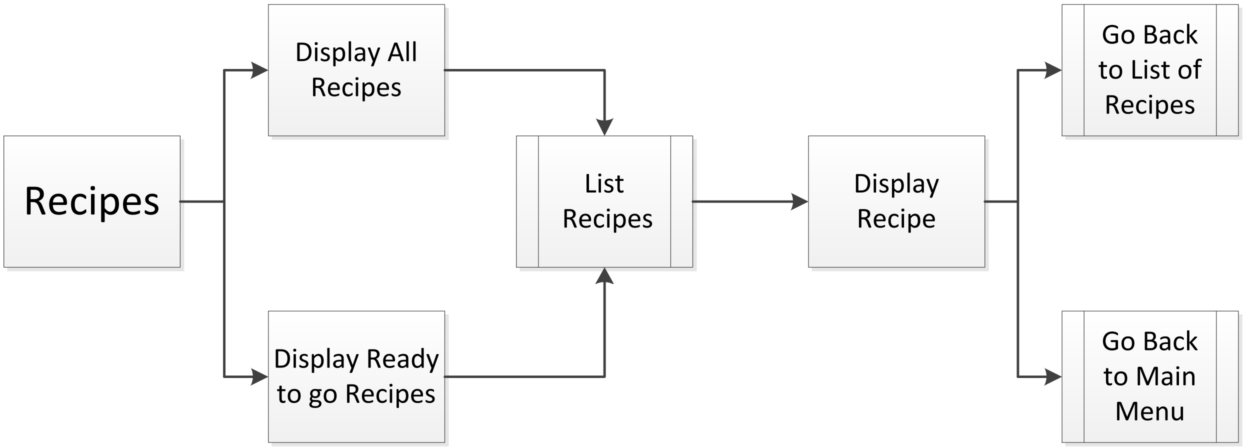


Figure 13: Recipes Menu Breakdown

Recipes - The second Item on the main menu is Recipes. This allows the user to access any of the recipes stored in the database. It does not however, allow the user to create recipes from this menu. We decided against giving the user this option for two reasons. The first one is that this information is probably not easy to enter through a seven inch touch screen monitor. If the user wants to type a lot in the description then this would take a long time with this interface. Here, the alternative is to create the recipe in the website, which is discussed in a later section. Another reason is that we wanted to allow each interface (fridge display, website, and mobile app) to have something unique about them. The fridge display already has something unique about it in that it is the only interface that controls the scanning of items and up keeping its information. The Recipe portion of the display is discussed in this section and is illustrated in Figure 15.

When the user selects the Recipe button in the main menu, he or she will be redirected to the Recipes. The Recipes page will give the user the option to either go to all of the recipes or go to the recipes that are ready to be made with the items currently on the fridge. When the user selects to display all recipes it is redirected to a display all page. The Display all page will display all of the recipes it finds stored in the database. These recipes will likely have a name or title given by the author at the time of recipe creation. The user can scroll up and down the list and then select one of the recipes he or she wishes to view. The recipe will then be loaded. The first thing the recipe displays is the items required (ingredients). These items will be separated between the items that are already on the fridge with the ones that are missing. If the user has selected view all recipes he or she wants to pick a recipe regardless of what is inside the fridge. By letting the user know what ingredients are missing, he or she can add them to the shopping list. If the user selects the option of recipes that are ready to be prepared then the recipes will be listed in the same manner. By having the ingredients displayed at the top of the recipe, the user can easily see what ingredients he or she needs to get out of the fridge. From the recipe, the user can go back to the recipes or back to the main menu.

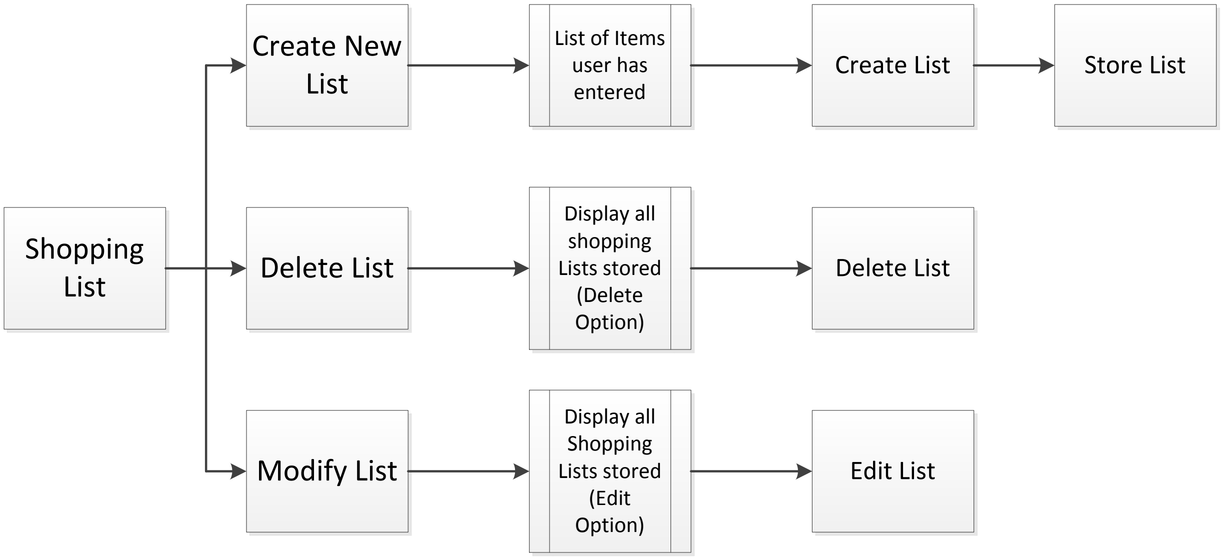

Shopping List
Create New List
List of Items user has entered
Create List
Store List
Delete List
Display all shopping Lists stored (Delete Option)
Delete List
Modify List
Display all Shopping Lists stored (Edit Option)
Edit List

Figure 14: Shopping List Menu Breakdown

Shopping List - The third option on the main menu is the Shopping List function. When the user selects this button the user is redirected to a different page. This new page will give the user several options regarding shopping lists. This portion of the display is described in this section and is illustrated in Figure 16.

The first option will be to create a new shopping list. If the user selects this button he or she will be redirected to another page. This page will list all the items that the user has ever purchased. Here the user can select to add items from this list as they see fit. Once the user has selected all of the items he or she desires, there will be a button called ‘Create List’. Once the user selects this button the user will see a summary of the list and the page will prompt the user to provide the list with a unique name or title (since there may be other shopping lists). If the user decides that it needs to add or remove more items it can also do so by going back to the items list or by removing the item in the current page.

A second option within the shopping list is the Delete function. If the user selects this option, he or she will be redirected to another page. This page will display all of the shopping lists that have been created. The user can then select a list to be removed. The user can choose to delete one or more lists before going back to the main menu. The third option is to modify a shopping list. This option also redirects the user to a page that displays all of the lists that are currently stored in the database. Here however, when the user selects a shopping list, the system will pull out the shopping list so that the user can edit it. Here the user will be able to remove any items from the list or go to the list of items so that he or she can add items to this list.

Settings - The settings option in the main menu is for up keeping the password used in the website. From here, the user can create or change the password to access the system remotely. The interface will consist of the password display as well as an option to change it.

4.2.1.2 Mobile App

Smidge shall have the ability to share information with a mobile device, more specific a cell phone with Android OS. This section describes the design that shall be implemented for the mobile app. As a reminder the phone app implements some of the functionalities that shall appear in the LCD display mounted on the fridge, but not all of them, since the option for scanning shall not be needed here; the user is not expected to scan items from the mobile device.

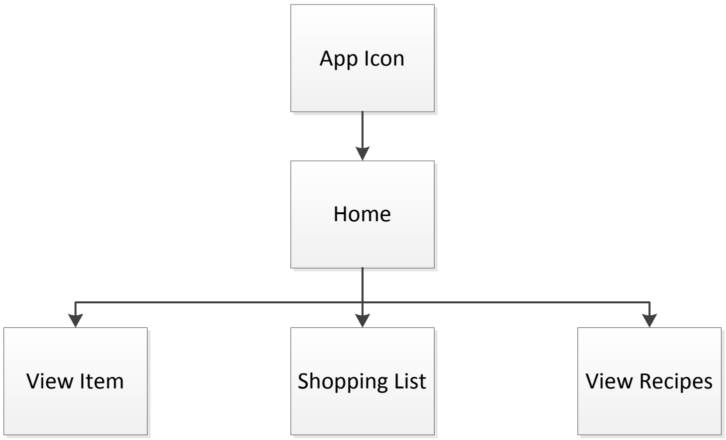


Figure 15 Mobile App Breakdown

First thing the user shall do is hit the application icon on their phone, right after doing this it shall show three main sections or buttons reading the following: View Item, Shopping List, and Recipe. Following is a more detailed explanation of what each of this button does.

View Item - The screen is almost identical to the one in the web page with some minor differences in the way formatted and the way information is presented. This screen allows the user to view a list of the different items that currently are saved in the inventory. It shall also allow the user to select an item and see information about it, such as name, and quantity. On this screen the user should not be able to make any change to the database. To make any changes to the database it would have to go to the refrigerator unit and make the changes through the LCD display on the Modify Items screen.

The functionality of this screen it is so that in the case the user wants to check how much is left of certain item in order to make a recipe.

Shopping List - This shall be the key feature in the mobile app. As mentioned before each interface is going to have a key feature, LCD display have the adding items to the system through the scanner, website has the recipe section where new recipes can be added to the database, and the phone shall have a more interactive shopping list.

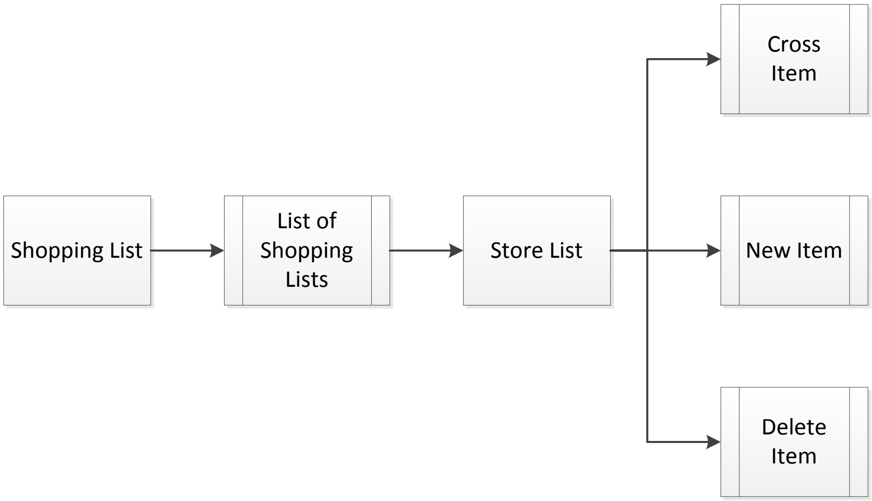


Figure 16 Shopping List Menu Breakdown

The idea of having a more interactive shopping list on the phone contrary to the other user interfaces is because the user always carries its phone everywhere. Once they are in the grocery store it shall be convenient to have a shopping list with all the items needed, the user shall then be able to add new items to the list, once the user got all the items from the list it can proceed to delete them.

When the user hits the shopping list button, a list of the different shopping list created so far shall show up. The user shall then pick one of the shopping lists and then another one shall come up showing the items names. After picking up an item and setting it in the shopping cart the user has to select the item name from the list and it shall get cross out of the list, meaning that is already in the cart. The user shall now be able to add new items to the list.

Recipes - The last item in the menu is Recipes. Similar as in the LCD this allow users to access recipes store in the system; however the user can not enter new recipes in the systems, since this is an exclusive feature of the Website interface.

If the user picks the Recipes button it shall give the option to either go to Display All Recipes or go to Display Ready to Go Recipes, this last group consists of the recipes ready to be made with the items currently on the fridge. The Display All page shall display all the recipes that it finds stored in the database. These recipes shall be order by name or title given by the author. The user can scroll up and down the list and then select one of the recipes he or she wishes to view. The recipe shall then be loaded. The first thing the recipe displays is the ingredients. These items shall be separated between the items that are already on the fridge with the ones that are missing. Once the user selects the option "View all recipes", if it is the case that the desire recipe includes ingredients that are not currently in the fridge, then the user can quickly add the items to the shopping list and get them right away. If the user selects the option of recipes that are ready to be prepared then the recipes shall be listed in the same manner. From the recipe, the user can go back to the recipes or back to the main menu.

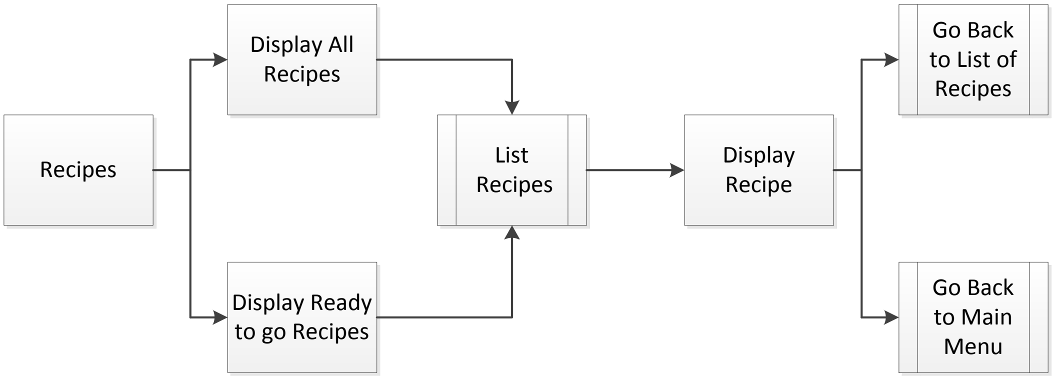


Figure 17 Recipe Menu breakdown

4.2.1.3 Web Page Design

This section describes the design and visual interface of the smart fridge website. This and the phone app are secondary interaction between the user and the system. The web app implements some of the functionalities that will appear in the LCD display mounted on the fridge, but not all of them, since the option for scanning shall not be needed here; the user is not expected to scan items from the computer.

The first thing the user shall see when entering the website is a login screen. Here the user will use the user name and password used at the LCD display. This is a very crucial part because if the wrong password or username is entered then website will show an error message saying that the password or username is incorrect. Once the user login he will see the Home screen that it will be mainly comprised of three main components. The components are: View Items, View Shopping List, and Recipes.

View Items: This screen allows the user to view a list of the different items that currently are saved in the inventory. It will also allow the user to click in an item and see information about the item, like name, expiration date, quantity, and date that it was bought. On this screen the user should not be able to make any change to the database, in order to make a change he would have to go to the refrigerator unit and make the changes through the LCD display.

The functionality of this screen is so that in the case the user wants to check how much is left of certain item in order to make a recipe.

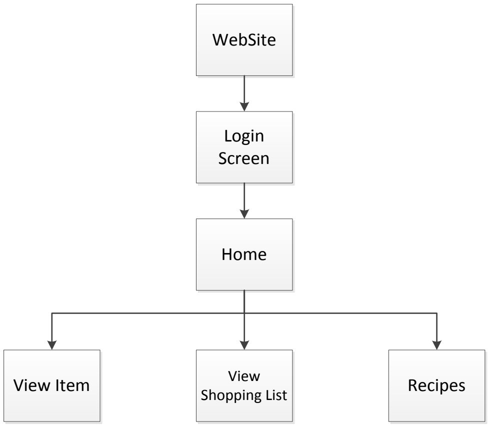


Figure 18 Website breakdown

View Shopping List: Another thing that the user should be able to do from the website is to view the current shopping list. When the user selects this option is redirected to a different page. This page contains a list of the different shopping lists that are in the system at the moment. From here the user will pick the list that he wants to view, and a list of items will popup. In this page the user can review all the items in the shopping list. This shopping list page will look almost identical to the Store List screen in the LCD display, the only difference will be that instead of having a button to go back and modified the list like in the LCD display; the web page will have a Print List button. The print out option will have the name of the item, brand, and quantity to buy. The information will be presented in a tabular way, easy for any user to understand.

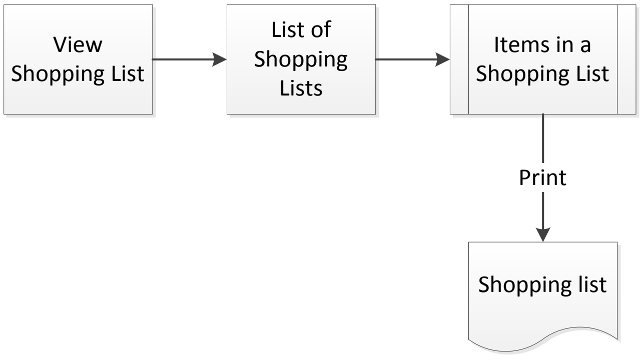


Figure 19 Website Shopping List breakdown

Recipes – It will be the last item shown by the web site and probably one of the most useful for this interface. The recipe screen will have two options, first to View Recipes and second to Create Recipes. This last one is not going to be implemented in the LCD or the mobile app because is probably not easy to enter information through a seven inch touch screen monitor, especially if the user want to enter a long description of how to make the recipe. Another reason is that this will be the unique characteristic of the web site, entering new recipes to the system.

The View Recipes will show, just like on the LCD, Display All Recipes and Display Ready to Go Recipes options. When the user clicks on the Display All Recipes a list of all available recipes found in the database shall appear. The list shall have the name of the recipe or the title given at the time of creation. The user shall be able to scroll up and down the page and select any of the recipes to view. The recipe page will show a column with the ingredients needed to complete the meal. Some of the ingredients will have a check mark next to them, meaning that the item is in the inventory and the ones that do not have the check mark are out of stock. Next to the list of ingredients there shall be a picture of the final product (if available) and under the picture there shall be instructions on how to prepare the meal. Back to the View Recipe screen the user can pick from the second option Display Ready to Go Recipes. By selecting this option the user is going to see the same list as in the Display All Recipes menu, but with the difference that these recipes only have items that are available and ready to make. By clicking on the desire recipe the website will show a list of ingredients, all having a check mark next to them, a picture of the final product (if available) and below it shall show instructions on how to prepare the meal.

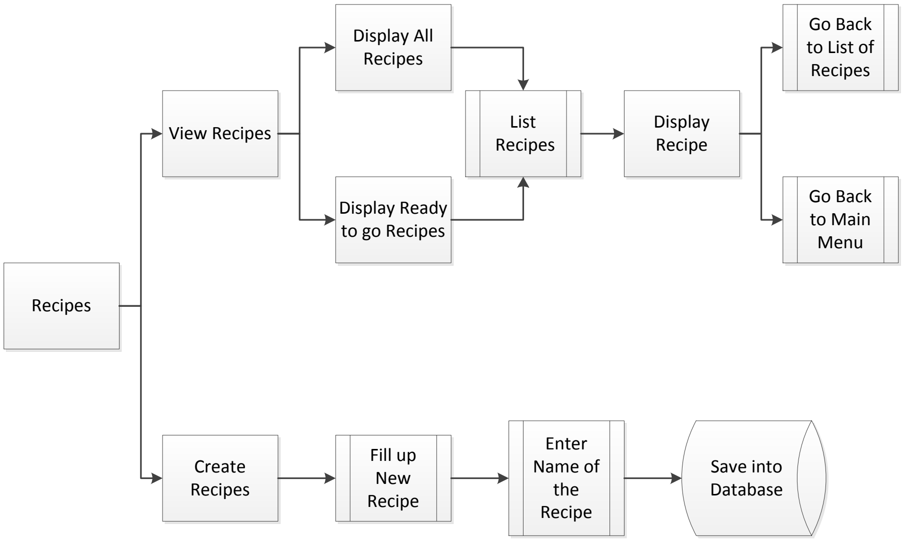


Figure 20 Website Recipe's Menu Breakdown

The Create Recipes button, like we said before, is unique for the website since neither the mobile app nor the LCD display has this capability. The fact of having a key board and be sitting in a comfortable chair to type ingredients, quantities, and instructions make this the perfect set up. In this screen the user is going to enter the ingredients, amount needed, and step by step instruction on how to mix these ingredients. It is also going to give him the option of uploading a picture that is related to the recipe. After entering all the info and before saving it, the system asks for the name or title of the recipe. Once the user enters the name the recipe gets saved into the database for future use.

4.1.2 Use Case Diagram

To start with the software design phase of the project, Fig 23 shows a general idea of the functionality provided by this system in terms of actors, their goals, and dependencies between those use cases. This diagram has 4 actors User, Fridge Interface, Web Interface, and Phone Interface. The actors are shown to be interacting with actions implemented on the system.

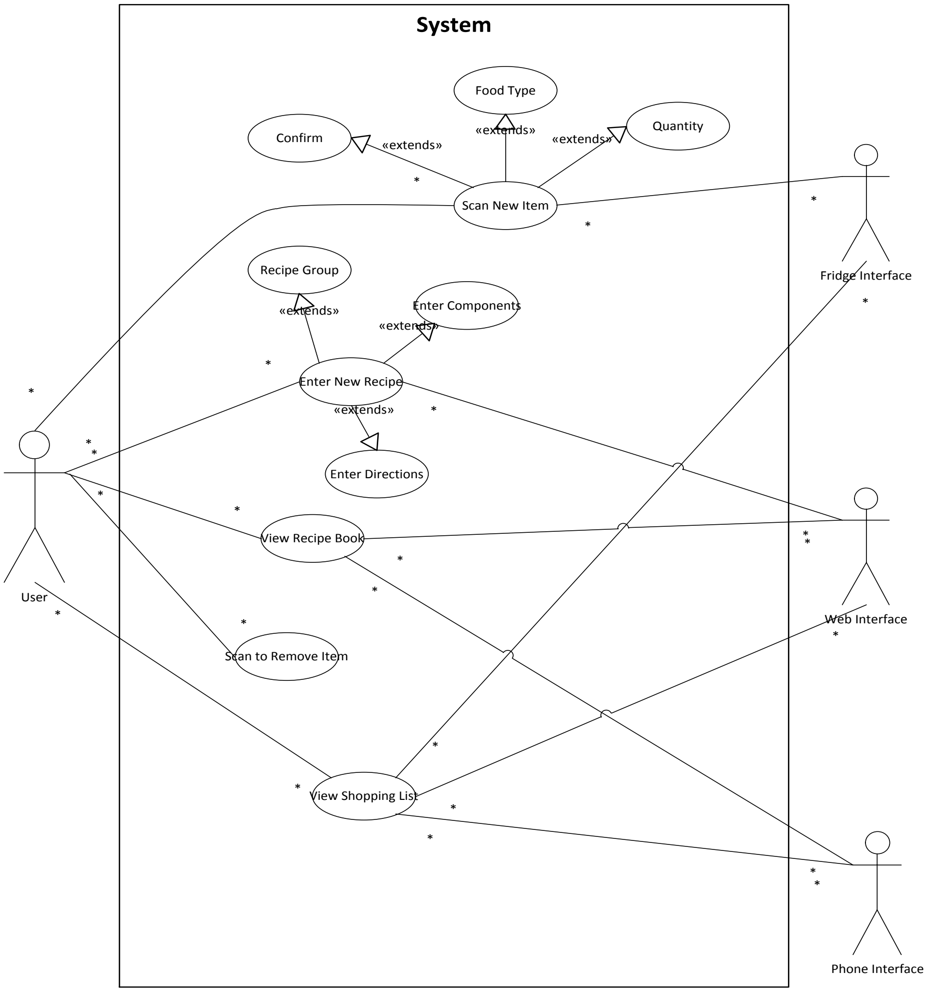


Figure 21 UML Use-case diagram

Note: this is a general view of how the system is intended to work

Action	Description
Scan New Item	This option is only available to the LCD display since is where the scanner is going to be connected. It allows the user to enter new items to the system.
Confirm	Confirmation screen, once the item is found the system is going to show a message with the name of the items and user have to confirm if this is right or not
Food Type	The items are going to be divided into categories by the user
Quantity	The user enters the quantity for specific item. This is going to be used every time the user makes change on any of the items.
Enter New Recipe	This option is only available to the Web app. It allows the user to create a new recipe and save it into the database.

Enter Components	Here the user can enter the components or ingredients necessaries to make a recipe.
Enter Directions	This is where the user enters the directions or instructions of how to make a recipe.
Recipe Group	This will be the name of the list in which this recipe is going to be saved
View Recipe Group	This option is available the three interfaces. It is going to allow access to the different recipes store in the database.
Scan To Remove Item	This option is only available to the LCD display since is where the scanner is going to be connected. It allows the user to remove an item by scanning the UPC code
View Shopping List	This option is available the three interfaces. It is going to allow access to the different shopping lists store in the database.

Table 12 Use Case Diagram contents

4.2.3 Flow of operations

4.2.3.1 LCD Flow Diagram

From all the different operation that the user can choose from, the flow of the operations is going to vary. Figure 24 shows when an item is scanned and added to the database. Every time the user performs this operation the following steps are going to be taken by the system. First click "Scan New Item", the next screen will prompt the user to scan the item. Next the LCD will connect to the server and this one will sent a query to the UPCOnline database with the UPC code. The UPCOnline database is going to return the information related to that code and the server is going to store that information into the Item's database. The server then returns a confirmation i.e. adds the items to a textbox on the LCD display. After that the user can scan a new item or return to Main Menu.

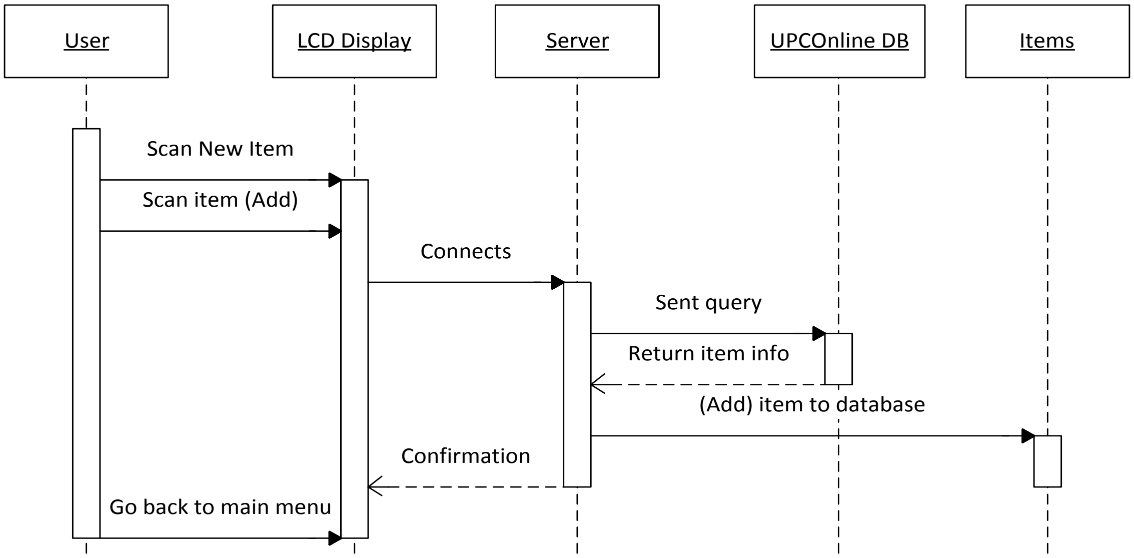


Figure 22 Sequence Diagram for the LCD Adding New Item

The second function that can be performed on the LCD display is to View a Recipe. Figure 25 shows the flow of operations that are taken by the system. First click the “View Recipe” button on the LCD, this one connects to the server and the server sends a query requesting the list of recipes store in the Recipe database. The Recipe database returns a list of all the recipes in the system and the server shows that list on the display. Next the user picks one on the recipes from the list. The LCD connects to the server and the server sends another query to the Recipes database. The Recipes database then search for all the items needed to complete the recipe in the Items database. The Items database returns the result of the search to the server and the server shows the complete recipe to the screen. Finally the user can go back and pick another recipe or go back to Main Menu.

The last function the can be performed on the LCD display is to modify a shopping list. Figure 26 shows the flow of operation that are taken by the system. Start by clicking the Shopping List button on the LCD, then a connection to the server is establish this request a list of the different Shopping List store in the Items database. The Items database returns the information and the server displays it in the screen. The user picks one from list and scans the empty item to be added to the database.

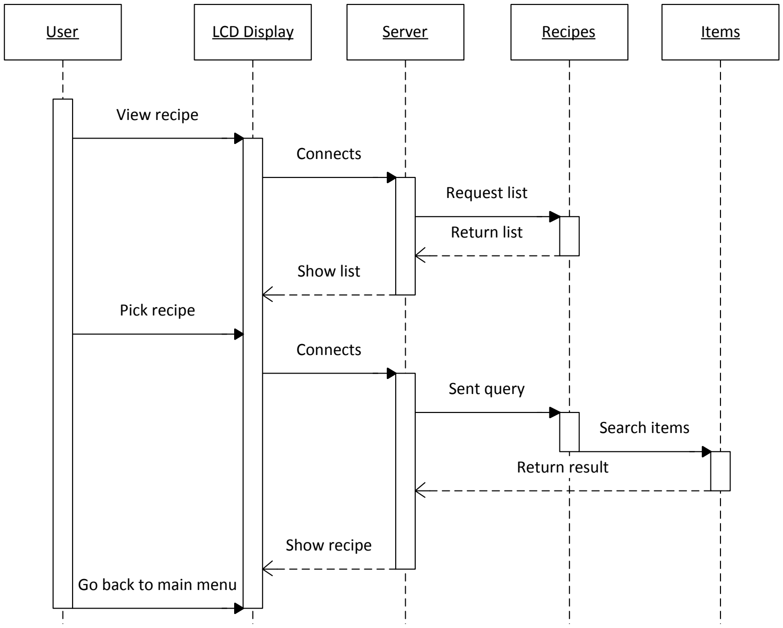


Figure 23 Sequence Diagram for the LCD View Recipe

The LCD connects to the server and the server sends an update query to the items database, adding the item to the shopping list. The server then sends a confirmation to the LCD i.e. adds the item to the textbox shopping list. Finally the user can go back to Main Menu or add another item.

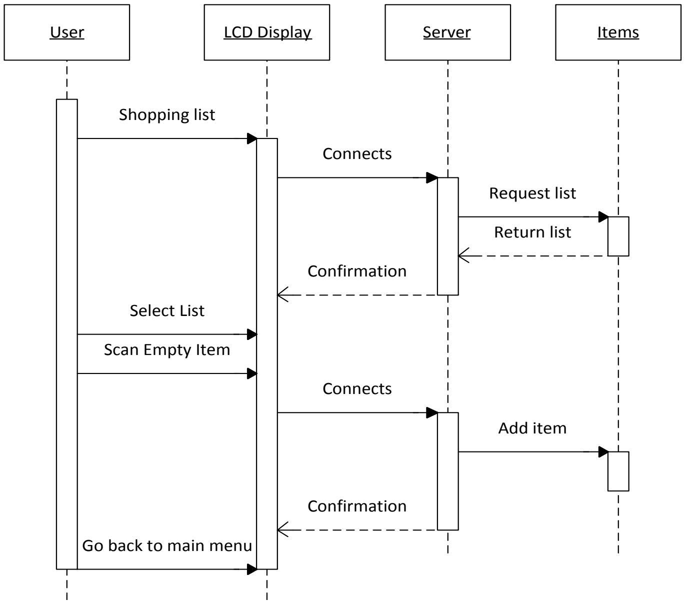


Figure 24 Sequence Diagram for the LCD Shopping List

4.2.3.2 Web Application Flow Diagram

The first thing that the user has to do is log in to the web application. This operation must be done every time the user wants to enter the website for fridge. The user enters the login information and the website connects to the server if the information is correct the server returns the user web section. To view the items in stock the user can click on the View Item button or the tab on top of the page. The website connects to the server and the server sends a query requesting the information for every item in stock. The Item database return a list with of items and the server displays it on the website. After that the user can pick any other option or can go back to main menu. Figure 27 shows the flow of operation taken to login to the website and to view the items in the inventory.

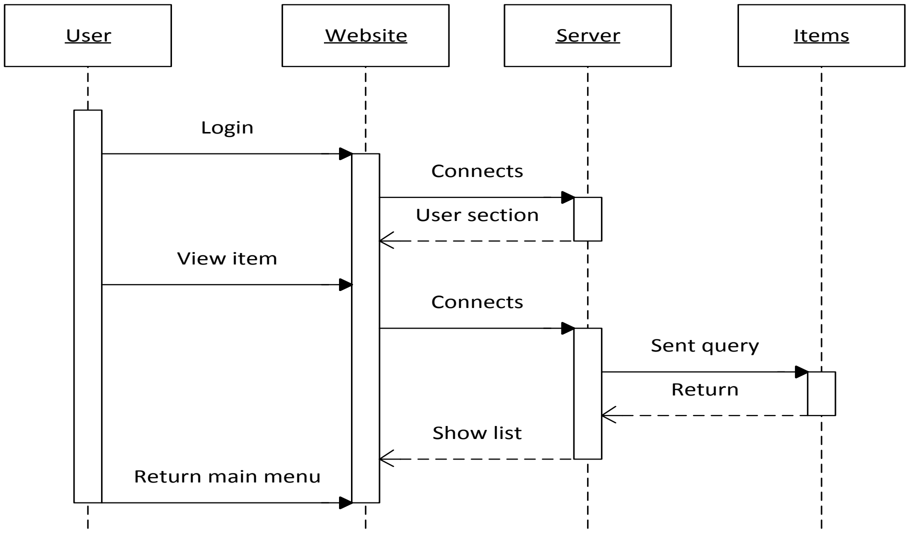


Figure 25 Sequence Diagram for the Web Application Login and View Items

The user is able to view a shopping list through the website. Fig 28 shows a sequence diagram of the View Shopping List. To view the shopping list the user has to click in the View Shopping List button or tab on the top of the website. Next the website connects to the server and it sends a query to the items database requesting the list of shopping list. The Items database sends back the results and the server displays the list on the website. After this the user can choose to print one of the lists and then pick any other option or can go back to main menu.

The last section covered by the website is Recipes. Figure 29 shows a sequence diagram of how the user can create a new recipe from the website. On the webpage the user can click on the Recipe button or on the tab located on top of the website. After doing so he can click on the Create New Recipe button.

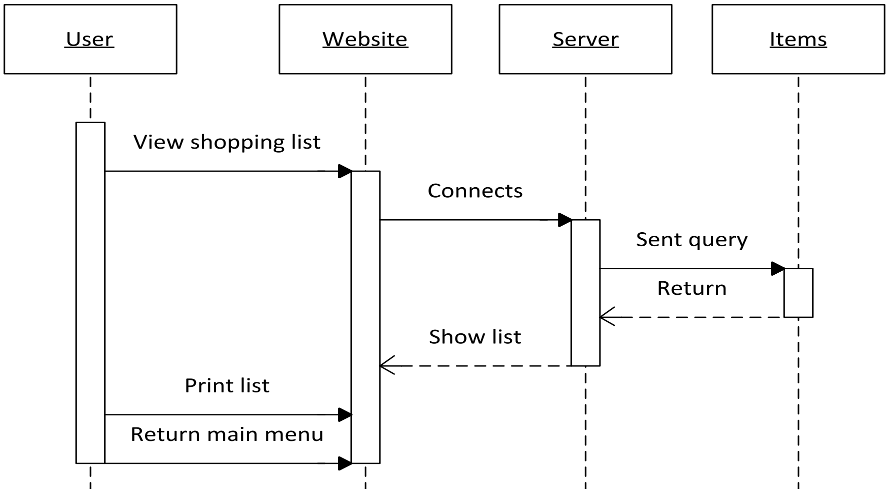


Figure 26 Sequence Diagram for the Web Application View Shopping List

On this last section, the user adds the ingredients needed for the recipe and the instructions on how to make it and when finish hits submit. The website then connects to the server and the server sends the data of the new recipe to the Recipe database. The server then returns a confirmation to the screen. After this the user can pick any other option or can go back to main menu.

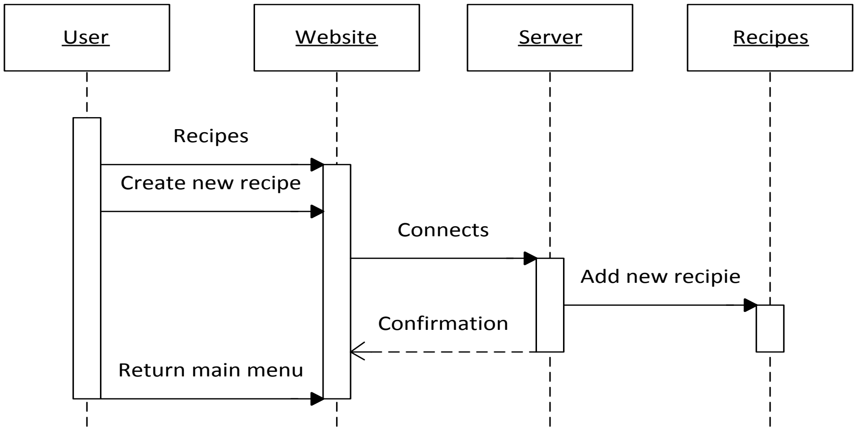


Figure 27 Sequence Diagram for the Web Application Recipes

4.2.3.3 Mobile Application Flow Diagram

The user is going to have more than one operation to choose from on the phone application, and the flow of these operations is going to vary depending on the type. Figure 30 shows when the user wants to view specific recipe. Every time the user performs this operation the following steps are going to be taken by the system. The user is going to click on the View Recipe button on the screen, then the phone is going to connect to the server and the server is going to send a query to the Recipe database requesting a list of the different recipes that are in the system. The Recipe database return the list to the server and the server shows the items to the screen. Now the user picks one of the recipes from the list and the phone connects one more time to the server and the server sends a query to the Recipe database. Next the Recipe database is going to search in the Items database to look for the items available to make the requested recipe and returns the results to the Recipe database. The Recipe database gets all the information and sends the ingredients available, the ones that are out of stock and the instructions of how to mix them to the server. Finally the server displays the information to the screen. After this the user can pick any other option or can go back to main menu.

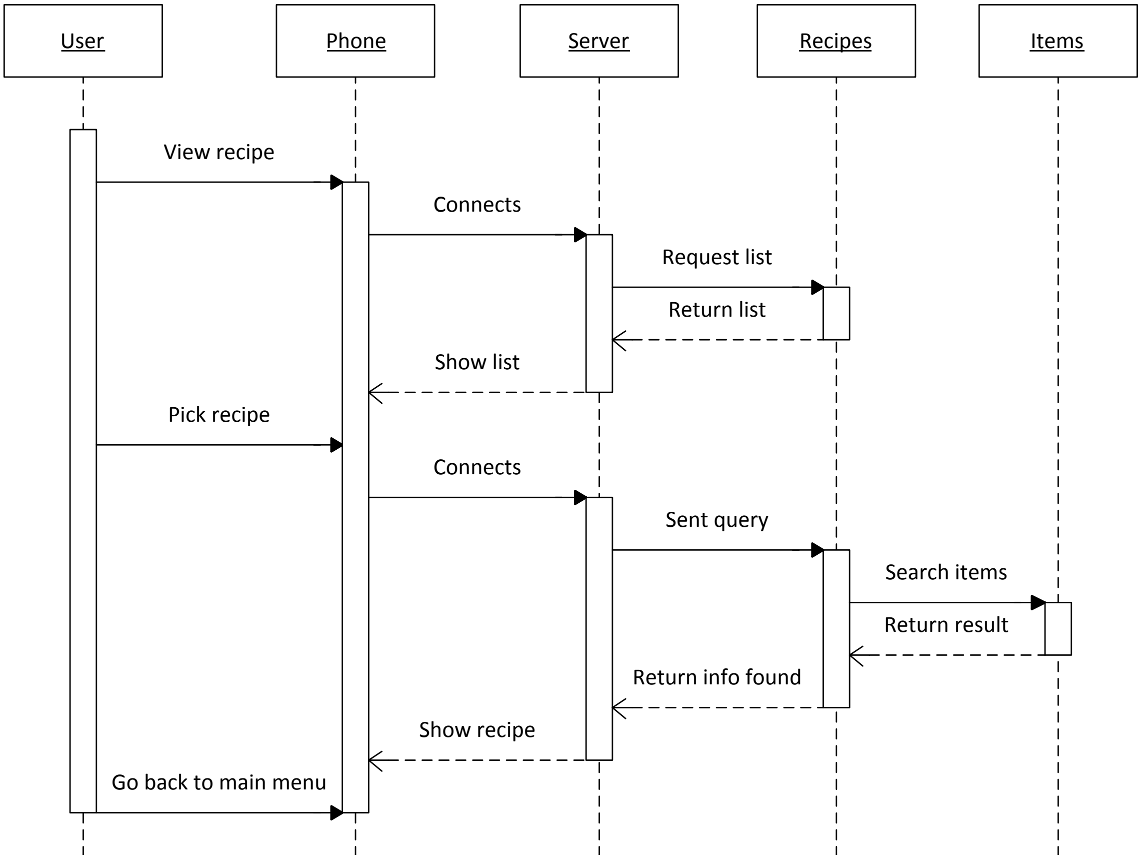


Figure 28 Sequence Diagram for the Phone Application Recipes

Figure 31 represents the flow of operations for the shopping list. When user click the shopping list button the phone connects to the server and the server sends a query to the Items database requesting to see the list of shopping list. The Items database returns the data and the server then shows the information on the phone screen. Next the user picks a list and wants to enter a new item to the selected shopping list. The phone is going to connect to the server and the server is going to send the information of the new item to the UPC Online database, then the UPC Online database is going to return the corresponding information to that item and the server is going to display it on the phone screen. The user now has to confirm that it is the right item and one more time the phone connects to the server and the server adds the information to the Items database. No confirmation is show since the user already confirmed that that was the right items. If at any point the user wants to make sure that the item was added then he has to go to the specific list and search for the item. Last the user can pick any other option or can go back to main menu.

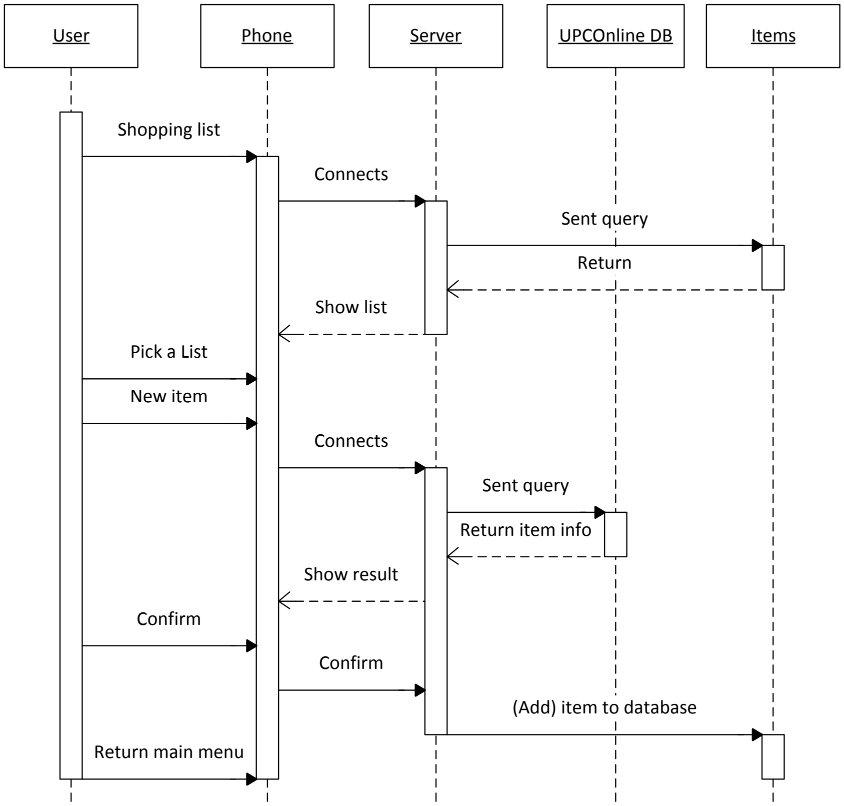


Figure 29 Sequence Diagram for the Phone Application Shopping List

To user is also able to search for item in stock through the phone. Figure 32 shows a sequence diagram of the View Item. When clicking on the View Item button on the phone, a connection with the server is establish. The server then sends a query to the Items database, requesting a list of all the items that the user has in stock. The Items database then return the result to the server and the server displays a list with all the items on the phone screen.

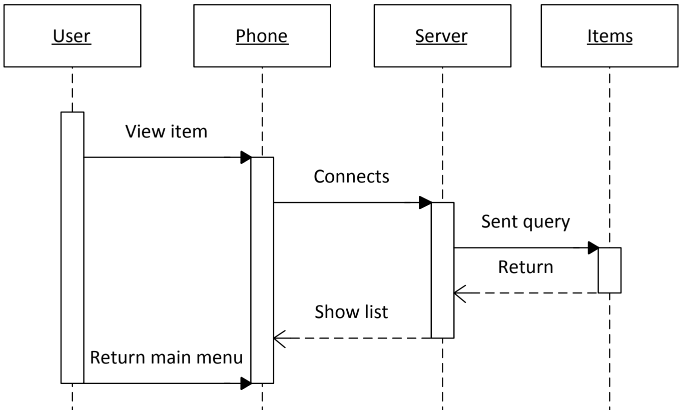


Figure 30 Sequence Diagram for the Phone Application View Item

4.2.3 Class Diagrams

LCD Display Class diagram – Figure 33, displays the class diagram for the LCD display that was developed during the software design phase of the project. There are five tables that encompass this portion of the design and are described in this section. Each method describes its parameters as well as what type they return. The circles signify public methods while the squares signify private.

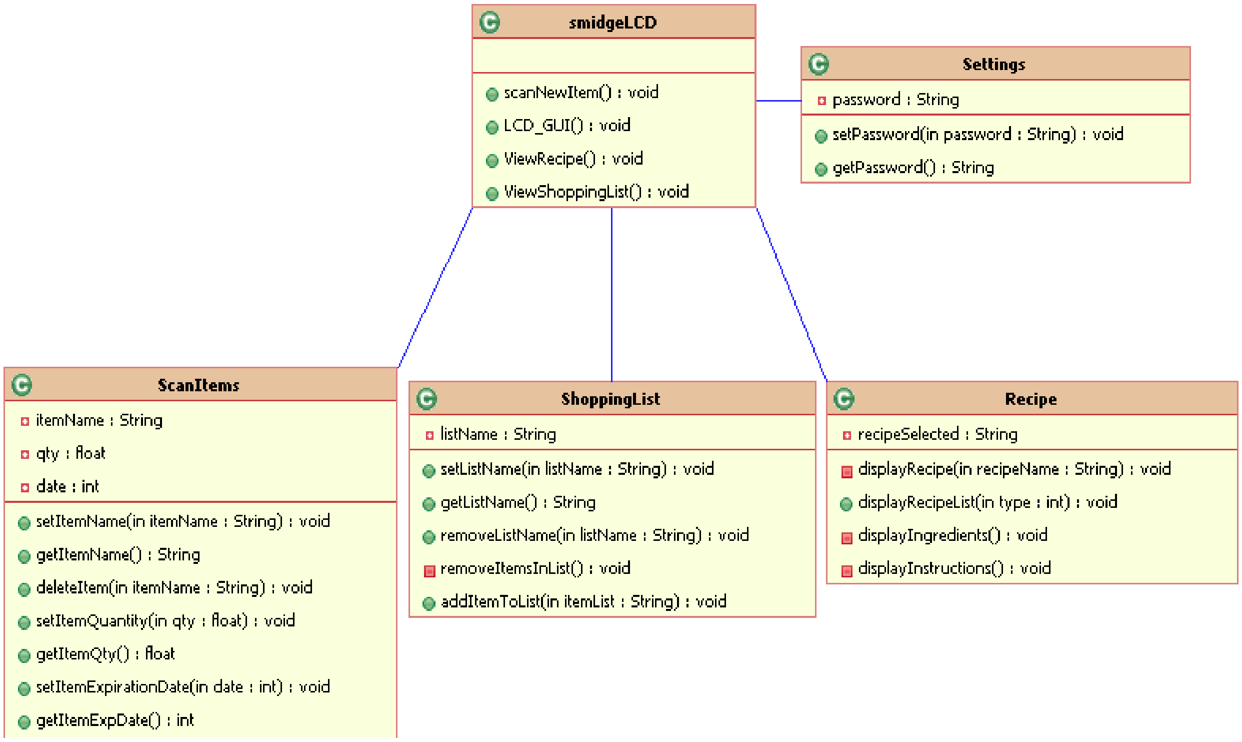

smidgeLCD
scanNewItem() : void
LCD_GUI() : void
ViewRecipe() : void
ViewShoppingList() : void
Settings
password : String
setPassword(in password : String) : void
getPassword() : String
ScanItems
itemName : String
qty : float
date : int
setItemName(in itemName : String) : void
getItemName() : String
deleteItem(in itemName : String) : void
setItemQuantity(in qty : float) : void
getItemQty() : float
setItemExpirationDate(in date : int) : void
getItemExpDate() : int
ShoppingList
listName : String
setListName(in listName : String) : void
getListName() : String
removeListName(in listName : String) : void
removeItemsInList() : void
addItemToList(in itemList : String) : void
Recipe
recipeSelected : String
displayRecipe(in recipeName : String) : void
displayRecipeList(in type : int) : void
displayIngredients() : void
displayInstructions() : void

Figure 31: LCD Display Class Diagram

SmidgeLCD – The smidgeLCD class contains the main methods of the program which control the different features of the program. LCD_GUI () is a method that creates the interface for the user to use. Every time a page loads, this method is called to display the items that the page is composed of. The method scanNewItem() creates an instance of ScanItems. This method controls the interface with the barcode scanner. The method ViewRecipe() creates an instance of recipe which controls the portion of the program that deals with the recipes. The method ViewShoppingList() creates an instance of ShoppingList which controls the portion of the program that deals with the shopping list features.

ScanItems – The ScanItems class is the class that controls the interface with the barcode scanner and is in charge of dataflow regarding the items on the system. The method setItemName() takes in an item name which is assigned in the database to the item currently being controlled. Conversly, the method getItemName() gets the item name from the database of the item being controlled. This method returns a string with the name being requested. The method deleteItem() deletes an item that the user wishes to remove. This method takes in the name of the item and removes the item from the database. The method setItemQuantity() takes a quantity input and sets that amount for the item in the database. The method getItemQty() retrieves the quantity value of the item being controlled and returns this quantity to the program. The other two set and get methods are for the expiration date. These work in a similar way as the previous methods described.

ShoppingList - The ShoppingList class controls the back-end functionality of the shopping list feature of the program. The set method setListName() in this class takes in a string and sets it as the name for that list. The get method getListName() in this class gets the shopping list name for from the database the shopping list being controlled. The removeListName() takes care of any lists that need to be removed by the program. The method removeItemsInList() and addItemsToList() take care of any modifications that need to be done on a shopping list. One of them removes a set of items specified by the program and the other adds items in the same way.

Recipe – The recipe class controls the back-end functionality of the recipe feature of the program. The displayRecipe() method simply gathers all the information regarding the recipe being controlled and displays it through the GUI. The method displayRecipeList() gathers all of the recipes stored in the database and displays them. The methods displayIngredients() and displayInstructions() are methods called by displayRecipe() that take care of retrieving the specific information of the recipe and providing it to the displayRecipe() method.

Settings – The settings class is in charge of managing the settings option in the main menu. Mainly, this option deals with the password settings for the website of the system. It contains two methods, set and get that retrieve and store password information to and from the database.

Phone App – Figure 34, displays the class diagram for the phone application that was developed during the software design phase of the project. There are four tables that encompass this part of the design. The main table is SmidgePhone which controls the overall functionality of the mobile application. The other tables are ShoppingList, ViewItems, and Recipe which control each section of the application respectively.

ShoppingList – The ShoppingList class for the mobile application is identical to the class designed for the same functionality in the LCD display. It contains set and get methods to facilitate the dataflow of these objects. The class also contains methods to remove items from the shopping list, add items from the shopping list and remove a shopping list all together.

ViewItems – This class is in charge of entering and retrieving the information from the database that is necessary to manage the items in the system. The method createItemList() creates a list of items that can be used by other methods to be displayed. The method printInventory() uses a list of items that has been gathered and outputs it through the GUI.

Recipe – The Recipe class is a duplicate of the one used for the LCD display program. This class contains four methods that handle the display of the recipe. The methods displayRecipe() and displayRecipeList() control the output of recipes and list of recipes respectively. The methods displayIngredients() and displayInstructions() are helper methods that are used in displayRecipe() to gather the specific information of that recipe.

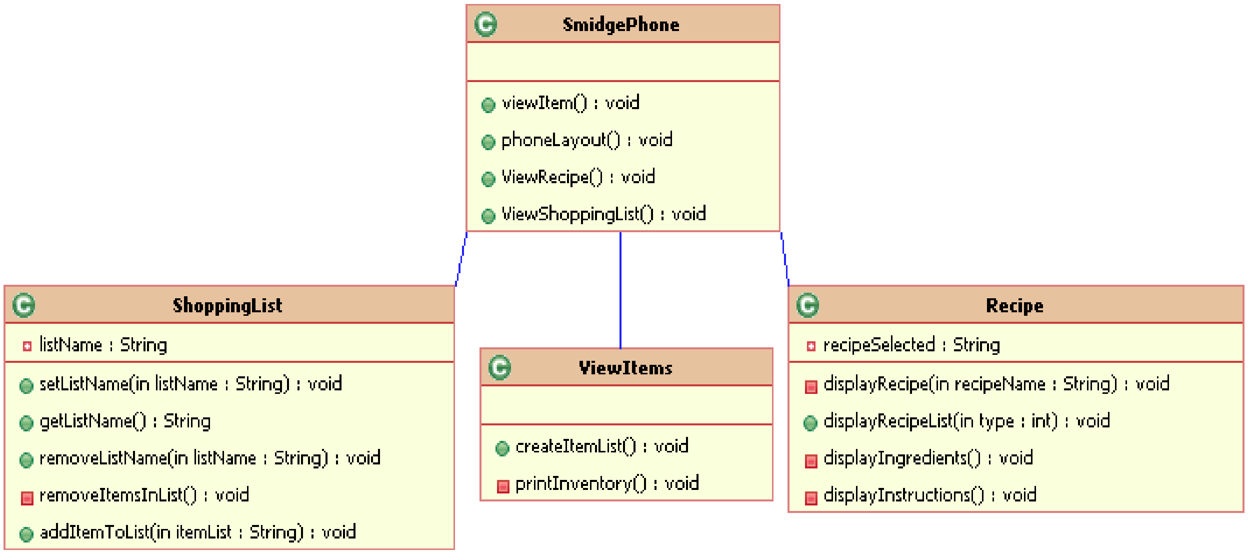

SmidgePhone
viewItem() : void
phoneLayout() : void
ViewRecipe() : void
ViewShoppingList() : void
ShoppingList
listName : String
setListName(in listName : String) : void
getListName() : String
removeListName(in listName : String) : void
removeItemsInList() : void
addItemToList(in itemList : String) : void
ViewItems
createItemList() : void
printInventory() : void
Recipe
recipeSelected : String
displayRecipe(in recipeName : String) : void
displayRecipeList(in type : int) : void
displayIngredients() : void
displayInstructions() : void

Figure 32: Phone Application Class Diagram

4.2.4 Database Structure

SMIDGE database structure shall be base upon the following information.

- There shall be a main unit which it is the fridge. Each fridge attributes shall be Fridge_Number, User login, User password, Products inside the fridge, Phone_related and Web site.
- There must be only one fridge related to each item. There can be many items inside a fridge or there can be none items.
- The fridge shall be connected to one and only one phone application and a phone application shall be connected to one and only one fridge.
- A phone application attributes are user login (identifier) and user password.
- The fridge shall be connected to one and only one web application and a web application shall be connected to one and only one fridge.
- Attributes of a web application are domain (identifier), user login and user password.
- A web application can be connected to one and only one phone application. A phone application can only be connected to one web application.

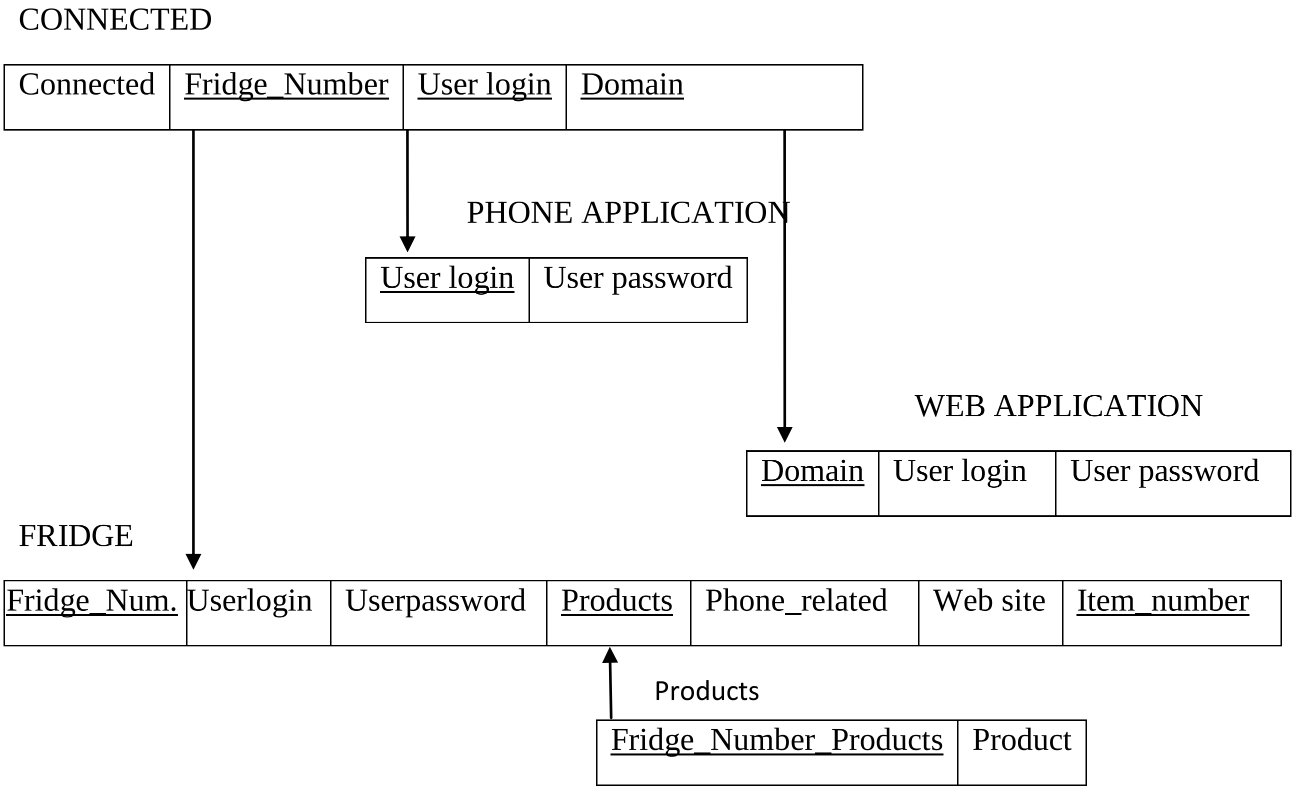
- There shall be many items. Attributes of each item shall be item number (identifier), ingredients, classification which shall say what kind of item it is, calories, quantity and weight.
- The systems provides the costumer with several recipes where each item, if applies, can be used. Each recipe can be access through the fridge, web application or phone application.
- The fridge, web application and phone application can have more than one recipe or may not have any.
- Attributes of recipe are recipe number (identifier), items, cooking time, cooking instructions and number of servings.
- Every recipe must have at least one item.
- Items may be listed in many recipes or may be in none.
- Through the system's phone application the customer shall receive a weekly grocery list to replace the items that have been consumed. The grocery list attributes shall be grocery list number (identifier), number of items, date, items.
- Each grocery list must have one item to exist.
- An item may not be in a grocery list.

The database shall be updated every time an item is taken out of the fridge, either if it was partially or totally consumed; the user will choose the option to save the changes. Once there are no leftovers of an item the customer will choose an option given by the system to delete the item from the inventory and the database will remove the item too. When the groceries are done there shall be a new set of items being introduced in the database. The system shall have an option to create a printed report with all the information in the database.

4.2.4.1 Tables

The connected relation shown in Figure 35 relates the Fridge, the User and the Domain through their key attributes; fridge_number, user_login and domain. From the key attributes we can access the rest of the table and the rest of the attributes. From fridge_number we access the fridge table which has the information for Userlogin, Userpassword, and phone number related to this fridge, the smart fridge's web site and all the products inside. Since products is a multivalue attribute there will be a table for Products where each product shall have as a key attribute the Fridge_Number. The user_login key relates to the phone application table where the attribute password shall be stored. The domain key relates to the web application table where it is the key attribute. Other attributes in the web application table are user login and user password.

The fridge table also has an item_number key attribute that links this table to the Item table. For each item inside the fridge there is a corresponding Item table with all the information about it. The diagram below simulates the relation generated by the Item table starting from the item_number attribute in the fridge table.



CONNECTED

Connected	Fridge_Number	User login	Domain

PHONE APPLICATION

User login	User password

WEB APPLICATION

Domain	User login	User password

FRIDGE

Fridge_Num.	Userlogin	Userpassword	Products	Phone_related	Web site	Item_number

Products

Fridge_Number_Products	Product

Figure 33 Connected Relation

The item table shown in Figure 36 has a key attribute Item_number. Other attributes are classification of the item, calories, quantity there is in stock of the item, weight and ingredients of the item. Since certain items can have more than one ingredient this is a multi-value attribute, therefore other table shall be generated just for ingredients, in this table the key attribute is the item_number to which the ingredient corresponds. The item table is linked to the recipe table and the grocery list table through the key attributes for each of these tables, recipe_number for the first one and list_number for the second one.

The key attribute for the recipe table is recipe_number, the rest of the attributes are cooking time, cooking instructions, number of servings estimated and items that will be used. Most recipes are based on at least 2 items or more therefore the attribute items in the recipe table it is a multi-value attribute. There is an item table where the key attribute for each item is the recipe_number that it corresponds to.

The grocery list table can be accessed from the items in the fridge table through its key attribute list_number. Other attributes in the grocery list table are number of items, the date that list was built and the items that are on it. Every list must have at least one item to exist and it can go up to any number of items, for this reason he attribute items in the grocery list table it is a multi-value attribute. Each item shall be in a separate table where the key attribute is the list_number to which it is related to.

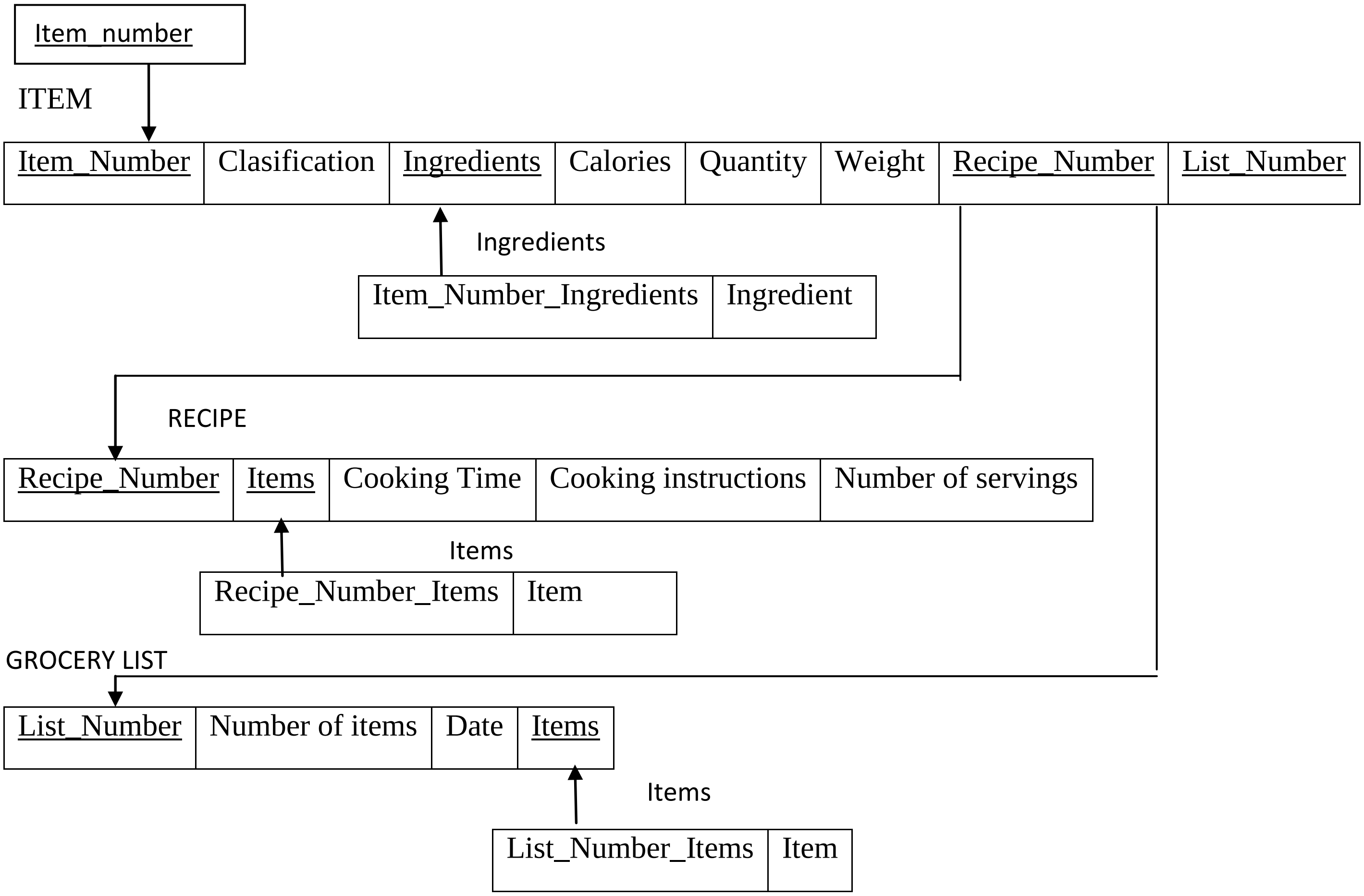
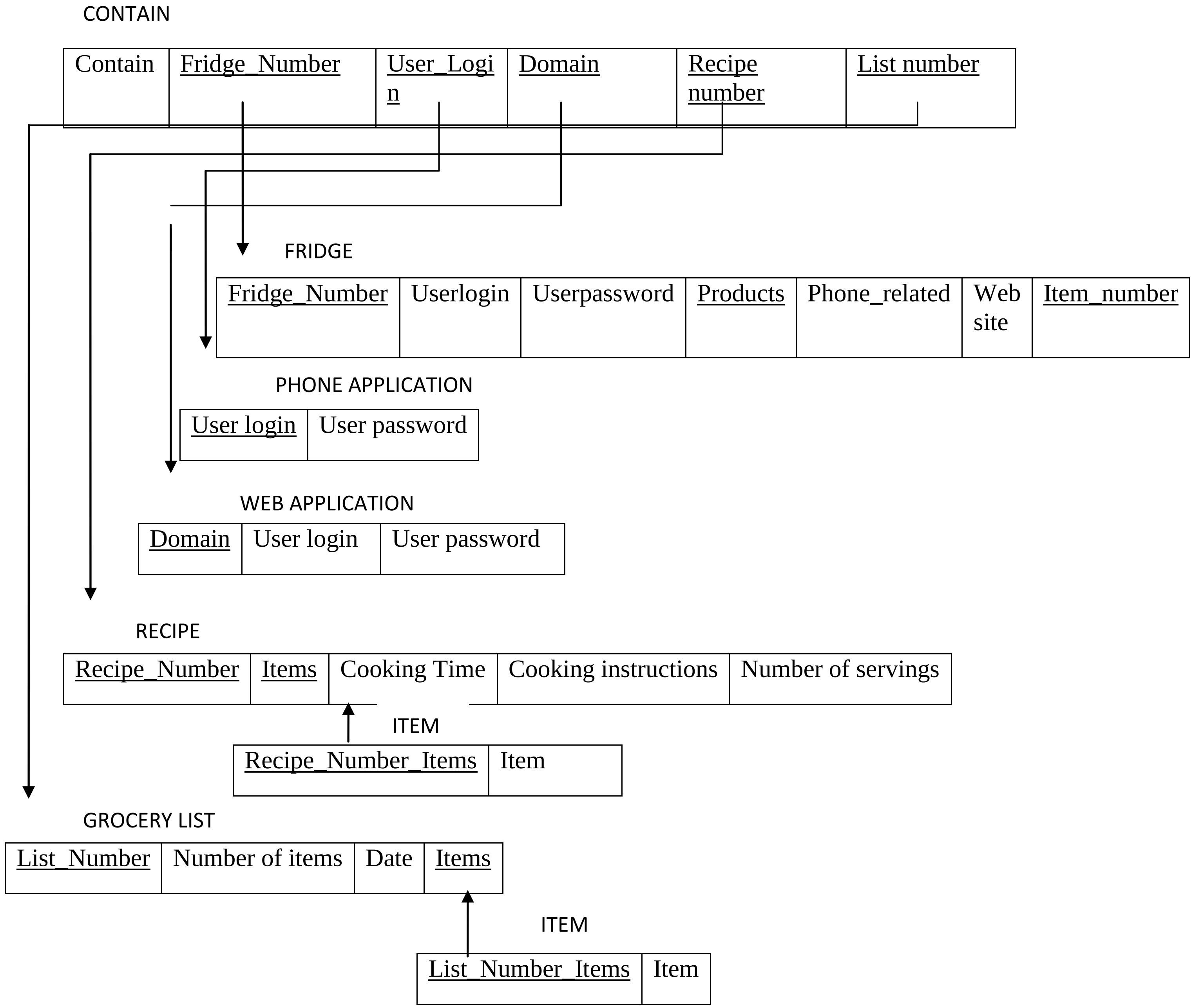


Figure 34 Item Table

The Contain relation links the fridge, phone application, web application, recipe and grocery list tables. This relation relates every one of these tables by their key attributes. Therefore this relation saves the attributes fridge_number, user_login, domain, recipe_number and grocery list_number. If a table is not included in the relation the value of the attribute shall be null.



CONTAIN

Contain	Fridge_Number	User_Login	Domain	Recipe number	List number

FRIDGE

Fridge_Number	Userlogin	Userpassword	Products	Phone_related	Web site	Item_number

PHONE APPLICATION

User login	User password

WEB APPLICATION

Domain	User login	User password

RECIPE

Recipe_Number	Items	Cooking Time	Cooking instructions	Number of servings

ITEM

Recipe_Number_Items	Item

GROCERY LIST

List_Number	Number of items	Date	Items

ITEM

List_Number_Items	Item

Figure 35 Contain Relation

4.2.4.2 Entity Relationship Model Diagrams

The following diagram shows the database different tables with its corresponding attributes and how they are related. The tables in the database are Fridge, Phone application, Web application, Item, Recipe and Grocery List. The relations that link the tables are Connected, Contains, Stores, Requires and Include. The relationship Connected links the tables Fridge, Phone application and Web application. The relationship Contain links the tables Fridge, Phone application, Web application, Recipe and Grocery List. Tables Fridge and Item are linked by the relationship Stores. Tables Item and Recipe are linked by the relationship Requires. Tables Item and Grocery List are linked by the relationship Include.

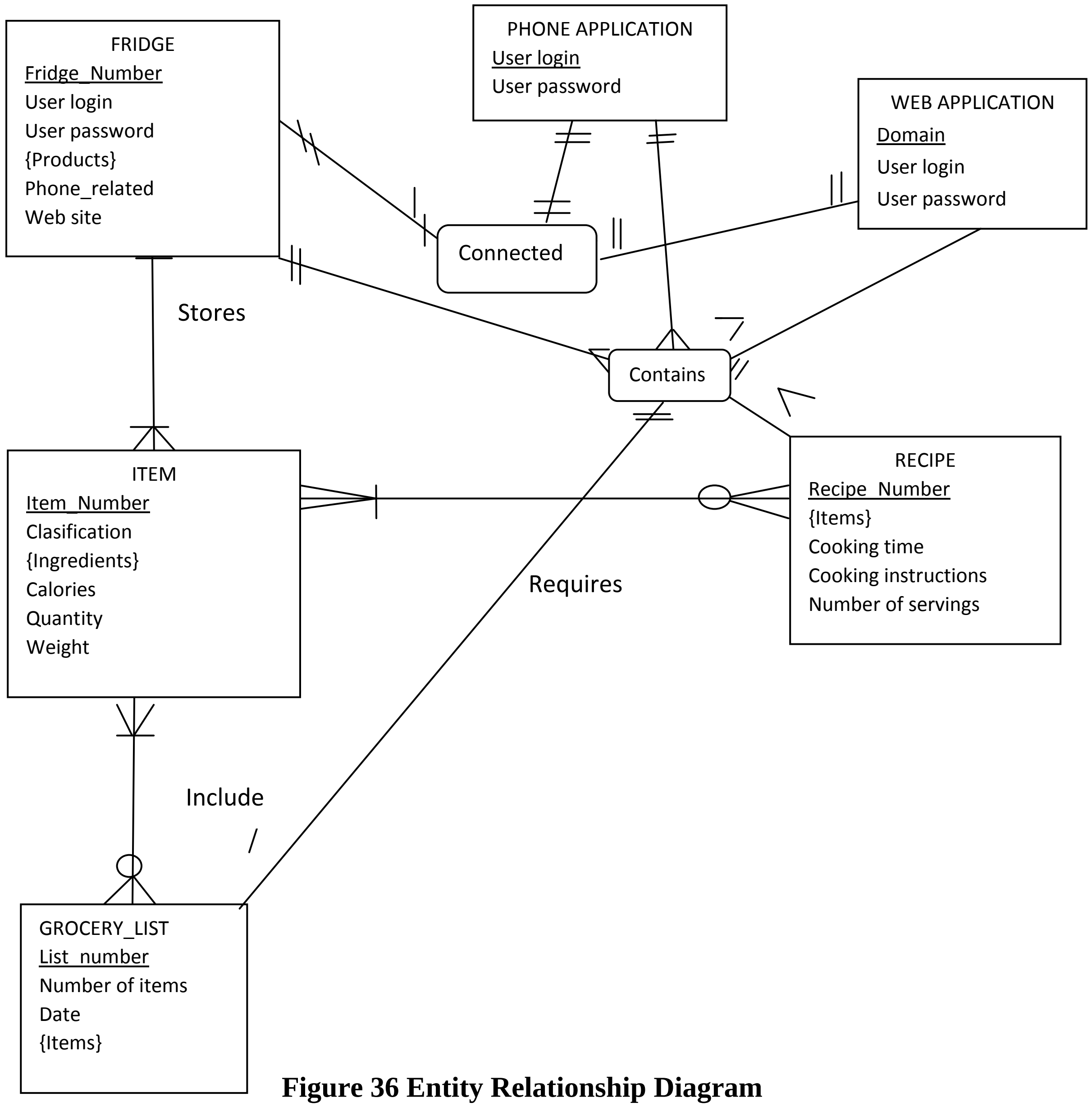


Figure 36 Entity Relationship Diagram

4.2.4 Server

For this project many web server options were researched, finally we decided that the most financially accessible and reliable option shall be to use Google Base.

4.2.4.1 Google Base

Google Base is an online database that Google provides. In this database any user can add any type of content and structures information in formats such as XML, PDF, Excel and more. Files can be uploaded to the Google Base servers by browsing your computer or the web using various FTP methods, or by API coding. To view the number of downloads online tools are provided, it also include other performance measures.

Google Base is a free service for submitting all kinds of content for Google to host and to make searchable online. It allows content providers to upload structured data to Google, surface it across Google search properties, and syndicate it via APIs, gadgets and gadget ads.

The Google Base data API is designed to allow developers to query Google Base data in order to create applications and input and manage Google Base items. There are two item feeds, snippets feed and customer's items feed. The snippets feed have all Google Base data and is available to anyone to query against with no need for authentication. The customer items feed is a customer-specific subset of data and only a customer or owner can access this feed to insert, update, or delete their own data. Queries are constructed the same way against both types of feeds.

4.2.4.2 Server Structure

The server shall manage the web application, the phone application and the database for the fridge. Each application will connect to the server in case of requesting, changing or adding data. When new items are added to the database the server will search for the items' description and characteristics by using an online UPC database.

The server shall have two databases, one database that contains the information regarding current items on the fridge, history of items ever bought, generally items characteristics; and another database with all the recipes. These databases shall be access from the fridge using the touchscreen, from the phone application by login in with the user name and from the web site application by login in with the user name and password. The server will manage the connection between the system's different components.

The LCD panel on the fridge shall allow the user to interact with the system by adding or changing information or browsing through what has been already saved. Every time the user request an action related to the database the fridge will connect to the server in order to access the information on it.

The phone application shall allow the user to access the database and make changes to it. Through the phone application the user can view items, review the shopping list and view the recipes. From the phone the user can make changes to the saved data when it updates the shopping list. The figure below corresponds to the server structure diagram.

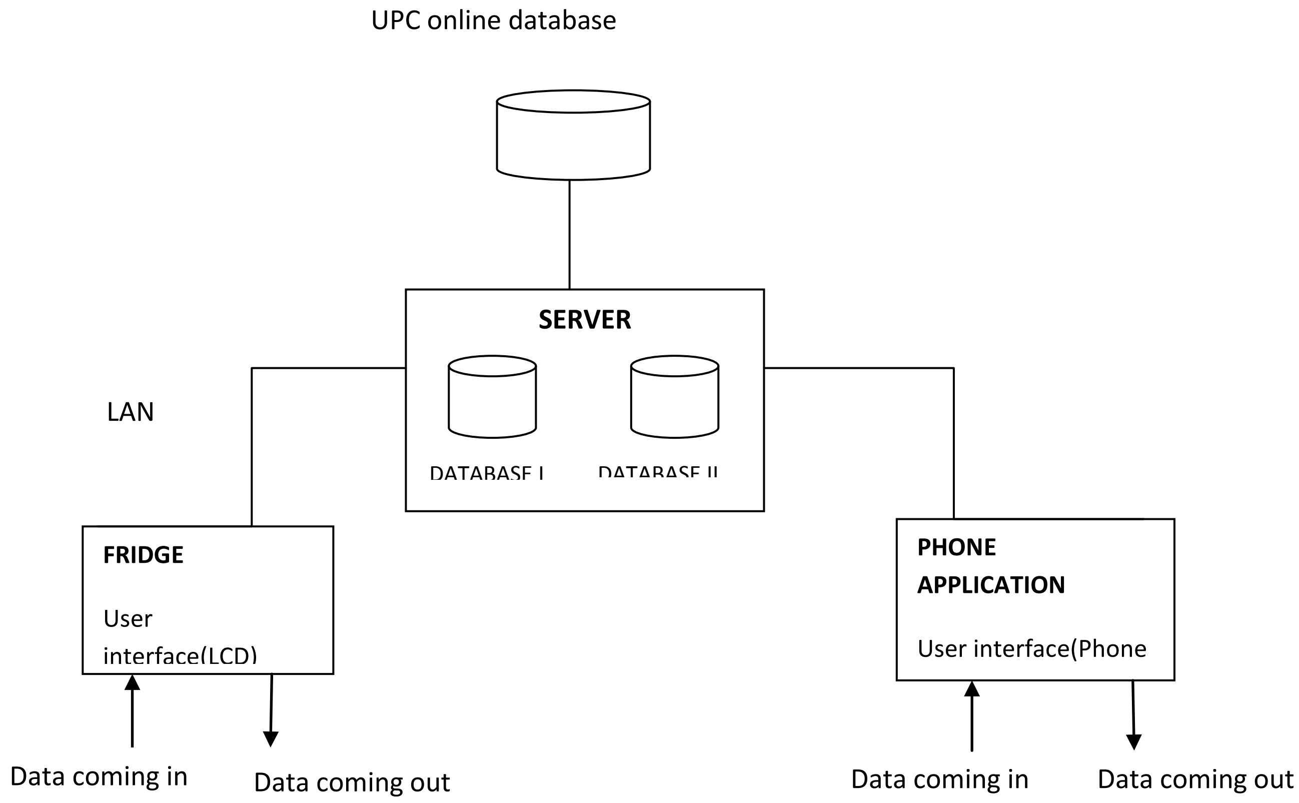


Figure 37 Server Structure Diagram

4.3 Hardware Design

4.3.1 Hardware Comparison

The hardware comparison is summarized in table 39. It ultimately comes down to the price-performance ratio between the boards analyzed, and the option of having extra peripherals and help when it comes to building the actual system. The BeagleBoard seemed to be one of the most popular choice in projects built in the past. However, the price was somewhat high for the performance offered. The OK6410 was the most accessible when it came to price; however, the processor was also not competitive and we failed to locate any group or online forum that had done work with this board before. The third choice was the best in our opinion, since even though the price is still somewhat high, the board has a great performance speed (1 Ghz), a variety of peripherals are available, and various sites with development and technical help are also accessible if needed at the time of assembly and coding.

The drivers were also a very important item in our search. If we don’t have the specific drivers for two hardware components to interact with each other, it means we need to create them on our own. This poses an issue when building the system, as we are not completely sure If we will be able to create these drivers without having to change some of the components chosen. The prices of each component are available on the table, as well as a column for the prices of solely the components we have chosen for our project, labeled as ‘3rd choice PRICE TOTAL’. The extras are added to the total at the bottom and in this column in the same way.

	BeagleBoard $149	**OK6410 board $110**	**PandaBoard $175**	3rd choice TOTAL PRICE	**Extras and notes**
Board Processor	600 Mhz processor	600 Mhz processor	Dual Core 1Ghz processor (a lot faster)	$195	Board = 179+16 (shipping)
Board Memory	128 Mb RAM	128 Mb RAM	1 GB RAM (Much bigger)	$20	power supply offered at same site $20
7" LCD	7 inch USB LCD available (no less than $170)	7 inch LCD by the same manufacturer: $105	7 inch USB LCD available (no less than $170)	$191.59	(screen + shipping and tax)
LCD Drivers	Generic Drivers (might be harder to configure)- same as PandaBoard	Drivers for LCD included	LCD: Generic Drivers (might be harder to configure)	0	-
WIFI	Wifi module through USB - $30	Wifi module through USB - $30	Integrated Wifi Module	0	-
Wifi drivers	Generic Drivers (might be harder to configure)	Generic Drivers (might be harder to configure)	Wifi module Drivers included	0	-
Scanner	Acquired $35 on ebay (actual price varies from $210 - $550 -- No drivers needed (acts as keyboard input)			$35	
USB Hub	Needed for extra USB connections (only two available on the board. 2 needed for lcd, 1 needed for scanner, 1 extra needed for testing)			$15	USB Hub can be bought at local store
Support	Community Support (Forums, IRC, etc)	Only Email support	Community Support (Forums, IRC, etc)	$20	upcdatabase.com credits (For upc identification)

Total Price	385	275	380	$20	power implementation (still on research phase)
				$496.59	TOTAL
				$124.15	INDIVIDUAL

Table 13 Hardware Comparison and Price

4.3.2 Hardware Component Interaction

The Smart Fridge System is divided into two main components: hardware and software design. The hardware components will only be a third of the final product given that we are also designing a webpage and a mobile application. The physical system, however, is the main and most important piece of the project, since it will provide the scanning process and input into the refrigerator.

The main hardware component is the development board. By picking the right development board, we make sure to have every connection necessary to power and implement our design. The Pandaboard does not come with its own power supply. However, a 5V power supply can be purchased on the same website, this power supply would be connected to the power cord extension that will be attached (with Velcro) to the back panel of the refrigerator. The refrigerator's power cord will also be plugged into this extension power cord so that only one cable will need to be plugged directly into the wall outlet.

From there, we must connect every peripheral to the main development board. To do this, we are in need of a USB hub to suit our USB input needs. The LCD touch screen display is powered through USB. It comes with two cables that bring power and functionality to the screen. Similarly, the barcode scanner uses a USB connection to find power and functionality when scanning the UPC codes. For this reason we are in need of three or more USB port connections to the main development board. This is why, a USB hub is needed on our final implementation of the system.

The USB hub is connected to the development board through its own cable, allowing for the connection of multiple peripherals such as the ones talked about, the LCD touch screen display and barcode scanner. This would also mean we would have extra USB ports available. These would be very helpful in the installation process, when the use of a keyboard and mouse would probably be needed for the OS installation and peripheral components testing and implementation.

The other main connection of the hardware is done wirelessly. The development board has an integrated wifi chip that allows us to connect wirelessly to the server in order to access and store information. This is one of the most important connections in our system; without this, the system is not able to synchronize the user account with the website or mobile application, which would result in lack of functionality and failure of the whole scanning process.

Figure 39 shows the main hardware interaction and how it all ultimately receives its own power and interconnection with the rest of the system. Some of the components, such as the development board and the barcode scanner are shown floating in space. This is just for visual purposes. The lcd screen will most likely be placed on top of the mini refrigerator (although the stand is detachable if the user is using a regular-sized refrigerator and would like to place it elsewhere). The scanner is placed on the side of the mini refrigerator from which the door opens, and held up there by a piece of Velcro, in order for the user to detach it if it ever is needed. Finally the board will have its own encasing box to protect it from debris or electrical problems. It will be hidden behind the screen on the mini refrigerator or, if using a regular-sized fridge, it would be placed discretely in the back. The only connection that would be visually apparent from the system would be the extension cord coming out to connect to power in the wall outlet. Any other connection needed for testing purposes is not shown in the component interaction figure.

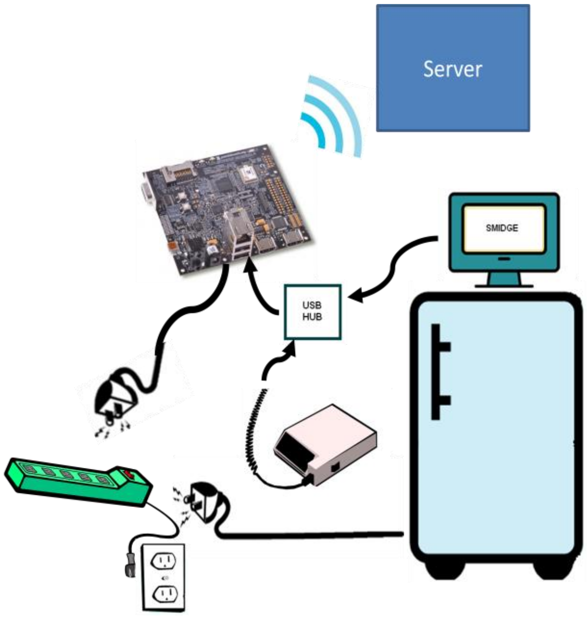


Figure 38 Hardware Component Interaction

4.3.3 Power

In our Power Implementation section on the research phase, we specified two different approaches on how to deal with connecting the system to power. The first choice was to unite the power supply cable of the development board and the power cord of the refrigerator by cutting and stripping the power supply cable and taking off some of the coating of the refrigerator’s power cord to wrap one inside the other, being careful to not switch or join different polarities together. This choice was somewhat unsafe and unreliable since one small mistake could end up causing damage to us or the equipment used; which in turn, would mean we would have to come up with more money and time for repairing or buying new parts for our project.

The second option was the one we decided to implement on our final design. It is a much simpler alternative and deals less with electrical issues. However, there is no risk of causing any harm to anyone working on the project, or to the equipment used. This choice consists of getting a simple cord extension that enables the connection of at least two power cords to its end. With this purpose, both cables coming from the refrigerator and development board respectively are plugged in one end.

The other end of the cable would be plugged into the wall, making it simpler as ultimately only one cable would need connection to power. We plan on using Velcro to adhere the other end close to the back panel of the refrigerator in a discrete placement. Figure 41 shows the final arrangement of how the system would be wired (the extension cable is not visually exact to the part we will ultimately be using, the figure only attempts to show a simple configuration of components).

4.5 Printed Circuit Board Design Summary

The Printed Circuit Board we designed is based on the PandaBoard development board design. We used the PandaBoard as a base for our design since we are choosing this development board to run all of our test and debugging procedures for our system. With our own custom board, we will be able to have a simpler, more compact version of the system.

For our custom printed circuit board, we would need the following hardware components:

- OMAP 3530 Microprocessor
- 5V input conection
- SD Card Slot (to port the operating system)
- JTAG (for debugging)
- Usb host
- Usb client
- Status LEDs
- RS 232 connection
- Power interface controller

These components are all included in the development board; however, there are a list of components also present on the development board that we are not in need of. Some of them include FM Radio, Bluetooth, HDMI, LCD expansion connector, camera expansion connection, etc. Therefore, we have come up with the schematic captures for the components we need by extracting them and modifying the inputs and outputs to only cater to the components we will use. The schematics for each layer of the processor are shown in the figures.

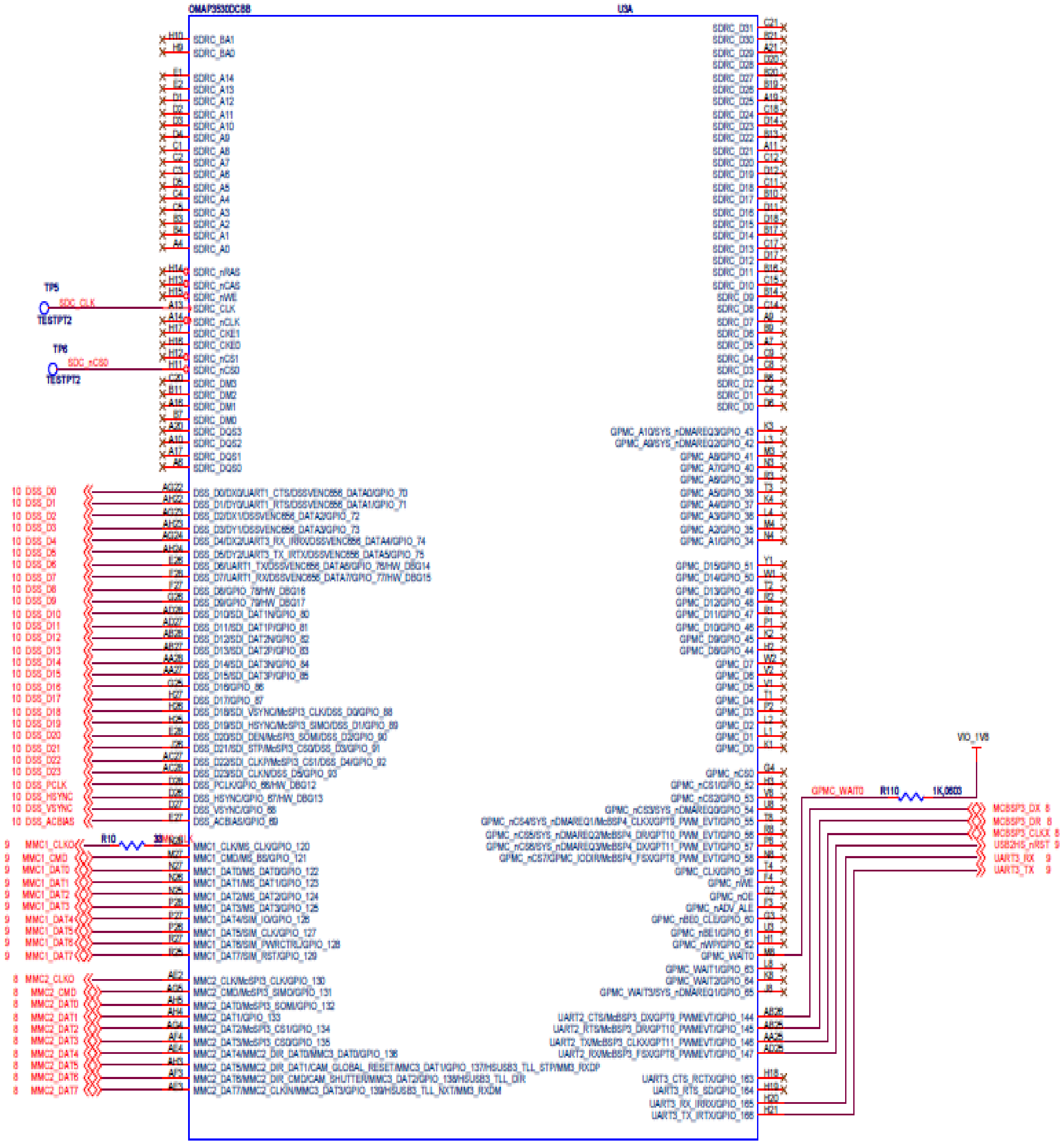


Figure 39 Schematic Capture of OMAP 3530 1st level

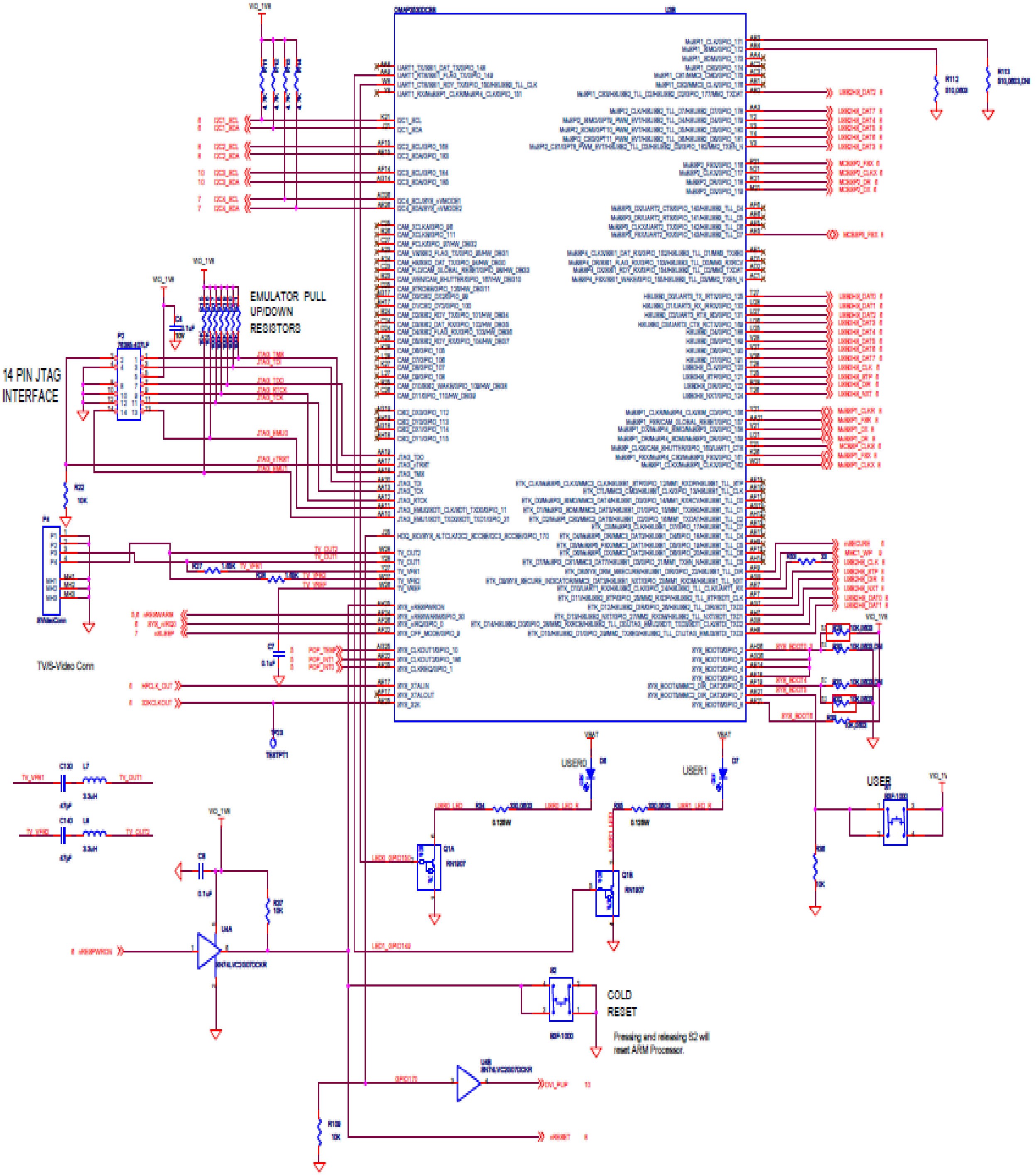

14 PIN JTAG INTERFACE
EMULATOR PULL UP/DOWN RESISTORS
TVIS-Video Conn
USER0
USER1
USER
COLD RESET
Pressing and releasing S2 will reset ARM Processor.

Figure 41 Schematic Capture of OMAP 3530 2nd level

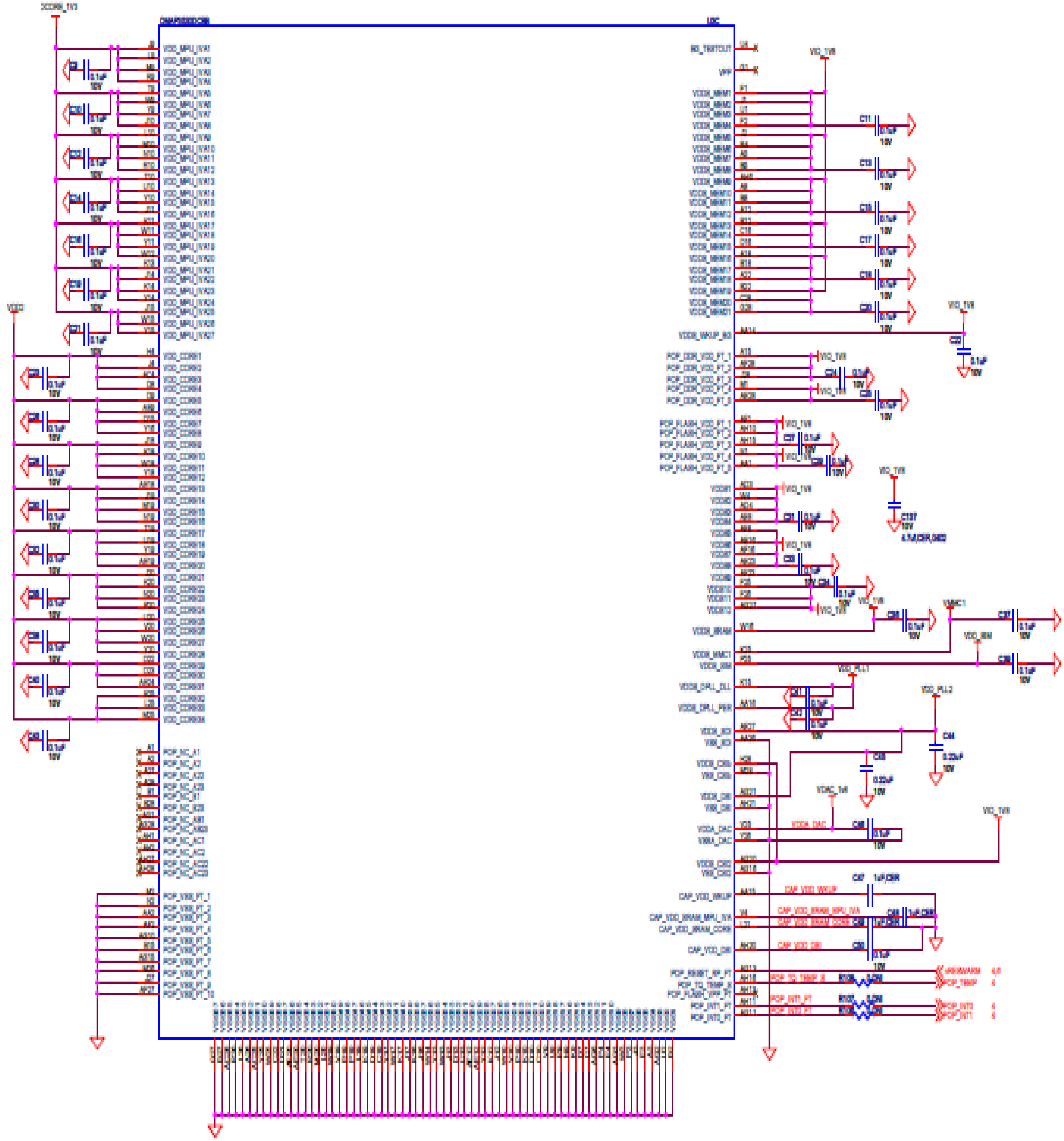


Figure 42 Schematic Capture of OMAP 3530 3rd level

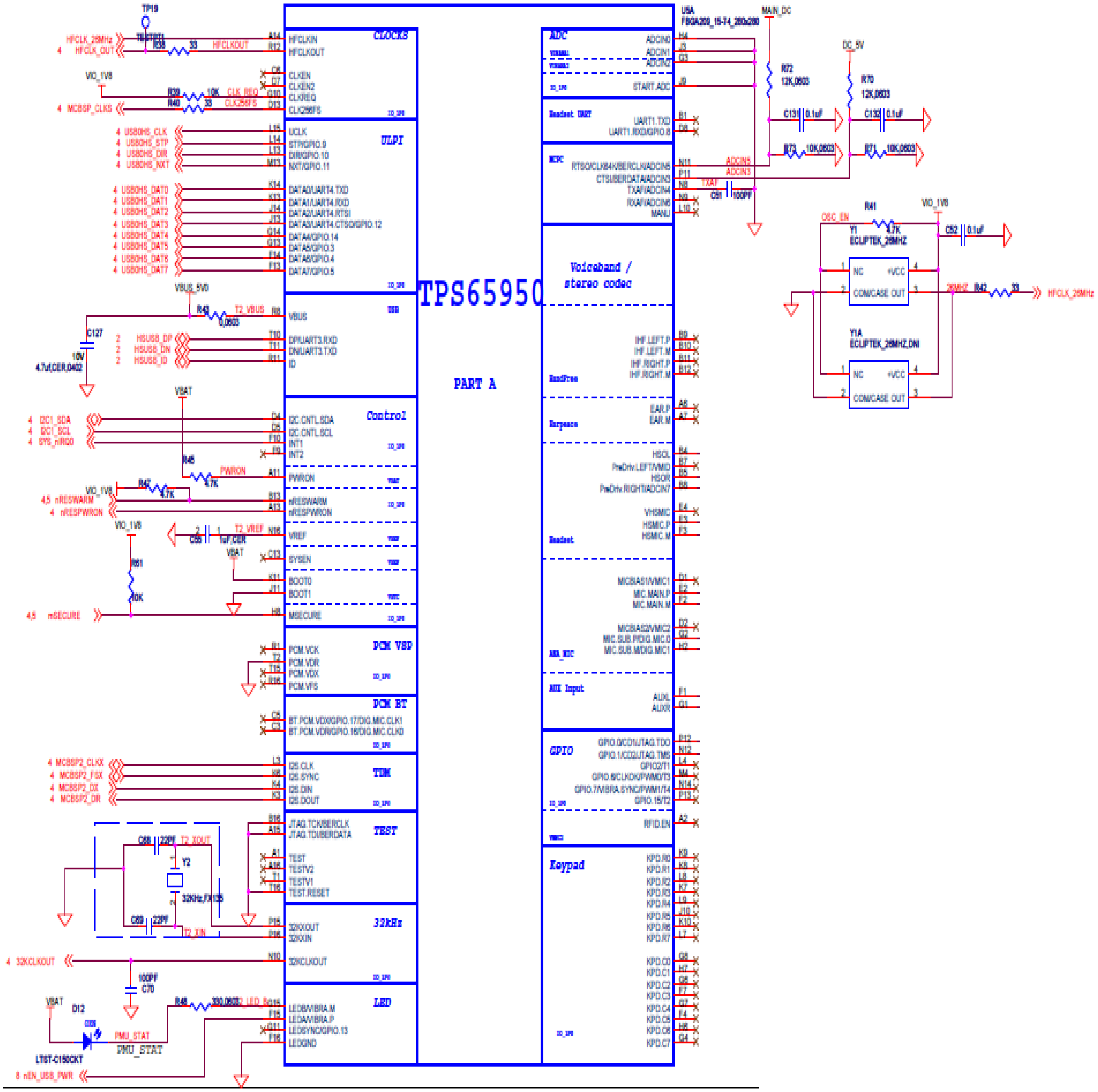


Figure 43 Schematic Capture of TPS 65950 1st level

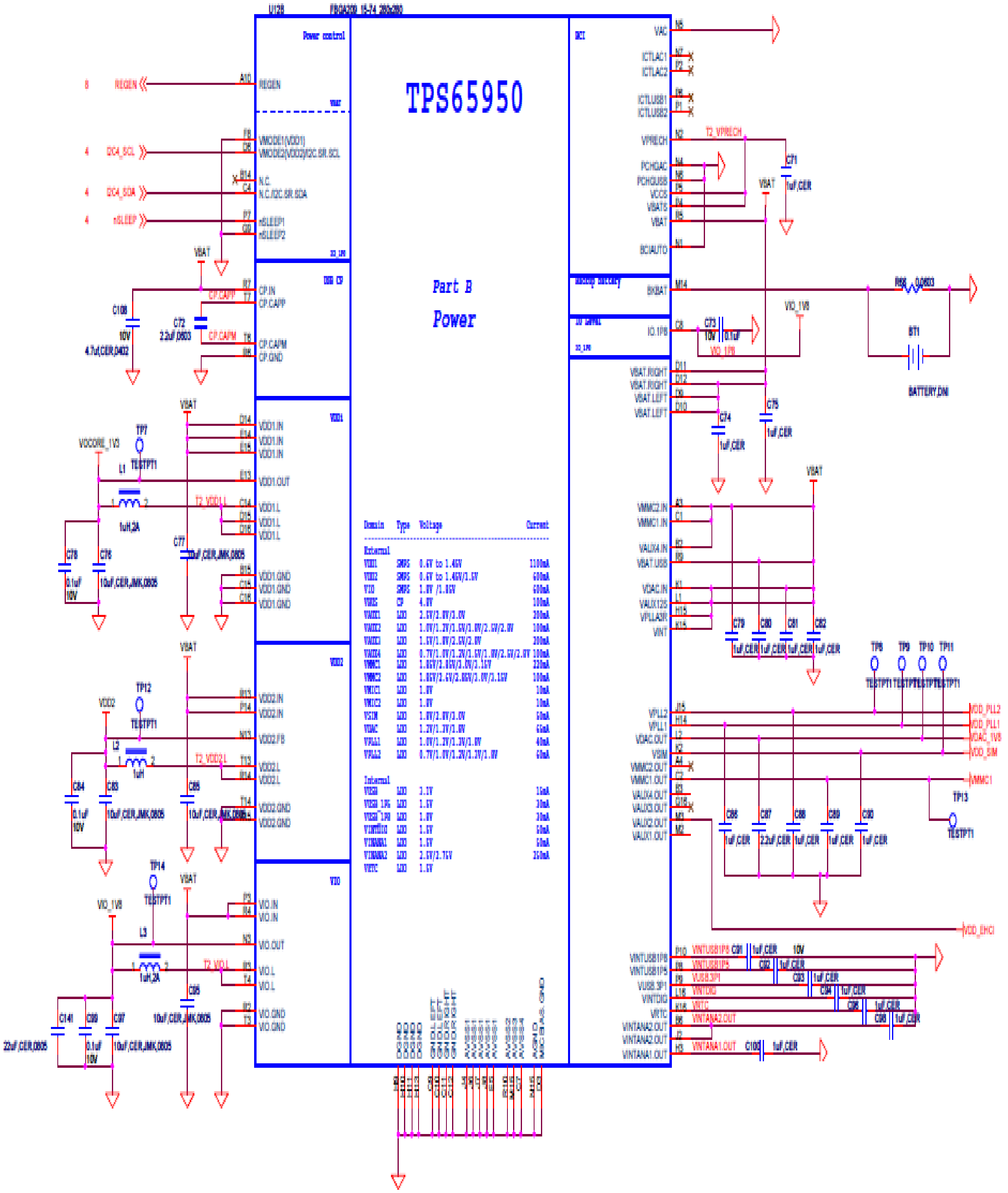


Figure 44 Schematic Capture of TPS 65950 2nd level

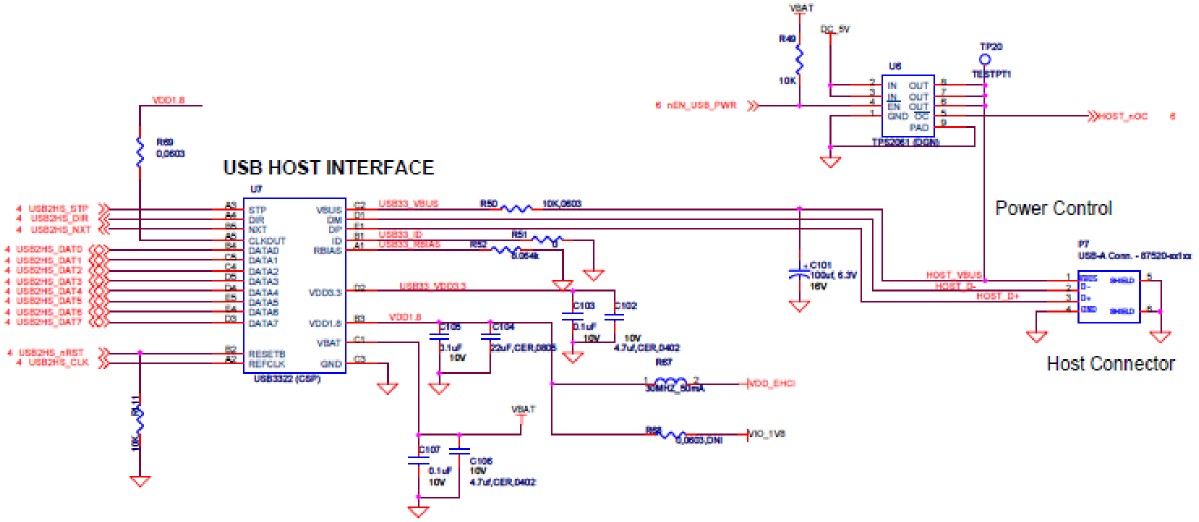


Figure 45 Schematic Capture of USB interface

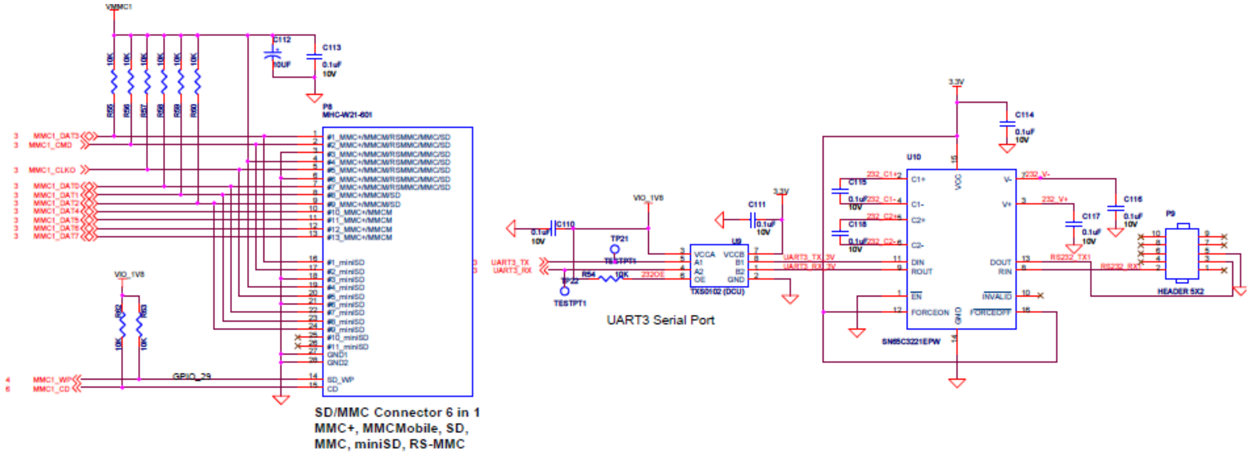


Figure 46 Schematic Capture of SD slot connector and RS232 interface

5. Prototype

This section displays and explains the prototypes that have been developed as part of the design phase of this project. The prototypes serve as an outline and preview of what the final product will look like. This section is broken down into three main parts. The first one will explain the prototype developed for the LCD fridge display. Then the prototype for the website will be displayed and that will be followed by the mobile application prototype

5.1 LCD Display

5.1.1 Main Menu

Figure 51 shows the page prototype for the main menu of the display. This display follows the look and feel of an Android application. At the very top of the page, the name of the system is displayed. This title might be left as it is now or a more sophisticated title could be developed. There are three main options in this page. These are the items, recipes, and shopping lists.

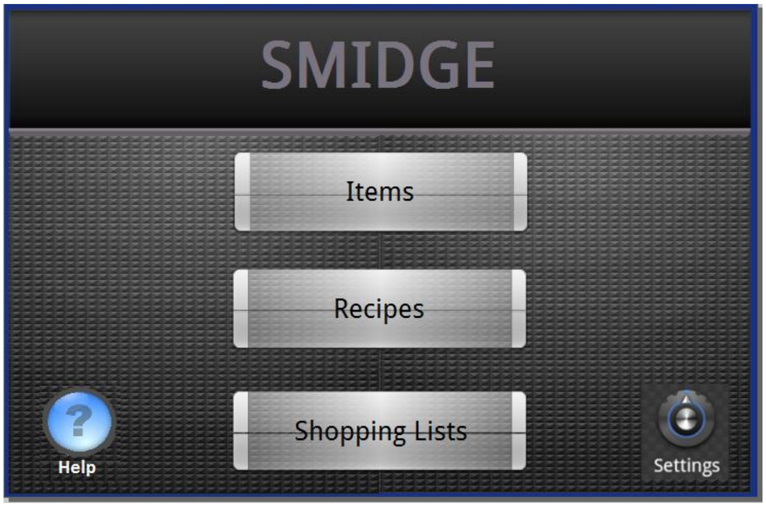


Figure 40 Main Menu page

For each option there is a button for the user to select. As seen on the display, these buttons are considerably large. Since this display will be implemented in a seven inch touch screen display, the buttons were made large enough to facilitate the user's selection while still retaining some aesthetic advantage. These buttons will be triggered when the user touches that part of the screen. The other two options on this main menu are help and settings. When the user touches the question mark button, help, a window will come up instructing the user of his/her possible options in this page. This was not discussed in the design phase but was added during the prototype phase. The settings button will function in the same manner as discussed in the design section. As seen on Figure 51, these buttons are not from the given template but are custom selected from the Android options. These buttons have not been integrated fully as one can tell by looking at the settings button. During the build phase of the project, one of the things that must be improved is the retrieval of buttons from Android websites and being able to integrate those buttons into this display seamlessly.

5.1.2 Items Menu

Figure 52 shows the prototype page developed for the Items main page. This page is accessed when the user touches the Items button in the main page. As seen in the display, this page also maintains the same look and feel of the main page. The three main buttons on this page are also implemented with large buttons to ease the selection for the user. These options are Add Items, Modify Items, and Remove Items.

The Add items option enables the user to access the page where items can be scanned and entered into the system. This page can be seen later in the development of the prototype. The Modify items option allows the user to access the page where he or she can modify the information regarding one or more products that are currently stored in the fridge. This page too will be shown later in the prototype development. The Remove items option is used by the user when one or more items. The help button will instruct the user of its options in this page as described in this section. As can be seen in Figure 52, the display will use tabs in the top of the screen as is common with many Android applications. The two tabs that are available in this page are the current one selected, Items, and a link to the home page. This tab menu can be improved during the build phase in many ways. As is the case with the main menu, the icon images in this page do now blend in with the background as they should. This must be taken into account while developing the final product. Furthermore, any additional tabs that might improve user friendliness should be taken into account as well.

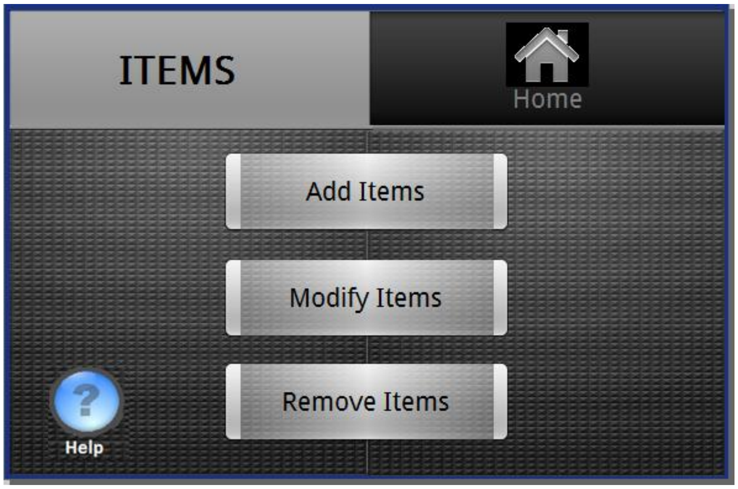
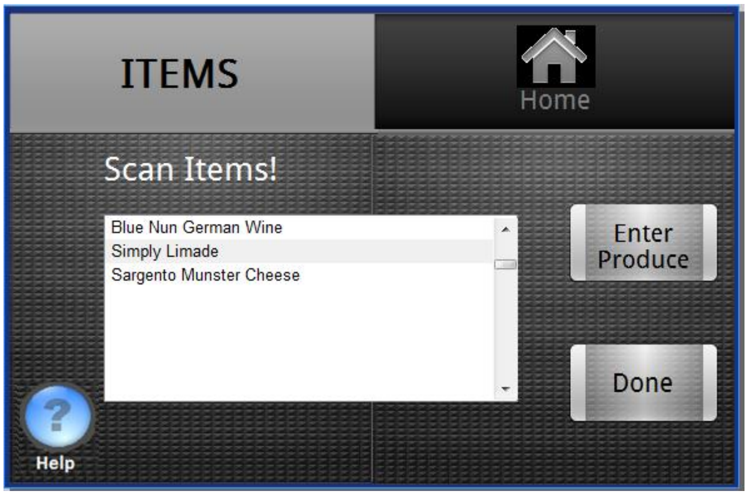


Figure 41 Items Menu page

5.1.3 Enter Items Page

Figure 53 shows the prototype page for the Add Items page. This page can be accessed from the Items menu when the user touches the Add Items button. This page serves as the user interface for the use of the barcode scanner. This page consists of an expandable list that displays the items being scanned. As the user scans in the items, the page adds the item scanned to the list.

The user can scroll through the list to see the items that have been scanned. There are two buttons to the right of the list. One of the buttons is Enter Produce. This button is for the user to enter items that do not have a bar code. Most of these products are produce items and therefore that is the title of this button. If it is determined during the build phase that this button should be titled different, changes will be made accordingly to satisfy this requirement. This button will redirect the user to a page where he or she can enter the product manually. The other button on this screen is the Done button. This button can be touched when all the items that the user wanted to enter into the Smidge are on the list shown in the page. Although the buttons are not as big as in the previous prototype pages developed, they are still big enough for the user to be able to use them properly on a touch screen. As usual there is a tab menu at the top of the display that gives the user the option to go back home to the main menu at any point. This might be subject to change depending on whether it is determined whether it is beneficial or not to have this option on this screen. This page will also have the help icon that instructs the user of the functionality of the page as described in this section.



Scan Items!

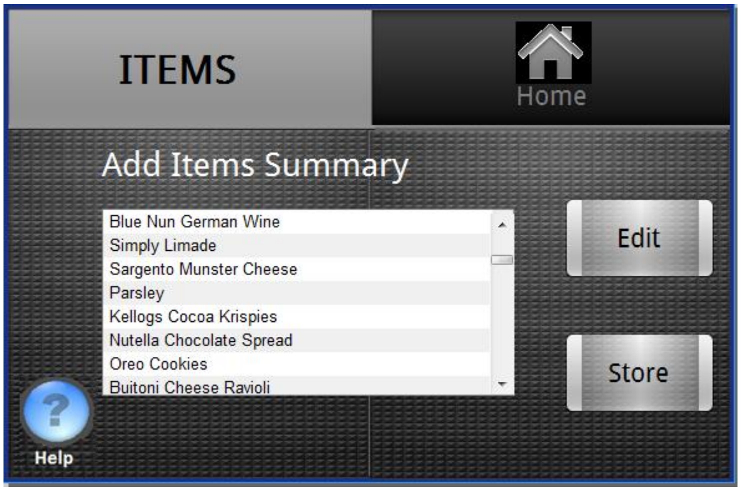
Blue Nun German Wine
Simply Limade
Sargento Munster Cheese

Figure 42 Enter Items page

5.1.4 Items List Summary

Figure 54 shows the prototype page for the Add Items Summary page. This page is displayed once the user is done scanning and entering items in the Enter Items page. That is, once the user touches the Done button in that page, this page will load. This page contains one list of all the items that have been entered by the user. The user can scroll up and down to look at the items that have been entered. The user can touch one of the items and edit the editable information to be determined in a future prototype page for that function. Items can be removed from this list by selecting them and removing them in the Edit menu. Once the user is satisfied with the list of items, he or she can touch the store button to store these items onto the database, and therefore, onto their account which synchronizes with the website and mobile application as well. Editing the item takes you into a different screen explained in a later section which allows the user to enter several fields of descriptions for a specific item if desired. Hitting the store button, takes you to the main menu of the system.

There are several aspects that can be improved during the build phase. The main aspect that should be taken into account is the height of each row in the list. The rows must be big enough that the user can select them on a touch screen but also small enough to be able to display quite a few of them. Another thing that should be considered during the build phase is whether more information should appear in this list such as amount, expiration dat, category or description. These decisions will be made based on complexity, time and order of task completion for every member of the group.



Blue Nun German Wine
Simply Limade
Sargento Munster Cheese
Parsley
Kellogs Cocoa Krispies
Nutella Chocolate Spread
Oreo Cookies
Buitoni Cheese Ravioli

Figure 43 Items List Summary page

5.1.5 Modify Items & Remove Items

Figure 55 shows the prototype page developed for the Modify Items page. This page can be accessed from the Items Main Menu page. As you can see from Figure 55, it has the same look and feel as the rest of the pages. This one contains a title of the page in the top part of the display and its options below it.

The two options that the user will be able to choose from to modify items is to either pick items from a list to modify them or to scan an item and modify it. The scan option is for a single item while the list option allows the user to view multiple items at once. As seen on Figure 55, the buttons are made wide to take up most of the space in this page.

This is done to allow the user to easily select their preferred option as well as to make it more aesthetically pleasing. When dealing with small touch screen displays, it is crucial that the buttons are made as big as possible and that is accomplished here in this page. As usual, there is a tabs menu at the top of the display. The selected option is Items since this page pertains to that section of the program. There is also an option to go back to the main menu by touching the home button.

The Remove Items menu would be very similar to the one displayed in Figure 55. There would be some slight modifications to make it fit for this functionality. The first change that would have to be made would be the title of the page. This page would instead be titled Remove Items. The buttons for the two options would reference different pages than the ones modify items would. The Show list of items button would take the user to a page where the user can quickly select multiple items and remove them from the system. Consequently, the scan item option would take the user to a page where he or she can scan an item and remove it. As usual, these pages contain a help button that would instruct the user what their different options are for these particular pages.

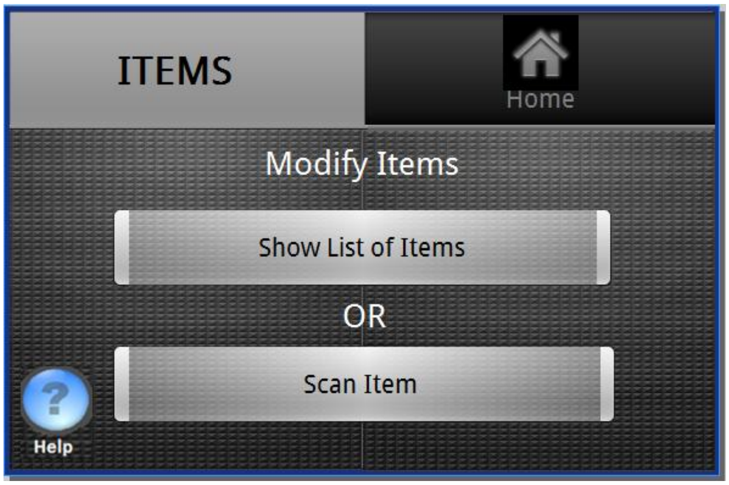


Figure 44 Modify Items page

5.1.6 Modify Items From List

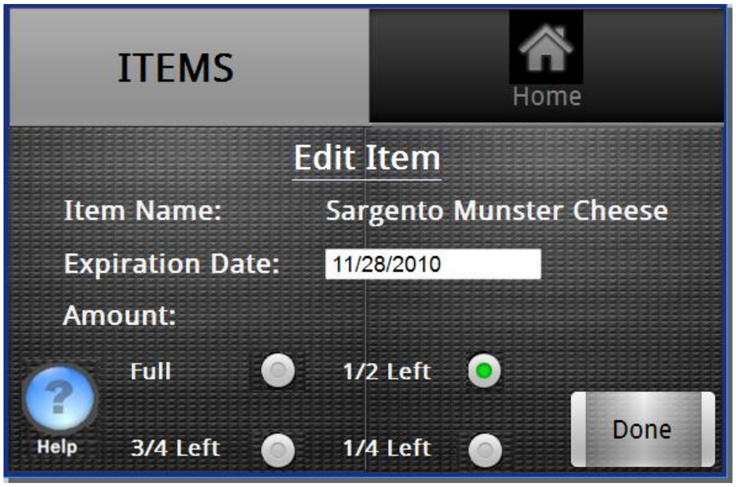
This page will not be prototyped as it is very similar to the Add Items summary List page. Since the functionality is very similar, the changes will be discussed in this brief section. The first difference is that the title will be changed so that it reads ‘Modify Items from List’. The items that are going to be displayed on the list are the ones that are currently in the system as supposed to the ones that have just been scanned. Just like on the other page, the user can select an item and hit the edit button. This will redirect the user to a page where he or she can update the information for that item in a page called ‘Edit Item’ discussed in the next section. Once the user is satisfied with all the modifications, he or she can hit done and the program will redirect them to the Items menu.

5.1.7 Edit Item

Figure 56 shows the prototype page developed for the Edit Item page. This page allows the user to modify the information of one item currently in the system. This page can be accessed from various places within the program. The first place that it can be accessed from is the Add Items summary page. If that is the case, then the information for expiration date for the item will be blank, since it probably won’t be available for retrieval via the bar code scan database, and the

default for the amount will be full. The user can then enter an expiration date before it is stored in the system. When the user is done modifying the information for this item, he or she can hit the ‘Done’ button and the information will be updated in the information for the program to use.

Another place this page can be accessed from is the modify items page. When the user selects scan item he or she will be prompted to a page what will ask the user to scan the item. That page will not be prototyped as most of it contains backend functionality. Once the user scans the item, it will redirect them to this page where they can modify the information for the item that has just been scanned. If this is the case, the user will most likely want to change the amount, as the expiration date doesn’t change. To do so, the page contains a set of large radio buttons that can be touched by the user to change the selection. Once the user hits a different radio button from the one currently selected, it will change selections. Again, once the user selects done, the page will update the information changed and save it in the database. A third place where this page can be accessed from is the 'Modify Items From a List' page showed later on in the prototype section. Just like for the scan option, once the user selects an item from that list to be modified, he or she will see this page come up. The information will be modified as mentioned previously. This page also contains the tabs menu on the top with the option to go back to the home menu. The help button allows the user to get information as to how to use the Edit Item page.



Edit Item

Item Name: Sargento Munster Cheese

Expiration Date: 11/28/2010

Amount:

Full ○ 1/2 Left ●

3/4 Left ○ 1/4 Left ○

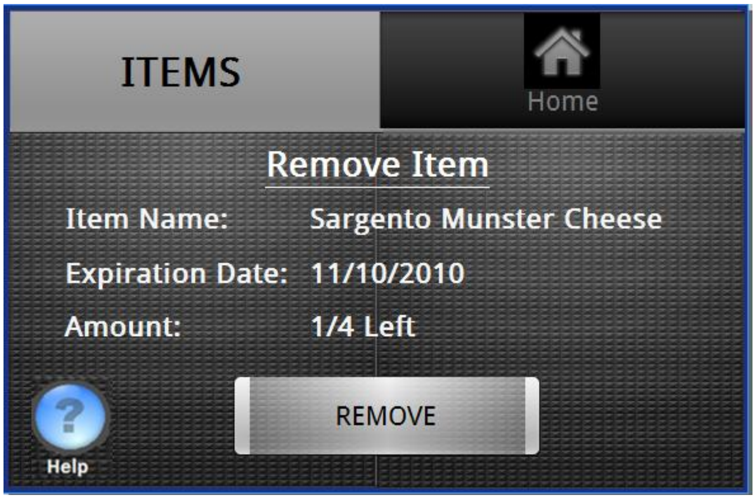
Figure 45 Edit Item page

5.1.8 Remove Item

Figure 57 shows the prototype page that was developed for the Remove Item page. This allows the user to remove the item being displayed. This page can be accessed from the Remove Items page.

When the user selects the Scan Item option in that menu, he or she is redirected to a page that prompts the user to scan the item. This page will not be prototype since it is of little interaction with the user. Once the user scans the item, this page will appear.

The page displays all of the information of the item that has been scanned. It displays the item's expiration date as well as the amount left. Once the user touches the remove button, the item is discarded from the system and the database is updated accordingly. The page will then redirect the user back to the Remove Items menu where they can then choose to scan another item to be removed. This page also contains the tab menu with the option selected being the items section. The home button allows the user to go back to the main menu of the program. This page also contains a help button that instructs the user of its functionality. Although the page might be self explanatory, this button is implemented to maintain consistency throughout the program and to increase the aesthetic feel of the display.



Remove Item

Item Name: Sargento Munster Cheese

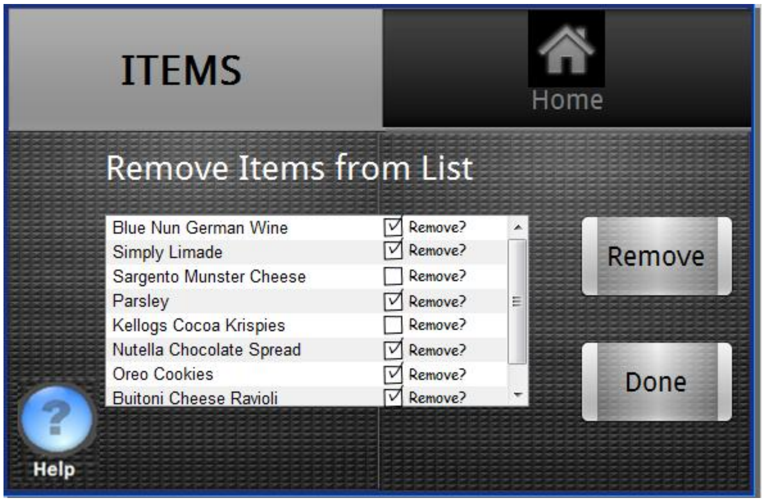
Expiration Date: 11/10/2010

Amount: 1/4 Left

Figure 46 Remove Item page

5.1.9 Remove Items from List

Figure 58 shows the prototype that was developed for the Remove Items for List page. This page can be accessed from the Remove Items menu page. When the user selects Show List of Items from said menu, the program redirects the user to this page. As seen in Figure 58, this page gives the user the ability to remove several items all at once. This page was developed for convenience purposes.



Remove Items from List

Blue Nun German Wine	☑ Remove?
Simply Limade	☑ Remove?
Sargento Munster Cheese	☐ Remove?
Parsley	☑ Remove?
Kellogs Cocoa Krispies	☐ Remove?
Nutella Chocolate Spread	☑ Remove?
Oreo Cookies	☑ Remove?
Buitoni Cheese Ravioli	☑ Remove?

Figure 47 Remove Items from List page

The page is made up of a list of all the items that are currently in the Smidge. This list can be scrolled up or down by the user by controlling the scroll bar with the finger. Each row contains an item on the fridge and it also contains a check box. This checkbox can be used by the user to specify whether he or she wants to remove this specific item. The user can mark the checkbox by hitting the row for the item he or she wants to remove. When the row is touched, the checkbox will appear marked as shown on the display. Once the user has decided on all of the items that are to be removed and has selected these items, he or she can hit the remove button.

This button will take every item that was selected from the list and it will remove them from the system. All of the information in the database will be updated accordingly. Once the items are removed, the program will reload this page with the updated list of items without the items that have just been removed. The user can then choose to remove more items by following the procedure mentioned previously, or simply go back to the Items menu by touching the button that reads ‘Done’. This page also contains the tab menu with the choice to go back to the main menu. If the user selects the help button, a page will pop up that will instruct the user on how this page works. The main thing it will clarify is where the Done button redirects the user to. The rest of the functionality can be understood by looking at the design.

5.1.10 Shopping List Menu

Figure 59 shows the prototype page that was developed for the Shopping List Menu main page. This page interfaces the shopping list features of the Smidge. This page can be accessed from the LCD display main menu. That menu gives the user the option to go to items, shopping list, and recipes. If the user selects shopping list from that list of options, this is the page that will come up. From this page, the user can do everything that is related to the shopping list functionality.

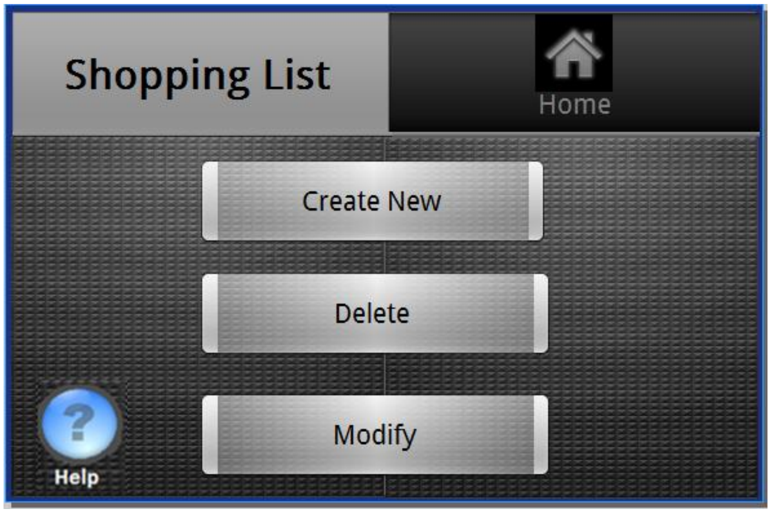
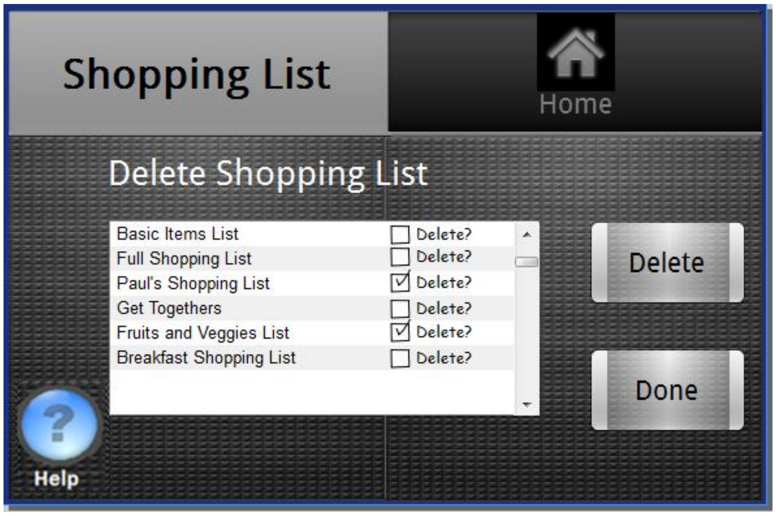


Figure 48 Shopping List Menu page

As seen in Figure 59, the page gives the user three different options. The user can choose create new, delete, or modify. The create new button redirects the program to a page where the user can create a brand new shopping list. This path allows the expansion of the inventory of shopping lists stored in the database. The delete button redirects the program to a page where the user can delete one or more shopping lists already stored in the system. This can be thought of as an up keeping option for the user. The modify button redirects the program to an interface that allows the user to edit an existing shopping list already stored in the database. As shown is Figure 59, this page follows the same design properties as the other components of the LCD display. There is a tab menu on the top with the current item selected being the Shopping List option. There also is an option in the tab menu to go back home. This option will redirect the user back to the main menu of the display. Furthermore, the usual help icon is located on the bottom let of the display. If the user hits this button, a pop up page will appear with the instructions of the page giving the user all of the different options.

5.1.11 Delete Shopping List

Figure 60 shows the prototype page developed for the Delete Shopping List page. This page provides the user with an interface to delete existing shopping lists in the system. This feature was implemented so that the list of shopping lists wouldn't grow infinitely large if the user just kept creating new shopping lists instead of editing them. In any case, should there be a shopping list that the user wants to get rid of this interface allows them to do so.



Basic Items List	□ Delete?
Full Shopping List	□ Delete?
Paul's Shopping List	☑ Delete?
Get Togethers	□ Delete?
Fruits and Veggies List	☑ Delete?
Breakfast Shopping List	□ Delete?

Figure 49 Delete Shopping List page

As seen in Figure 60, the user is presented with a list of shopping lists. This list is generated by retrieving all of the shopping lists stored in the database. The names of the shopping lists are displayed in each row followed by a checkbox next to it. This checkbox becomes selected if the user touches anywhere in the row for that item on the list. This allows the user to specify which shopping lists he or she wants to get rid of. There are two other buttons in this display. One of the buttons is the Delete button. Once the user has selected the shopping lists that he or she wants to get rid of, the user can hit the Delete button and it will redirect the program to a page where this shopping lists are permanently deleted. The other button is the Done button. Once the user deletes the lists on the following page, this page will load up once again and the list loaded will be updated without the deleted lists. By hitting the Done button the user can go back to the shopping list main menu. This is a way for the user to tell the program that he or she is done removing shopping lists from the system and wishes to go back to the shopping list menu. As shown by Figure 60, the layout follows the guidelines specified at the beginning of the prototype process, the tab item selected is shopping list and the other option given is the home button. This button redirects the user to the main menu. There also is a help button placed in the bottom right of the display as usual in case the user has any doubts as to how to use this page.

5.1.12 Delete Shopping List Confirmation

Figure 61 shows the prototype page developed for the Delete Shopping List Confirmation page. This page is accessed once the user hits the delete button in the Delete Shopping List page shown in the previous section. This page gives the user an interface to allow the user to make sure the shopping lists designated to be deleted are in fact the lists that are desired. This step is standard in most applications that allow the user to delete some sort of information from the database. It is done as a precautionary step to make sure the user does not delete something by mistake that can no longer be retrieved.

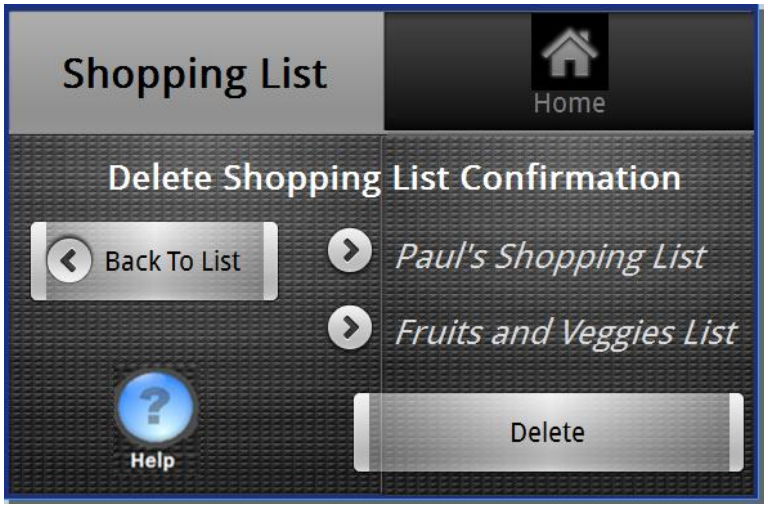
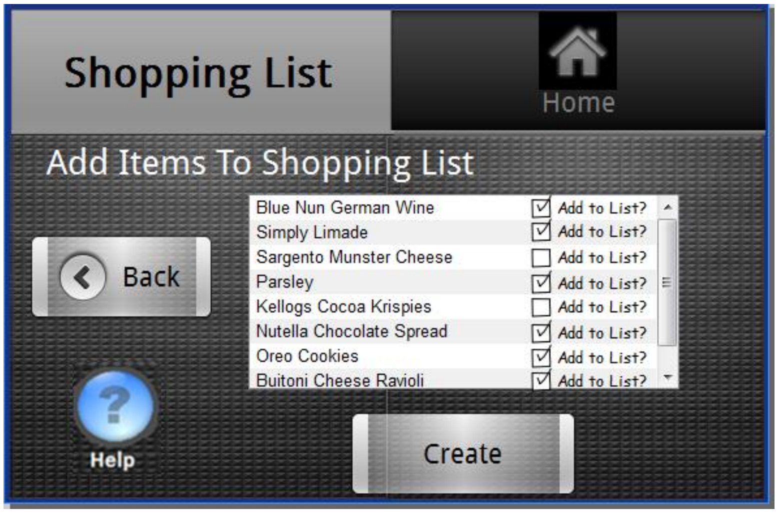


Figure 50 Delete Shopping List Confirmation page

As seen in Figure 61, this page acts as some sort of summary page. The main feature of this page is that it shows the lists that have been selected to be deleted. Next to the name of each shopping list, there is a button with an arrow pointing to the shopping list. If the user hits that button, the program will redirect to a page where the user can view the page in detail. This way, if the user is unsure of what shopping list is the one that is about to be deleted, he or she can click on the list, and view the items that are stored under that shopping list. Another button in this page is the back to list button. If the user decides that there are any shopping lists that need to be added or removed from the shopping lists that are going to be deleted, this button gives the user the option to go back and edit any of the selections. The last button in this page is the delete button. Once the user has made sure that these lists do indeed need to be deleted, he or she can press this button. This will remove these shopping lists from the database and redirect the user back to the Delete Shopping List page to see the resulting list. This page also contains the tab menu on the top of the display. The selected item is shopping list and there also is a button home. If the user selects this button he or she will be redirected to the main menu. The help button is placed in the bottom left corner of the display. If the user needs clarification as to how to use this page the instructions will pop up.

5.1.13 Add Items To Shopping List

Figure 62 is the prototype page developed for the Add Items to Shopping List page. This page is accessed by the user from the Shopping List page once the user selects create new shopping list. This page provides the user with an interface to create a shopping list from scratch and store it in the database along with all the other shopping lists. This is one of the most important pages since it adds one of the benefits of using the Smidge and facilitates the way the user selects what items to buy in the store.



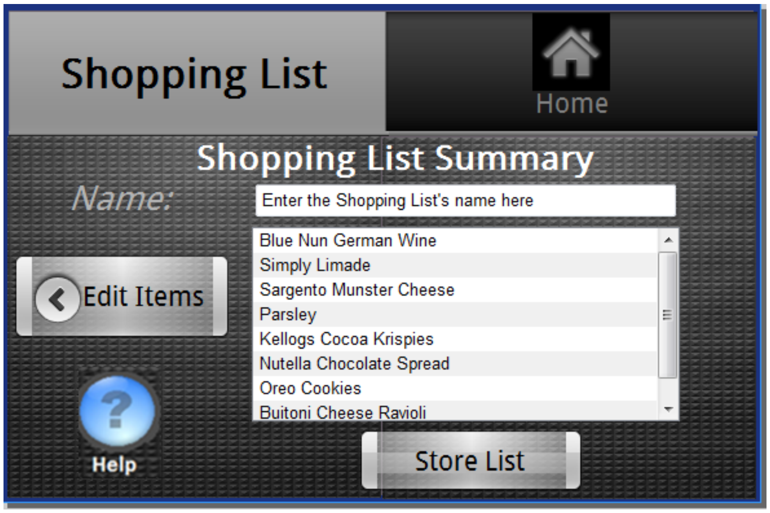
Blue Nun German Wine	☑ Add to List?
Simply Limade	☑ Add to List?
Sargento Munster Cheese	□ Add to List?
Parsley	☑ Add to List?
Kellogs Cocoa Krispies	□ Add to List?
Nutella Chocolate Spread	☑ Add to List?
Oreo Cookies	☑ Add to List?
Buitoni Cheese Ravioli	☑ Add to List?

Figure 51 Add Items to Shopping List page

As seen in Figure 62, this page contains a list with all of the previous items that have been entered into the system at some point. This is a feature that might need revision during the build phase. The reasoning behind displaying only the items that have at some point entered before is that those items are already saved in the system. If the system where to pull out all of the items available in the barcode database, this list would be quite extensive. Instead, by using the items that the user has purchased in the past, the user will get a list with items that he or she will most likely want again and would like to add to the shopping list. As seen of Figure 62, this list is scrollable. The user can use the scrollbar to scroll up and down the list or he or she can simply flick the list on the opposite direction to search through the list. Each row has the item names as well as a checkbox next to it. This checkbox is to allow the user to tell the system which items he or she desires to add to the list. The checkbox can be selected by touching the row of the item the user wishes to add to the list. There are two other buttons in the display. The first one is the Create button. Once the user is done adding items to the list, he or she can hit the create button and the program will redirect them to a page where the shopping list is stored in the database. The other button is the back button. If the user decides that creating a new shopping list is not the option they wanted to select, they can hit this back button that will take them back to the shopping list menu. In hindsight, some of the pages previously created during the prototype phase that do not have a back option, should probably include this option depending on the workflow of that particular page. This page contains a tab menu with the current option selected being the shopping list item. The other option is the home button which sends the user to the main menu. The page as usual contains a help button in the bottom left corner of the page and it provides the user with instructions on how to use this page.

5.1.14 Shopping List Summary

Figure 63 is the prototype page developed for the Shopping List Summary page. This page is accessed by the user once he or she hits the create button on the Add Items to shopping list page. This page provides an interface to the user for making sure the items selected are the correct items that are desired on the shopping list that is being created and also to allow the user to provide a name for this shopping list.



Enter the Shopping List's name here

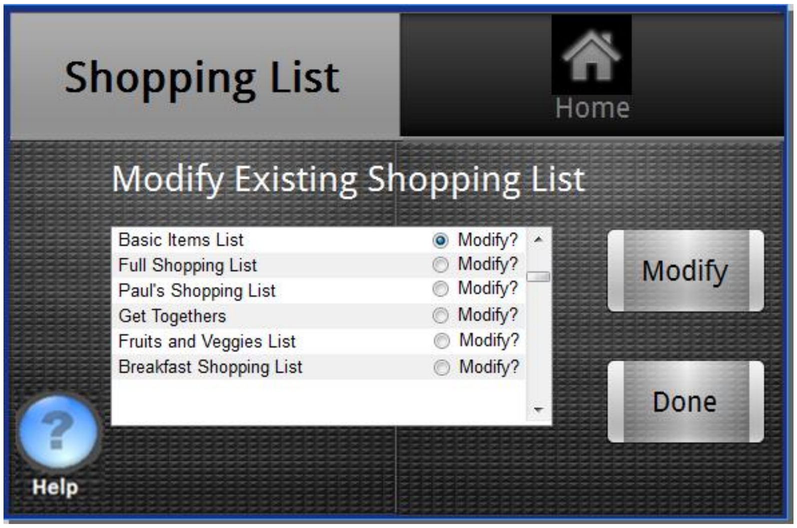
Blue Nun German Wine
Simply Limade
Sargento Munster Cheese
Parsley
Kellogs Cocoa Krispies
Nutella Chocolate Spread
Oreo Cookies
Buitoni Cheese Ravioli

Figure 52 Shopping List Summary page

As seen in Figure 63, the page consists of a scroll down list with all of the items. These items are the ones that were selected in the Add Items to Shopping list page to be included in this list. The user can scroll up and down with the menu bar or flick the list in the opposite direction to search through the list. This allows the user to make sure that all of the items that he or she wants in the shopping list are included in this page, and that no additional items that shouldn't be added to the shopping list were selected. The page also contains a text box so that the user can enter the name for that shopping list. This is done by touching the text box. Once the user does this, a keyboard will come up so that the user can use the touch screen to enter the name. There are two other buttons in this page. The first button is the Store List button. This button gathers all of the information that the user has specified to created the list, the items and name, and stores the list in the database. The page will create the shopping list and then redirect the user back to the shopping list menu. The other button in this page is the edit items button. If the user scrolls through the list of items and decides that there are items that were left out or items that should be removed, this button allows the user to go back to the Add Items to List page to edit the items that need to be stored on the shopping list. This page also contains the tab menu with the current item being shopping list. The home button redirects the user back to the main menu. The help button, located on the bottom left corner, provides a pop up window with instructions on how to use this page.

5.1.15 Modify Existing Shopping List

Figure 64 is the prototype page developed for the Modify Existing Shopping List page. This page can be accessed from the shopping list page as one of the three main options. This page is put in place as another up keeping feature such as the delete shopping list options. This page provides the user with an interface to modify any existing shopping list that needs to be changed.



Shopping List

Modify Existing Shopping List

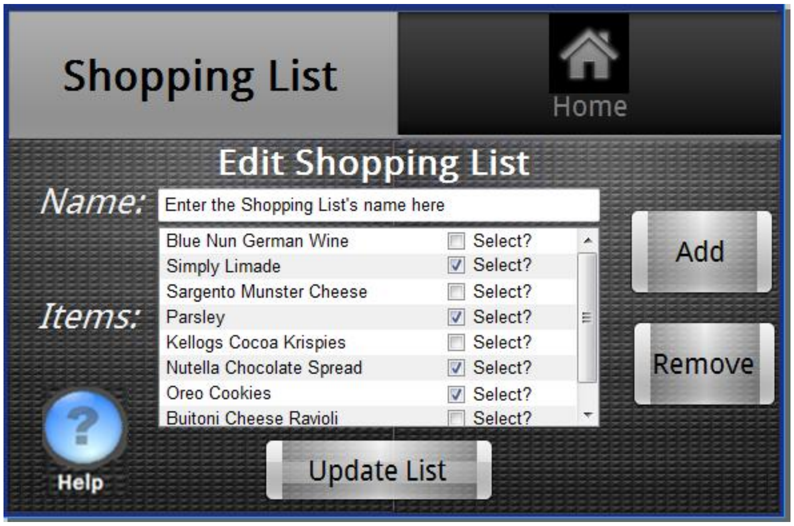
Basic Items List	● Modify?
Full Shopping List	○ Modify?
Paul's Shopping List	○ Modify?
Get Togethers	○ Modify?
Fruits and Veggies List	○ Modify?
Breakfast Shopping List	○ Modify?

Figure 53 Modify Existing Shopping List page

As seen on Figure 64, this page contains a list of shopping lists that are stored in the database. Each row contains the name of a shopping list along with a radio button to select one. Since the user can only select one shopping list then the selection of a shopping list deselects the previous selected shopping list if there was one. The user can scroll up and down by using the scroll bar or by flicking the list in the opposite direction to browse through the list. There are two main buttons on this page. One of the buttons is the modify button. Once the user selects the shopping list that needs to be modified, he or she can go to the page where this list can be modified by hitting this button. The other button available is the done button. Once the user modifies a shopping list he or she will be redirected to this page. If the user wants to modify another shopping list he or she can do so but if not, the done button allows them to go back to the shopping list main menu. This button is a way for the users to tell the system that they are finished modifying shopping lists and wish to go back to the previous menu. As usual, the page contains the tabs menu on the top of the page with the current item selected as shopping list. The home button redirects the user back the main menu. The help icon, located in the bottom left, can be used if the user is unsure of how the page works. If that is the case, instructions will pop up explaining the functionality of the page.

5.1.16 Edit Shopping List

Figure 65 shows the prototype page that was developed for the Edit Shopping List page. This page can be accessed from the Modify Existing Shopping List page after the user selects a shopping list and hits the modify button. This page provides an interface to the user for modifying any of the information regarding a shopping list. From this page, the user can alter the contents of the shopping list or change the name as well.



Name: Enter the Shopping List's name here

Items:

Blue Nun German Wine □ Select?
Simply Limade ☑ Select?
Sargento Munster Cheese □ Select?
Parsley ☑ Select?
Kellogs Cocoa Krispies □ Select?
Nutella Chocolate Spread ☑ Select?
Oreo Cookies ☑ Select?
Buitoni Cheese Ravioli □ Select?

Figure 54 Edit Shopping List page

As shown in Figure 65, the page consists of an expandable list. This list contains the items that are currently on the shopping list. Each row contains the name of the item and a checkbox next to it. These checkboxes can be used by the user to specify which items should be removed from the shopping list. One of the improvements that can be made during the build phase is that instead of labeling these checkboxes ‘Select?’ they should read ‘Remove?’ That way the user knows that the items being selected by the checkboxes are the ones being removed. The user can scroll up and down the list by using the scroll bar or by flicking the list up and down. There also is a text box on top of this list. This box is pre-populated with the name of the shopping list being edited. The user can change the name of the shopping list by hitting the text box and altering the name. When he or she does this, a keyboard will pop up so that the user can change the name. There are two buttons on this display. The first one is add. If there are any items that are not on the shopping list that the user wishes to add, he or she can hit this button to add the items. Then an interface similar to the Add Items page will appear. Once the user is done adding items this page will reappear. The other button is the remove button. This button takes the items that have selected and removes them from the list. The update list button updates the information that has been changed and stores it in the database. This page also contains the tab menu items and is filed under Shopping List. The home menu redirects the user to the main menu and the help icon gives the user directions to how to use this page.

5.1.17 Recipes Menu

The page prototype for recipes is shown in figure 66. This page is accessed via the main menu, when the user selects the ‘Recipes’ button. As seen before, this page maintains the same look and feel as the overall interface, to make it cohesive and user-friendly. This page consists of three main choices for the user: ‘Find recipes matching inventory’, ‘Recipes with [specified amount] missing ingredients’, and ‘list of all recipes’. The three choices are displayed in the form of large buttons to ease the execution of them by the user.

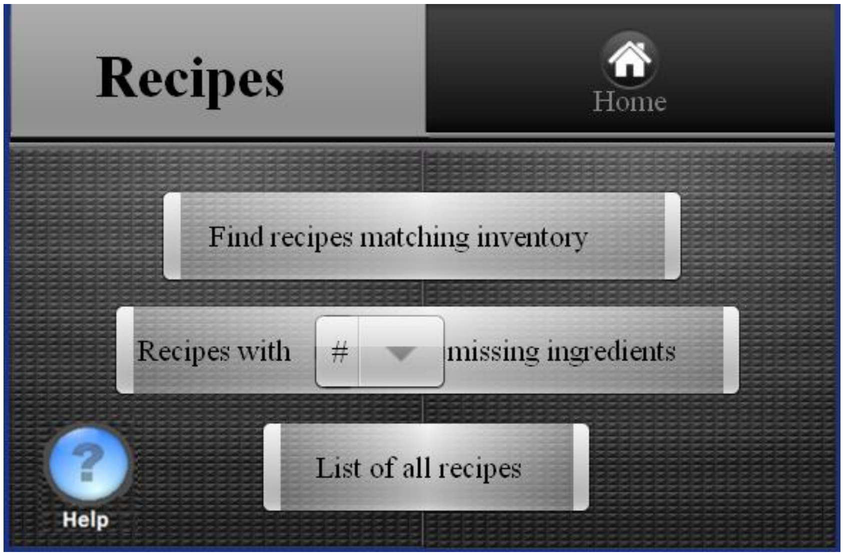


Figure 55 Recipes Menu

If the first option is chosen: ‘Find recipes matching inventory’, the program will attempt to perform a search on the recipes saved earlier on the recipe database. It will take a recipe, and one by one verify that all of its ingredients are present on the current refrigerator inventory. If it doesn’t find any one of those ingredients, it moves on to the next recipe. After going through all the recipes on the database, it will come up with a list of all the recipes you have enough ingredients for. If the system fails to find recipes for which the user has all ingredients needed, it will let the user know there were no results matching the query and it will suggest using the second option, ‘recipes with a specific amount of missing ingredients’.

If the second option is chosen: ‘Recipes with [specified amount] missing ingredients’, the user will first have to specify how many missing ingredients he would like to have skipped over before the system moves on to the next recipe. This option is mainly to accommodate for recipes that might have minor ingredients that can be replaced by others, or ones for which the list of ingredients could be completed with a small purchase. This page is shown in figure 67. The number of ingredients missing choice will be a dropdown menu, when the user selects it, a drop down with the numbers 1-10 will appear to allow the user to choose as they like. Then, they would press the bigger button to let the system perform the specified search on the recipes inventory. If the system fails to find any matching recipe, it will let the user know that no results have been found matching this search, and it would suggest to manually look at all recipes available in the inventory.

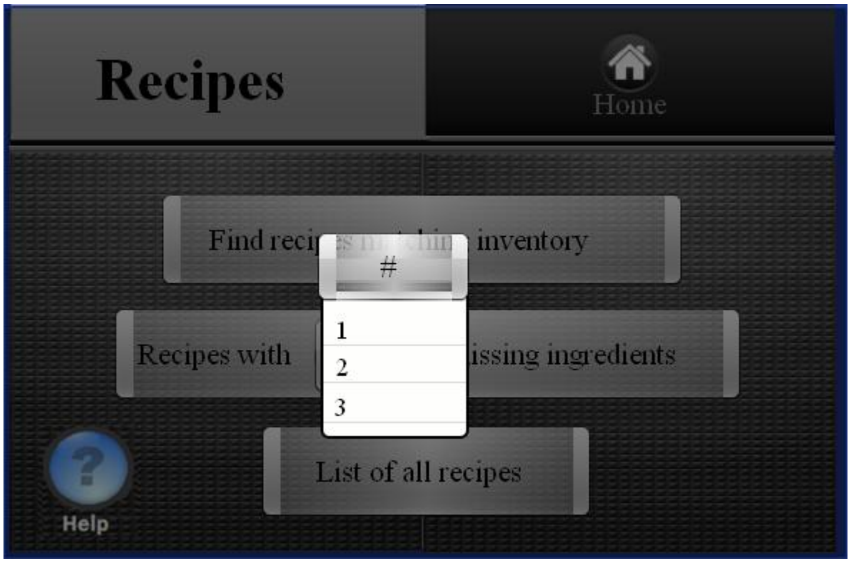


Figure 56 Pop up window when choosing amount of missing ingredients

If the third option is chosen: ‘List of all recipes’, the system will simply display all of the recipes available in the inventory without performing any searches. This will be the fastest of the three choices; however, the user will simply have to scroll through the list of recipes to find the recipe they are looking for. (For all of these, coding in the Android platform will allow for swiping your finger up or down to scroll through a page).

5.1.18 List of Recipes

The ‘list of recipes’ inventory page is shown in figure 68. It will simply display a list of recipes for any of the choices from the main menu. The user will be able to see this page if they have chosen to: ‘find recipes matching the inventory’, given that the recipes shown will only be the ones matching the current refrigerator inventory; ‘find recipes with a specific amount of given ingredients’, given that the recipes shown will only be the ones matching the set parameters; or finally if the user chooses to see the ‘List of all recipes’, in which case, all of the recipes available will be shown.

To this design, we hope to be able to implement a search button for the third menu choice: ‘List of all recipes’. This search field would make a keyboard pop up in order for the user to input the specific name of the recipe they wish to search for. Also, we could add a scrolling bar on the side with the letters A-Z si that the scrolling experience is more effective and user friendly, as the user would be able to simply touch the screen on the exact first letter of the recipe they are looking for instead of having to scroll down to it.

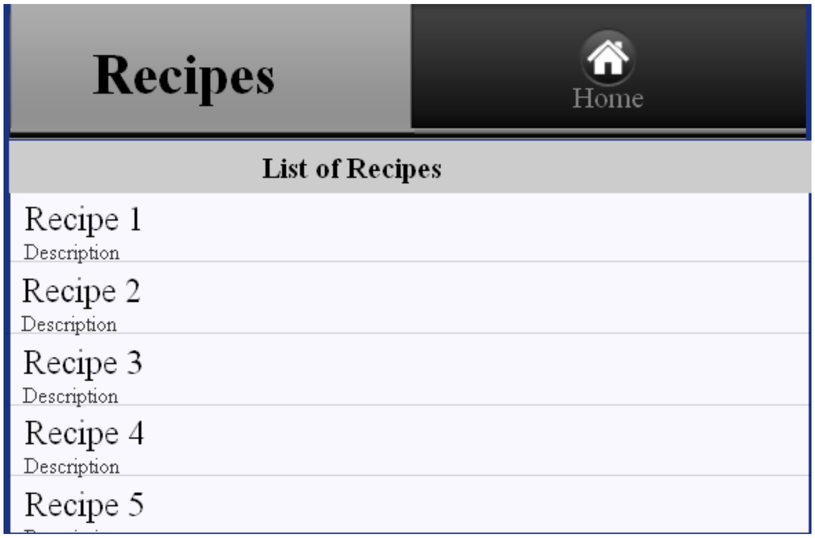


Figure 57 List of recipes

5.1.19 Recipe Description

The Recipe description prototype page is shown in figure 69. This page can be accessed whenever the user selects one of the recipes from the list of recipes shown by any of the three choices chosen at the beginning of the recipe menu. This page's purpose is to display the content of a specific recipe. It will be clearly divided into two sections: one displaying the ingredients needed to create the recipe, and a second one displaying the procedure with each step divided in a bullet point.

This screen would also show the amount of every ingredient right next to it, and when the system is performing a search of whether or not the user has the item in the inventory, the amount will also be matched to this query so that the results are much more specific and accurate. Without this, search results would not be of much use if the user has 1 apple but need 5 in order to create a recipe.

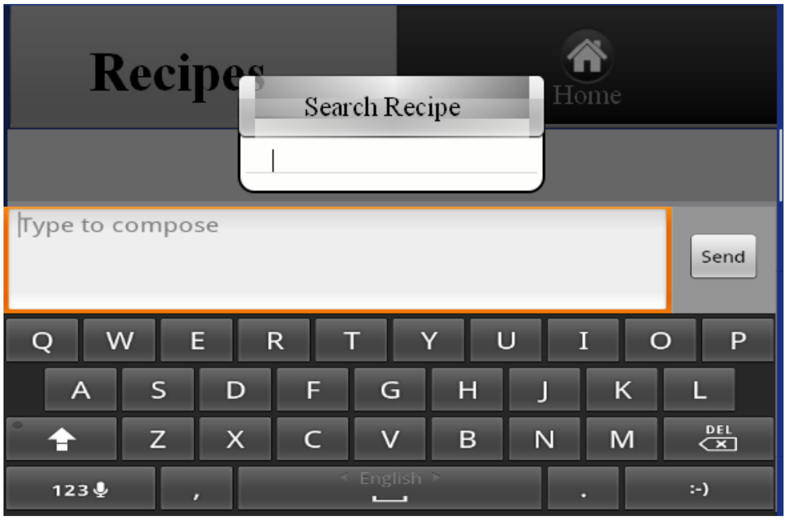
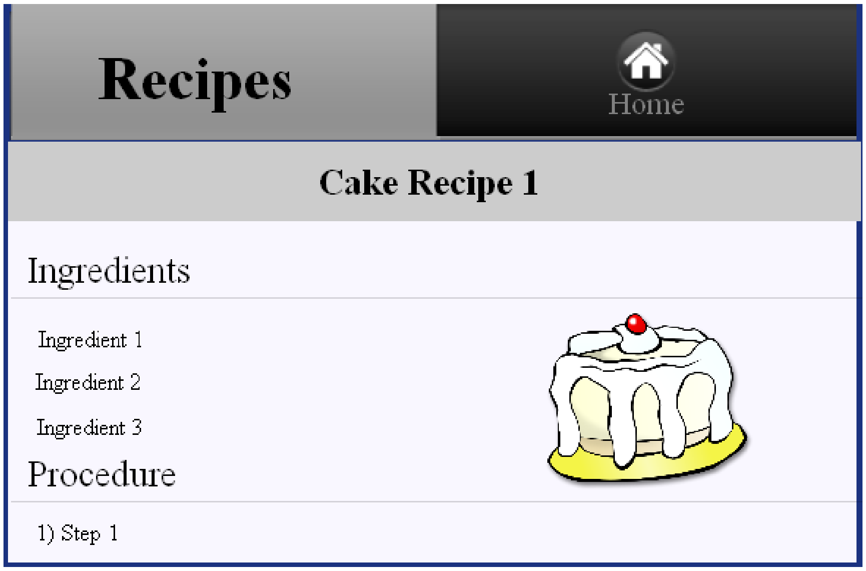


Figure 58 Optional Search Option for recipes

Alternatively, we could simply place a button below the ingredients labeled ‘procedure’. The user would be able to press only if they choose to see the procedure in the refrigerator system (as opposed to the website or mobile application). By pressing this button they would be able to see either one step on each screen, and a next button on the bottom of the page; or simply the entire set of procedures for that specific recipe.



Recipes

Home

Cake Recipe 1

Ingredients

Ingredient 1

Ingredient 2

Ingredient 3

Procedure

1) Step 1

Figure 59 Recipe description

As an option, we could allow the user to pick any one of the ingredients shown in a recipe, and add it to the shopping list of their choice. This could be implemented by having a popup window appear when any ingredient is clicked that will show a list of all available shopping lists, the user would then choose the shopping list they would like to add this to, and the system would go ahead and add the item, with the amount specified on the recipe. This type of popup choice with a list of all shopping lists is shown in figure 70. As you can see in the figure, the background is shaded darker since the user is not able to access it at the moment. The user must choose a shopping list created in the past in order from the popup menu, or a cancel option at the end if he does not wish to add it to any list (cancel button not shown on prototype page).

Having the recipes’ ingredients and procedures showing on the refrigerator display is not only convenient if the user wishes to see if he can manage to find the ingredients necessary, but also to have a close location on where the recipe is shown while cooking a meal. This helps the user have a better experience and the convenience of having everything stored and accessible from the same place. Therefore, it adds to the user-friendly aspect of the application.

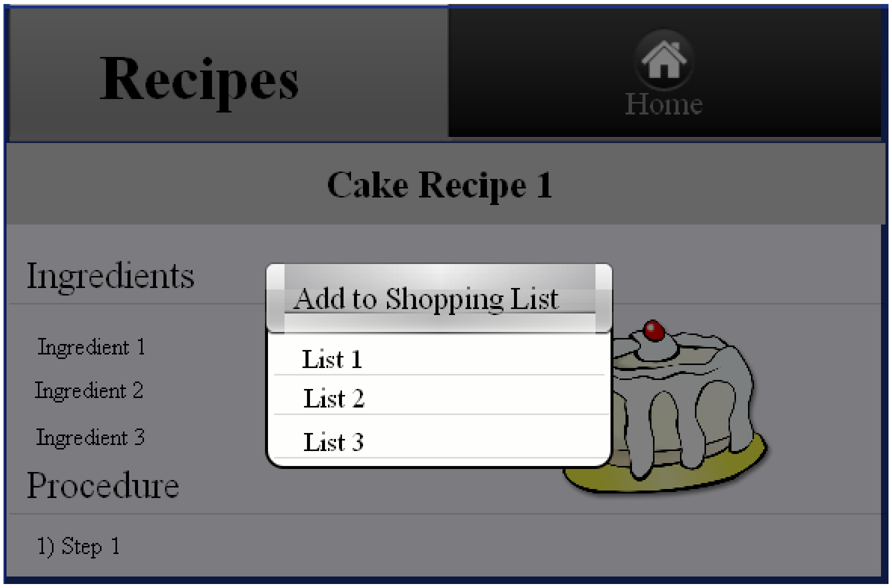


Figure 60 Adding a Recipe Ingredient to a shopping list

On every one of these prototype pages, the option of returning to the main home page exists on the top right corner of every page. If the user chooses to press this option, the system will return to the main screen where we will have again the three main choices of items, recipes or shopping lists. Also, on the recipes main menu page, a help button exists. When pressed, the user will be given basic directions on how to use the given pages and menus.

5.1.20 LCD Display Settings

Settings Main Menu - The settings prototype page is shown in figure 72. It can be accessed through the button located on the main screen of the system. The purpose of this Settings option is for the user to be able to see the account affiliated with the system at the moment. Many options could be added to this page in the future for a more custom feel to the application.

The Settings page displays the Account username, which the user can use to log onto the webpage or mobile application. It also displays the email associated with this account. If the user desires to change any of these fields, he will only be able to do so through the webpage. If the user is trying to sign in with a different account, he must first log out of the current account. These fields are only displayed for informational purposes, in case the user needs this information or wants to know which account the system is currently affiliated with.

The Settings menu also has a field for 'password'. This lets the user change the current password to a different one. In order to achieve this, the user must be aware of the current password; when the user clicks the field to change it, the system will prompt the user to write the current password. If the password written is correct, the system will then let the user change the password. It will prompt for a new password twice to make sure the user doesn't make any keyboard mistakes and avoid any entry hassles.

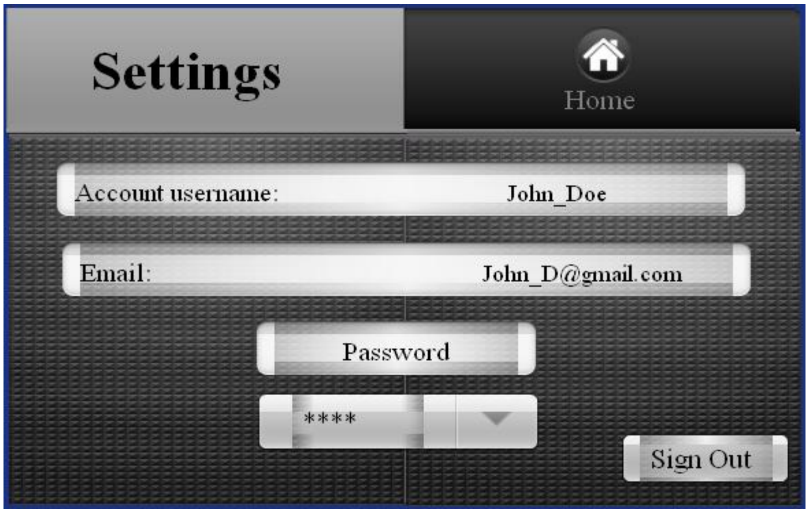


Figure 61 Settings Menu

When the user attempts to change the password by pressing the dropdown menu, a keyboard will appear in the bottom of the screen. This will allow for the better use of the system in order for the user to correctly and easily change passwords if needed. This prototype page is shown in figure 72. For brevity, not every step is shown, but having to write the old password, and the new password twice will have the same look and feel of this prototype page. In the case that the user does not type in the correct password, the system will advise as such. However, after the third attempt, the system will implement a timeout on which the user will not be able to attempt to change the password. If the user persists after the timeout has expired, and the password is still incorrect, the system will be automatically signed out and the login screen will be shown on the screen. The settings menu also has the choice to sign out of the account. If a user signs out, no one is able to access their shopping lists, recipes or inventory until the user signs in again. Whenever the sign out button is pushed, a popup will ask the user if they are sure they want to sign out of the account. If the user presses yes, the system will return to the main login screen until someone else attempts to sign in with the same or a different account.

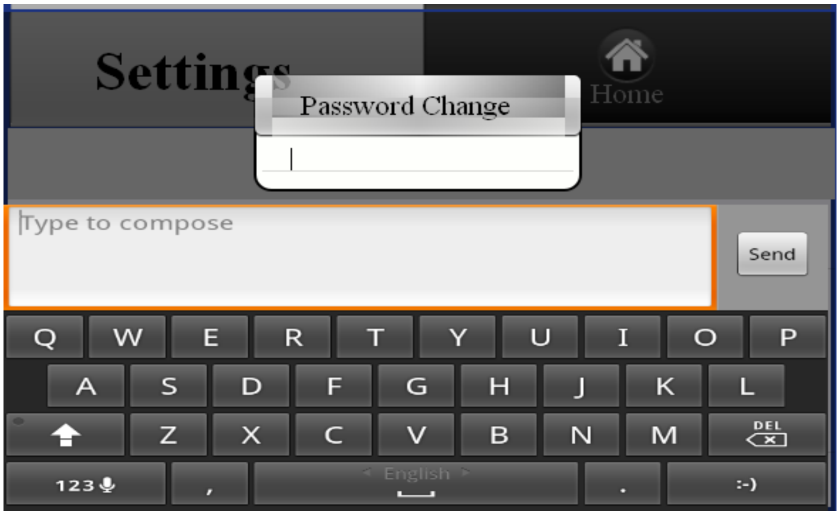


Figure 62 Settings Password Change

5.2 Mobile App

5.2.1 Main Menu

This is the prototype for the Main Menu Mobile App page. This first page starts the interaction between the user and SMIDGE through a mobile device. Once the user opens the SMIDGE Mobile application from its personal cell phone a Menu page should open with three buttons that represent different options: View Items, View Shopping Lists and View Recipes. On the bottom of the page there are two option buttons, Options and Exit. By selecting Options a menu with helpful links shall appear, this menu shall have an option to show all open applications, a Help option that opens a page with instructions on how the SMIDGE Mobile application works and at last the option to exit the current page to the previous one. If the Exit option is selected the application goes back to the previous menu. Once the user selects one of options buttons the application proceeds to open a different menu. The Figure below shows the Main Menu screen of the phone application.

Main Menu screen with its options:
-View items
-View shopping list
-View recipe

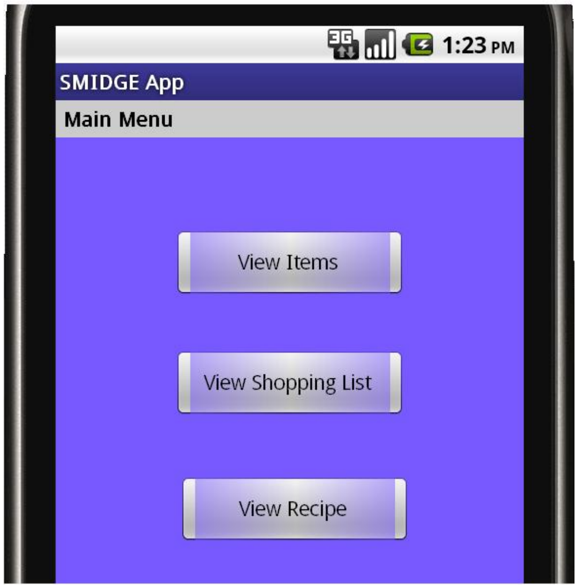
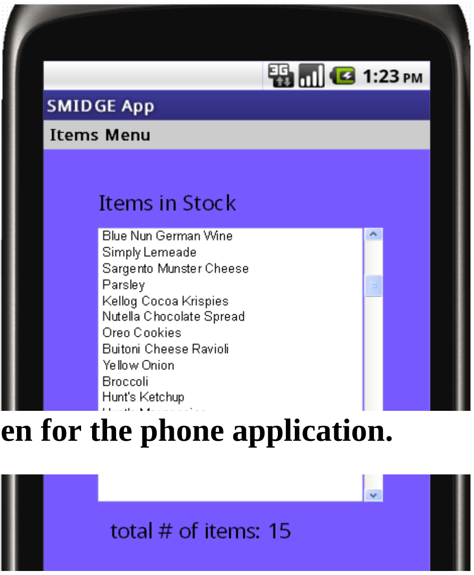


Figure 63 Main Menu screen of the phone application

5.2.2 Items Menu

This page allows the user to review the items in stock, go through every single one of them. It shows a list with all the items in stock and total number of products in the database. The user can scroll down and up the list to review all items. The user shall be able to select an item from the list and review its information such as how many items of the same kind are there in the fridge, expiration date, brand name and calories. The Figure below shows the Items Menu screen for the phone application.

Items Menu screen with a list of all items in stock



Blue Nun German Wine
Simply Lemeade
Sargento Munster Cheese
Parsley
Kellog Cocoa Krispies
Nutella Chocolate Spread
Oreo Cookies
Buitoni Cheese Ravioli
Yellow Onion
Broccoli
Hunt's Ketchup

total # of items: 15

Figure 64 Items Menu screen for the phone application.

5.2.3 Shopping List Menu

This page allows the user to access the shopping lists in the inventory. It has three options: Create New, Delete and Modify. If the user selects the Create New option the application created a new shopping list with new items. To enter the new items on the inventory a new page with a text box shall appear in the screen. The user will type the name of the new products in the text box by using the smart phone keyboard. The Delete option shows all the shopping lists and their corresponding dates allowing the user to choose the list that shall be removed. After a list is deleted the user can go back to the previous menu by clicking on the Exit option or can stay in the current menu if more than one list shall be removed. The Figure below shows the Shopping List Menu screen for the phone application.

Shopping List Menu options:
-Create New
-Delete
-Modify

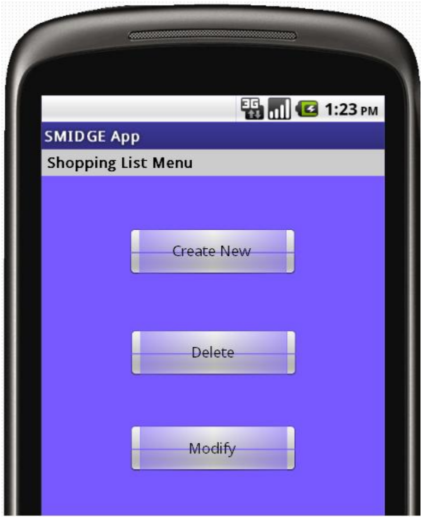
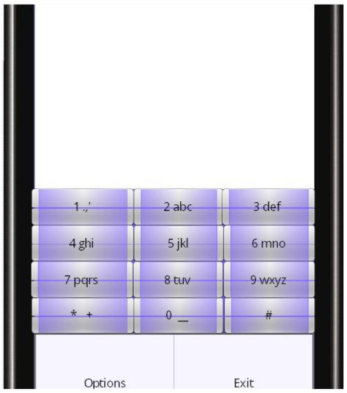


Figure 65 Shopping List Menu screen for the phone application.

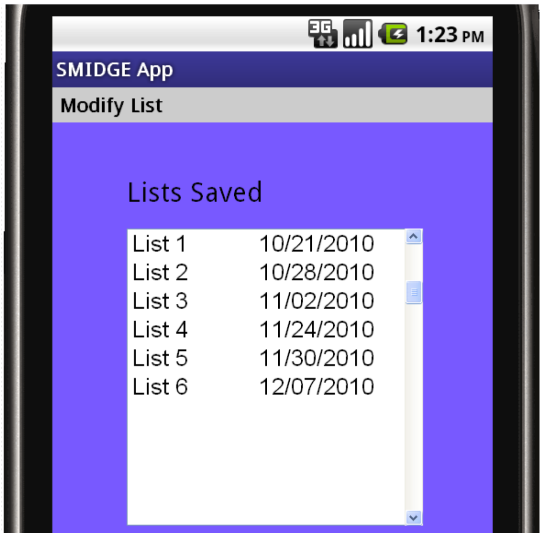
The Figure below shows the phone screen when the option Create New List is selected in the phone application.



Screen that allows the user to type in the new shopping list

Figure 66 Create New List screen for the phone application

If the Modify option is selected the application shows a new page with a list of the shopping lists enumerated and the date they were created. The user can scroll down or up through the list so it reviews all the shopping lists on inventory. The user shall select a shopping list from the list; the chosen one will be highlighted. The list selected will be shown on a new screen. Once the list is open it is possible to make changes to it. Using the smart phone keyboard the user can add the items desired to the list. The Figure below shows the Modify List screen for the phone application.



List 1	10/21/2010
List 2	10/28/2010
List 3	11/02/2010
List 4	11/24/2010
List 5	11/30/2010
List 6	12/07/2010

Shopping lists saved in the database and the date created.

Figure 67 Modify List screen for the phone application

5.2.4 Recipe Menu

The Recipe Menu page shows two options. First option to display all recipes in inventory and second option to display all recipes which ingredients are in the refrigerator, so these belong to the ready to go recipes group. The Figure below shows the Recipe Menu screen for the phone application.

Recipe Menu screen with its options:
-show all recipes
-show ready to go recipes

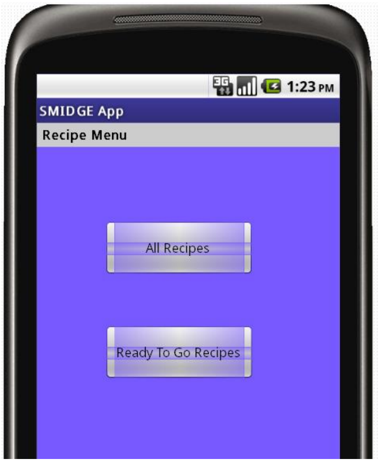
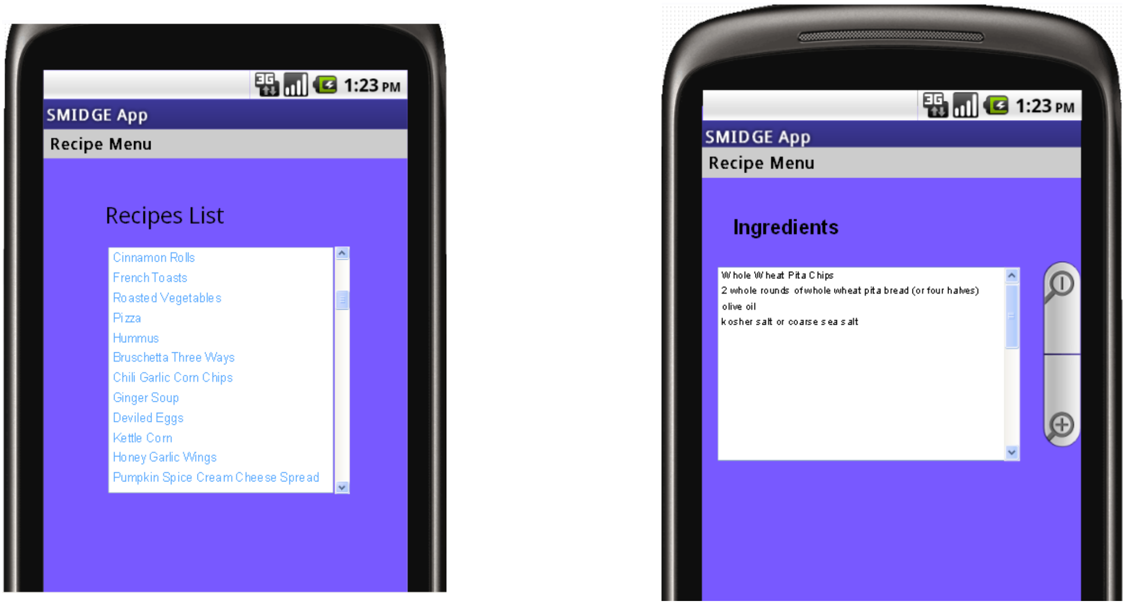


Figure 68 Recipe Menu screen for the phone application

From the Recipe Menu the user can choose to either see all recipes or to see just Ready To Go Recipes. After one of the options is chosen the application shall display a list of recipes names according to the previous menu. This screen has the tool to scroll down or up the list in order to read all the available recipes in the system as it shows in Screen #1 of Figure 80. The user shall choose one of the recipes from the list and the recipe will be highlighted. The selected recipe will be open in a different screen. Screen #2 of Figure 80 is the prototype of how the system proceeds to open a new page with the recipe name and ingredients needed. In this new page, that shows the ingredients corresponding to the recipe, there is a zoom in and out tool. In case of small letters or small phone screens the ability to zoom in or out makes it easy for the user to read the ingredients. The zoom tool is also very useful with recipes that contain a lot of ingredients, to make sure nothing is left out. The screens below corresponding to Figure 80 show the Recipe Menu different screens for the phone application; screen #1 list of all the recipes in inventory and screen #2 ingredients used in the recipe.



Cinnamon Rolls
French Toasts
Roasted Vegetables
Pizza
Hummus
Bruschetta Three Ways
Chili Garlic Corn Chips
Ginger Soup
Deviled Eggs
Kettle Corn
Honey Garlic Wings
Pumpkin Spice Cream Cheese Spread

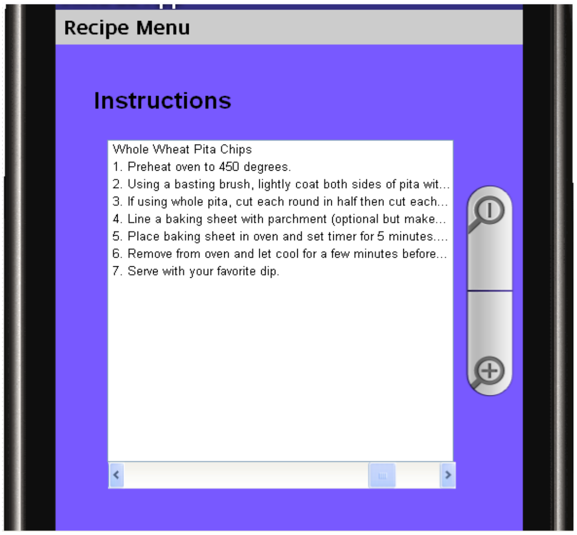
Whole Wheat Pita Chips
2 whole rounds of whole wheat pita bread (or four halves)
olive oil
kosher salt or coarse sea salt

Screen #1 Recipes list

Screen #2 Ingredients used in the recipe

Figure 69 Recipe Menu screen for the phone application

By clicking on the label with the word Ingredients in the Recipe Menu-Ingredients page, the system proceeds to open a new phone screen with the title Instructions. The Instructions screen will have a detailed procedure of how to cook a recipe. The screen will show the name of the recipe chosen and right below a list with all the instructions. The instructions will be enumerated so the user can follow the right order of steps. This page with the tool to scroll from left to right to read complete instruction's sentences and has also a zoom in and out tool to make the process more comfortable for the user, in case of a small font, small screen, or lost glasses zoom in and out and it shall be easier to read the steps to follow. The Figure below shows the Recipe Menu screen for the phone application with the instructions on how to cook the chosen recipe.



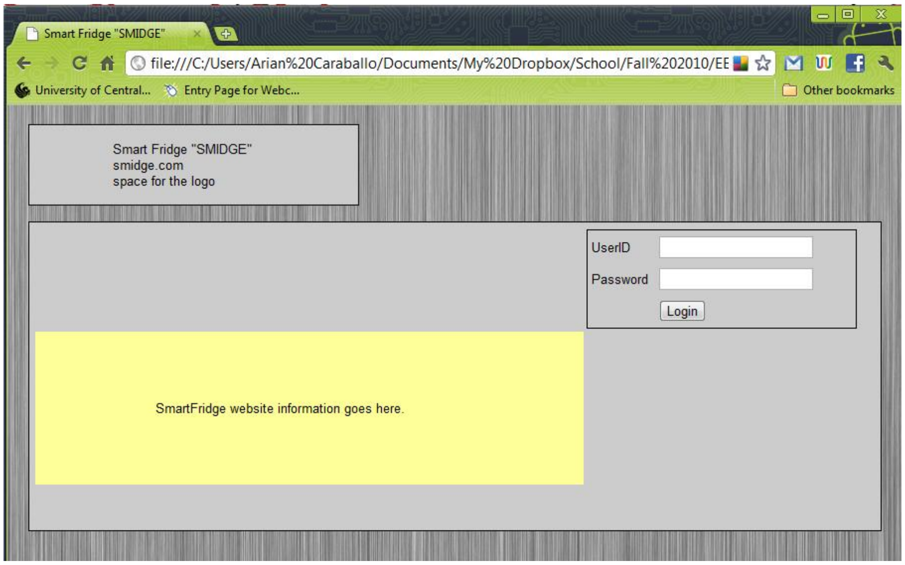
Whole Wheat Pita Chips
1. Preheat oven to 450 degrees.
2. Using a basting brush, lightly coat both sides of pita wit...
3. If using whole pita, cut each round in half then cut each...
4. Line a baking sheet with parchment (optional but make...
5. Place baking sheet in oven and set timer for 5 minutes....
6. Remove from oven and let cool for a few minutes before...
7. Serve with your favorite dip.

Phone screen with the instructions on how to prepare the recipe

Figure 70 Recipe instructions screen

5.7 Web application prototype

The web application is going to have a login screen that contains a place holder for the logo on the left top corner. On the center of the page there is a space that is going to be use for the explanation and promotion of the product and the website. This area will also contain a video tour of what the product can do and links to other related websites. On the right site there are two text boxes and a button used to login to the website. The design is not going to have any sign up page since the user, to use the website, have to create the account on the LCD display. A prototype of the login page is shown bellow in Fig 82.



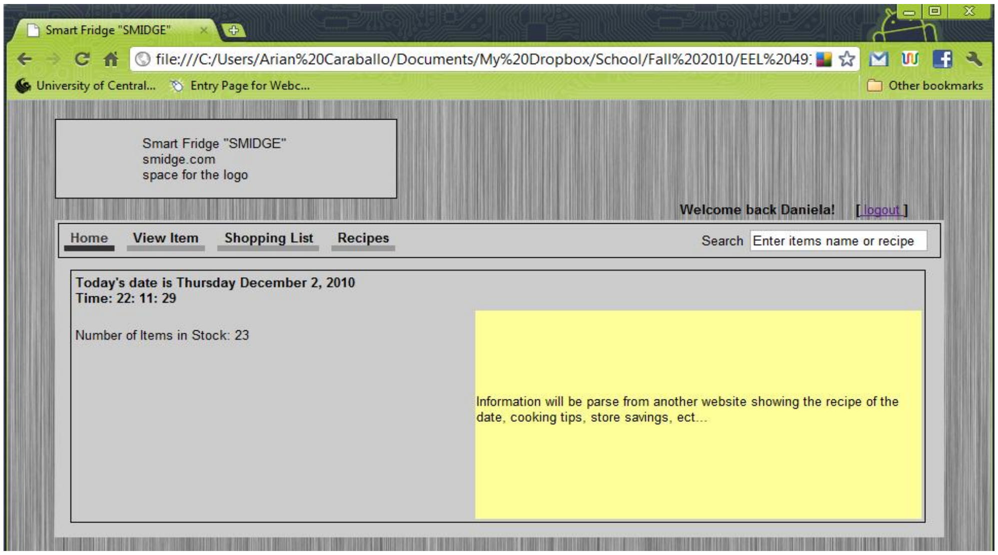
file:///C:/Users/Arian%20Caraballo/Documents/My%20Dropbox/School/Fall%202010/EE

Smart Fridge "SMIDGE"
smidge.com
space for the logo

SmartFridge website information goes here.

Figure 71: Login Page Prototype

After the users log into the system they will see the home page. The home page and all the following pages have a place holder for the logo on the top left corner. On the right corner there is a welcome message with the name of the user followed by a logout link that logs the user out of the section and redirects him to the login page. Right under the welcome message there is a tab menu with four different tabs with the following order: Home, View Item, Shopping List, and Recipe; these tabs are all linked to their corresponding pages. There is also a search textbox where the user can look for a certain item or recipe just by typing the name and hitting enter. The body of the home page contains text with the date and time and it shows how many items are currently in stock. To the right there is going to be information parse from another website showing the recipe of the date, cooking tips, and store saving. The page will probably have more information about the user such as monthly saving chart, caloric counter, healthy tips, etc… Fig 83 is a prototype what the user home page could potentially look like.



file:///C:/Users/Arian%20Caraballo/Documents/My%20Dropbox/School/Fall%202010/EEL%2049:

Smart Fridge "SMIDGE"
smidge.com
space for the logo

Welcome back Daniela! [logout]

Search: Enter items name or recipe

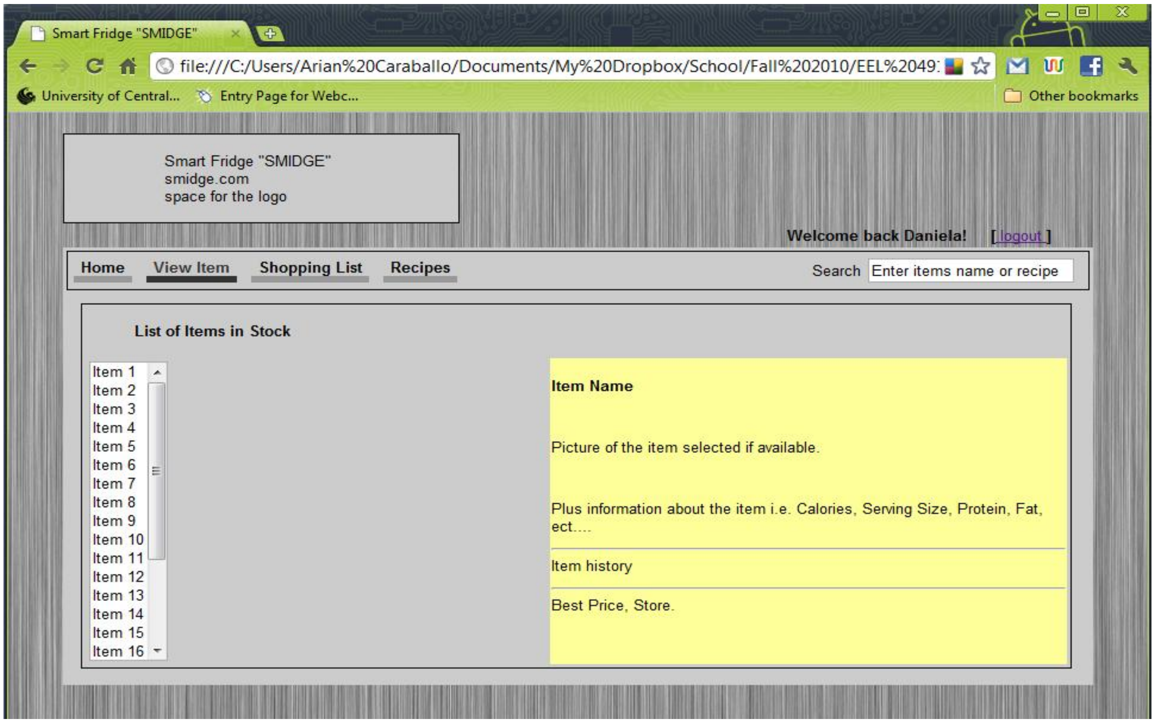
Today's date is Thursday December 2, 2010
Time: 22: 11: 29

Number of Items in Stock: 23

Information will be parse from another website showing the recipe of the date, cooking tips, store savings, ect...

Figure 72 Home Page Prototype

The view item page has, on the main body, scrollable textbox with all the items that are currently in stock. Here the user can select an item to get more information about it. To the right of the items list there is a box containing the information about the selected item. The information is organized the following way: Item Name follow by a picture of the item if available, nutrition facts table containing information such as calories, serving size, fat, and proteins. There is also an Item History that has information such as the last time the item was bought, its price, quantity left, and the name of the store that had the lowest price. This information is taken from the UPCOnline database, and from the user input. Fig 3 is a prototype of what the user home page could potentially look like.



Smart Fridge "SMIDGE"
smidge.com
space for the logo

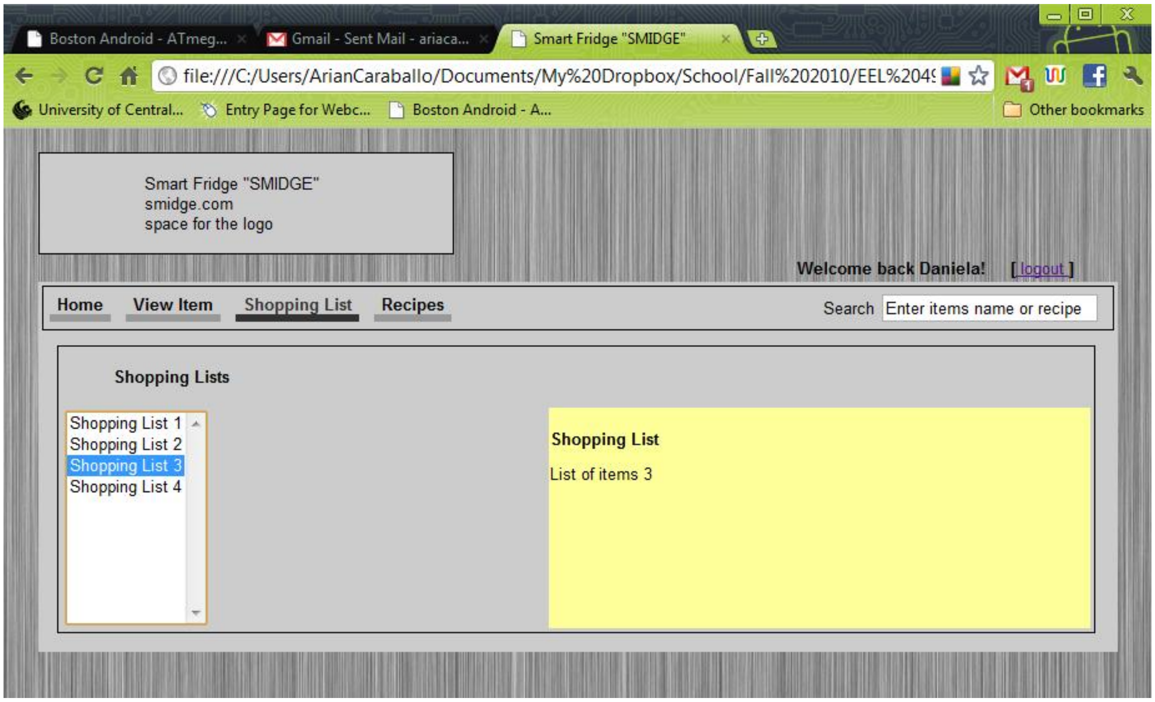
Picture of the item selected if available.

Plus information about the item i.e. Calories, Serving Size, Protein, Fat, ect....

Figure 73 View Item Prototype

Figure 84 shows the Shopping List screen for the Web application. On the left side of this page there will be a Shopping lists label with a list of shopping lists below. Every shopping list will be enumerated and a scroll bar will allow to scroll down or up through the list. The user must select one the lists to view its content. Once a shopping list was selected all its content will show on the right side of the screen where the label Shopping List is.

In the Recipe section of the web application there will be two options View Recipe and Create Recipe. If the View Recipe options is chosen the system will show the screen in Figure 82, if the Create Recipe option is chosen the screen in Figure 83 will show.



Smart Fridge "SMIDGE"
smidge.com
space for the logo

Welcome back Daniela! [logout]

Enter items name or recipe

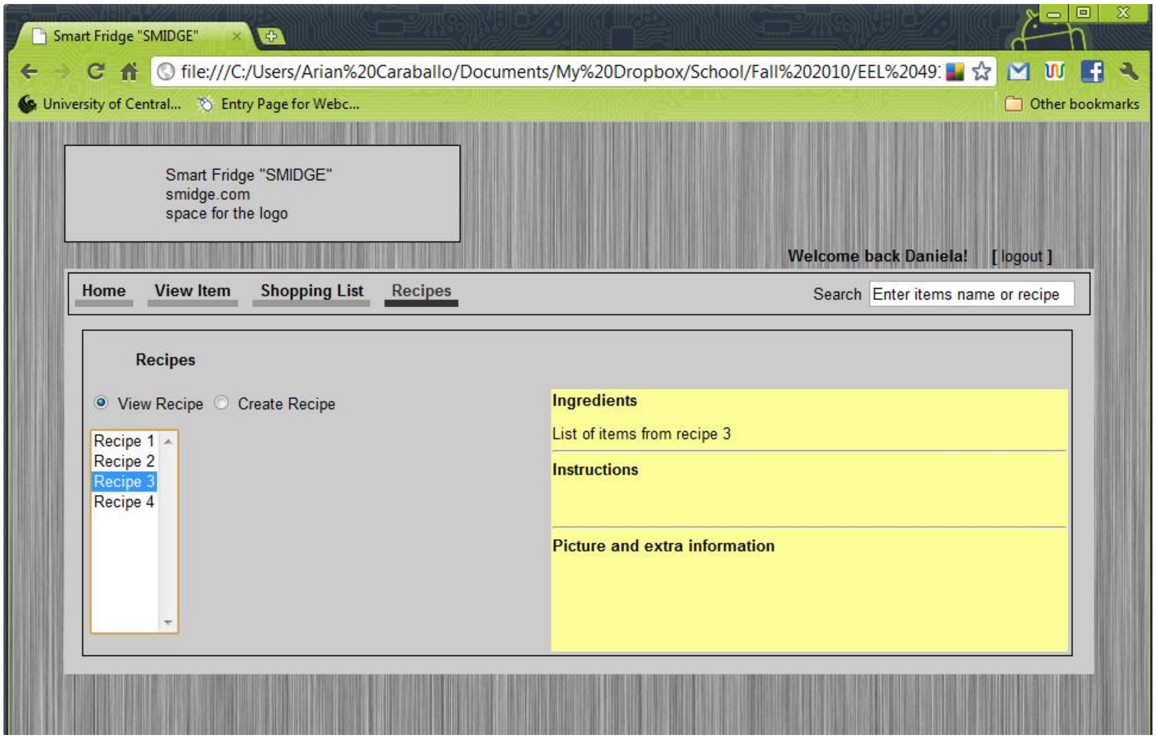
Shopping Lists

Shopping List 1
Shopping List 2
Shopping List 3
Shopping List 4

Shopping List

List of items 3

Figure 74 Shopping List Prototype



Smart Fridge "SMIDGE"
smidge.com
space for the logo

Welcome back Daniela! [logout]

Enter items name or recipe

Recipes

● View Recipe ○ Create Recipe

Recipe 1
Recipe 2
Recipe 3
Recipe 4

Ingredients

List of items from recipe 3

Instructions

Picture and extra information

Figure 75 View Recipe Prototype

The page shown in Figure 86 corresponds to View Recipe from the Recipe tab. On the left side of the screen a list of recipes will be shown. Each recipe will have a name and it is possible to scroll down or up through the list to view all recipes. One of the recipes from the list must be selected.

On the right side of the screen there are three labels ingredients, instructions and extra information. Below Ingredients the ingredients for the chosen recipe will be shown. Below Instructions the instructions on how to cook the recipe will be shown. If there is a picture linked to the recipe and any extra information that was not included in the instructions section it will show below Picture and Extra Information.

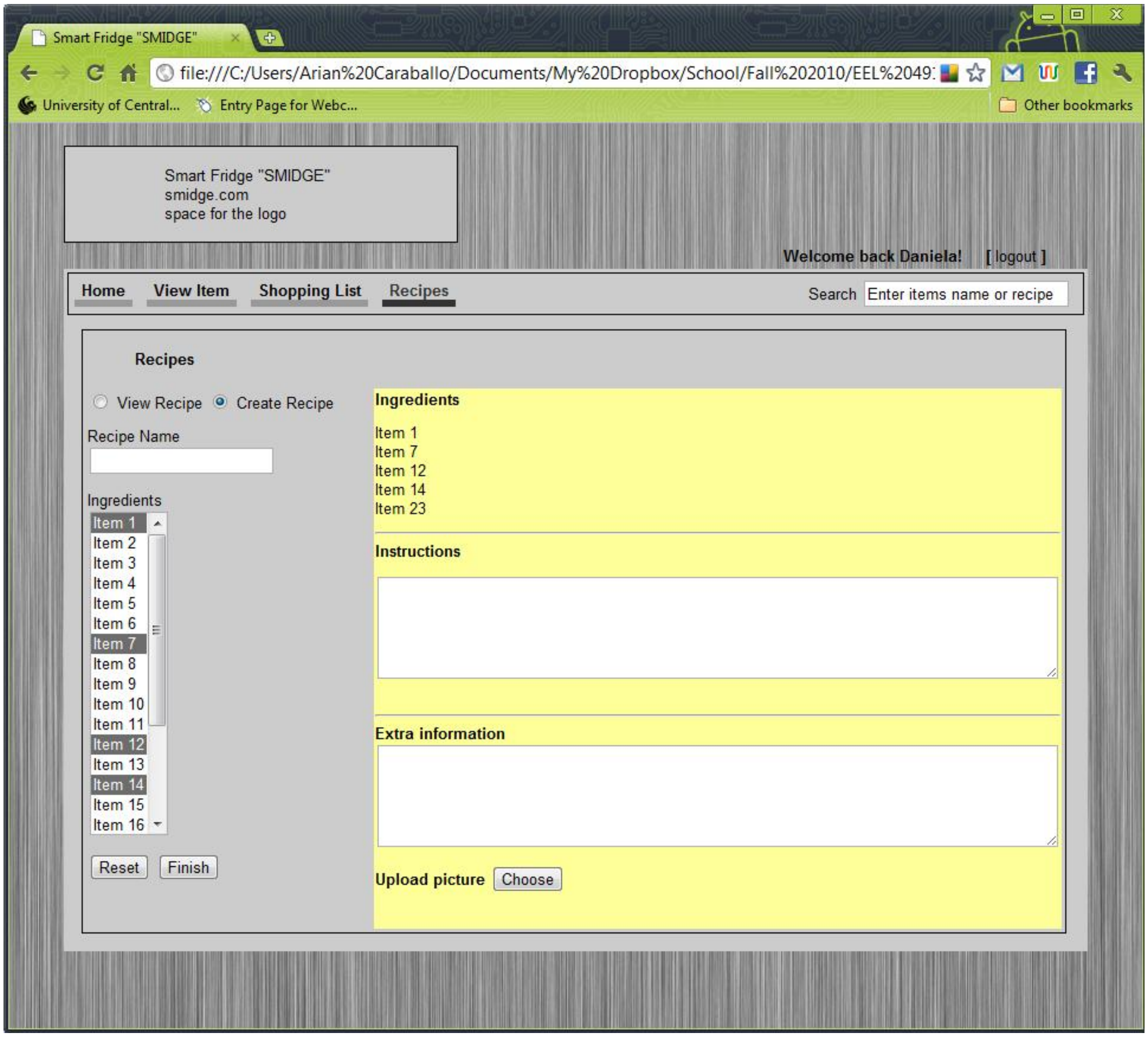


Figure 76 Create Recipe Prototype

The page shown in Figure 87 allows the user to create new recipes and save them into the system. On the left side of the screen there is a text box with the label Recipe Name on top of it, in this box the user will type in the name of the recipe that will be created. The user will choose the ingredients that will show in a column in the right side of the screen. It will enter the instructions on how to cook the recipe and any extra information on it. If there is a picture of the recipe that the user will like to attach it is also possible. If the Choose button on the bottom of the page is clicked it will allow going into the computer and looking for a picture.

One the left side of the screen a menu with ingredients will appear, all items will be enumerated and the user can scroll down or up through the list. The list has the option for multiple selections of items. Every item selected from this list it will be automatically copied to the Ingredients section on the top right side of the screen. Below the Ingredients list there will be two buttons with the options Reset and Finish. If the Reset button is click it will delete the selection made. If the Finish button is click all the information that was written in the text boxes on the right side of the screen will be saved to the database.

6. Testing

In order to assure the quality of our project and its ability of service under test it is necessary to test every software and hardware component on it. This section takes a lot of time from the project and must be done with all the right procedures. When testing the software components of our system all the different cases have to be tested, the right cases and the invalid ones. SMIDGE must be tested for every situation that may represent a hazard for it. To test the hardware components a different strategy has to be followed. Hardware components shall be test in case of temperature changes. We should pick a high and a low temeprature points that will test our components in case of real life temperature changes. After the project has been tested it shall be able to work as expected, meeting the business and technical requierements.

6.1 Code testing

To test the code the team decided to implement a Test Driven Development (TDD). Test driven development has become more popular in recent times and it is a new tool that the team has been interested in trying. This project is the right moment for our team to test how a TDD works and to give it a shot in a controlled environment. There are several TDD helper applications as plug-ins for multiples IDE’s. A test-driven development is hard to use when full functional tests are required in order to obtain complete faillure or success, our system is one of these situations since it is a program that works with databases. In this case TDD recommendation is to test small portions of code with large test files that simulate the most a real world situation.

When starting a set of tasks the first thing to be done is to identify the test cases for the result that we want to obtain. To test the code all the classes that shall be use in the system must be created with their functions. An example for our system will be to create a class ShoppingList as part of the smidgeLCD package, declared all its variables and implement all its methods. To test this class a test with all the right cases is necessary, but also a test with all the cases that will make the application fail. In the case of testing the user id a test case should have a valid user id and password, a valid user id and invalid password and invalid user id. This way all combinations that could make the security of our system fail have been tested.

To test the code the TDD software must be able to cover the following sections

- SmidgeLCD class
- ScanItems class
- ShoppingList class
- Recipe class
- Settings class

- SmidgePhone class
- Items class
- User class

6.2 Website/Mobile App testing

The Website and the Mobile Application in the SMIDGE project are essential for the user product interaction. Both applications have similar roles reggarding data access, with just a few changes.

6.2.1 Website testing

To test the Website is necessary to pay attention for GUI testing, compatibility with operating system testing, compatibility with browsers testing, performance test, interface test, interaction between web server, application server and database server, finally concentrate on security testing.

The Web app implements most of the functionalitites of the LCD Display stuated on the refrigerator. To open the web app is necessary to register in the system. Each SMIDGE shall have a different access number corresponding with the product. Once the product is registered we should login with a user name and a password set before through the LCD Display. Once login the steps to test the application are the followings

- Choose to View Items.
- Click on item to display information about it.
- Click on View Shopping List.
- Display all shopping lists.
- Click on a shopping list to review the items on it.
- Print a page with the shopping list.
- Click on Recipes.
- Click on View Recipes.
- Click on Display All Recipes.
- Click on Ready To Go Recipes.
- Click on Create Recipe.
- Add new recipe.
- Enter name and save new recipe.

6.2.2 Mobile App testing

We will use several different android phones owned by the developers and emulators, both using Wi-Fi connections and 3g/4g data connections. This will accurately simulate real world tests in the field. We will also access the database for an administrator using several different computer systems, both Mac and Windows based. In order to test the "check in" application for use in buses, we will use windows machines, both Vista and Windows 7 based, we will also test it on Linux machines.

To test the Mobile App the following should be done

- Open application through the application icon.
- Click on the View Items button from the Main Menu screen.
- Click on Options button.
- Click on Exit button.
- Click on the View Shopping List button from the Main Menu screen.
- Create new shopping list.
- Delete existing shopping list.
- Choose the option Modify from the Shopping List Menu.
- Choose a shopping list from the inventory.
- Add new item to the shopping list.
- Delete item from the shopping list.
- From Main Menu choose the View Recipe button.
- Choose All Recipes option.
- Choose Ready To Go Recipes option.
- Scroll down and up through the recipes list.
- Display ingredients for choosen recipe.
- Display cooking instructions for a choosen recipe.

6.3 Database testing

Database testing is done primarily to guarantee the relevance of search results, data integrity, data validity, data recovery and security. In database testing it is necessary to check for field size validation, check constraints. Due to performance related issues check that indexes are done and check storage procedures. Validate the columns length with the design requirements and check that all the data from the application is being inserted into the database properly.

The process of database testing is a crucial step in our project. All the data related to SMIDGE shall be store in the database and no errors can be made when handling the data. In order to make sure the database works as our system requires, the test file must request the following actions

- Add inventory to the database.
- Remove inventory from the database.
- Add a new item to the database.
- Get information about an item if exists in the database.
- Change the quantity of an item in the database.
- Delete an item from the database.
- Output messages to server about the database status, total amount of tables and elements.
- Supply a list of all items added in the past 2 weeks.
- Suply a list of items not modified in the last month.
- Supply a list of all items deleted in the last month.

- Create new shopping list and add it to the database.
- Add an item to a shopping list in the database.
- Remove item from an existing shopping list.
- Supply a list with all the shopping lists and date created from the last 2 months.
- Based on the date supply the shopping list for the current week.
- Delete a shopping list from the database.
- Provide a list of all recipes in the system.
- Provide a list of “Ready to go” recipes in the system.
- Provide the ingredients for a given recipe.
- Provide instructions on how to cook a given recipe.
- Add a new recipe to the database.
- Delete a recipe from the system.

6.4 Server testing

Tests the web server other tests have to run simultaneous. To test the web server is necessary to test the phone application, the LCD Display functionality and the Web app. To run the test the development board should run Android OS as well as a http daemon (httpd). To connect the phone application to the server an Android networking application should be developed using the java.net package.

To test the web server the following should be accomplished

- Connect to the internet via a DHCP.
- Ping external hosts on LAN and WAN.
- Being pinged by the external hosts.
- Access web pages from external hosts.
- Try all the database tests from a web page.
- Shutt down the system from the Web app.
- Send signal to the development board from the Web app.
- Review the number of tables and data in the database from the Web app.

6.5 Hardware Components testing

The hardware components that shall be use in this project are: LCD Display, Scanner, Wi-Fi Module, UPC Database and temperature sensor.

6.5.1 LCD Display testing

To test the LCD its necessary to make sure it works when voltage is supplied. The LCD can be connected to any computer with a USB port just to verify it turns on. It it lights up correctly then proceed to the next test. To test the LCD Display all the functions that can be done through it must be tested.

First the LCD should display the welcome screen that greets the user and provides the products' name and information. Once the LCD is on in order to test it fully functionality is necessary to go through every section and make sure works how is supposed to. The steps to follow are

- Choose Items option.
- Add item to the database.
- Scan new item to be entered in the database.
- Verify the information display on the LCD about the item scanned is correct.
- While scanning items check the list is being created does not contain any erros.
- Modify items in the database.
- Change item in stock quantity.
- Remove Item from the database.
- Remove several items from the database.
- Open the Help menu.
- Choose Recipe option.
- Choose Shopping Lists option.

6.5.2 Scanner testing

To test the Metrologic ScanGlove IS4225 scanner does not need to be configured as it specifies in the instructions. Plugg it into a USB port and just make sure it is ready to read UPC bar codes.

- Plugg the bar code reader into the development board using a USB port.
- Pull the trigger on the bar code reader and verify the laser comes out of it by putting an item in front of it.
- Scan a UPC bar code on a grocery item. The bar code should beep and or link to indicate the item was succesfully scanned.
- Scan items and save the barcode into a file.
- Compare barcodes in file with the actual items to verify no errors are being introduced.

6.5.3 Wi-Fi Module testing

To test the Wi-Fi module first it has to be plug into a computer to make sure it works correctly. Plug into a USB port in a place where there is WiFi available, check it recognizes the network, if it does not recognize any network then is not working.

After verifying that the Wi-Fi module works correctly the next step is to test it once connected to the system, the following steps go through this procedure

- Plug into the development board.
- Check it turns on once plugged in.
- Check the supply voltage range where is the port connected.
- Wide temperature range: -40 degrees C to + 125 degrees C

6.5.4 Temperature sensor testing

Temperature is not a crucial element in this project but still needs to be test and make sure it works how is supposed to. To test that temperature sensor is working right the following should be test

- Verify it detects the temperature.
- Range test.
- Check the temperature that it is being read.
- Modify the fridge temperature.
- Check its response to the temperature change.
- Extreme temperature tests.
- Monitored extended use test.

6.6 Barcode Recognition testing

In order to test the the barcode readings the scanner has to be tested before, make sure it functions as it is suppose to. Make sure it reads the barcodes correctly, that does not introduce any extra numbers, that it takes exactly the same code that it scans.

The test consists in translating from barcodes to item's names and viceversa. For this test we use an online UPC database that given the barcode number it access the name of the product. The system has to be connected to the internet and the scanner functioning right.

- Scan items or enter the code number manually.
- Verify the information scanned is the right one.
- Check the information obtained from the online database.

If the information from the online UPC database is not correct then the barcode recognition test failed.

7. Reflections

The name of this project is SMIDGE and it is an implementation of a smart fridge. The goal of the project was to transform a simple kitchen appliance into a very smart technology equipment that any person shall be thrill to have at their home. Many features has been added to this simple fridge converting it in the equipment able to do a lot more operations that any other in today's market. Most concepts we have studied along our school years have been included in this project, bringing together all we have learned.

The SMIDGE project has provided us an opportunity to experience a real life software and hardware project. Only a few months away from graduation and joining the working force we have this amazing experience that shall help us be more prepared for future projects and situations. We did not have the direction of any sponsor but we count with the help of our professor.

7.1 Future Improvements

In this document we have presented the Smart Fridge system "SMIDGE". We presented our projects features, goals and objectives and specifications. There are many other functions that can be implemented in a project like ours. A Smart Fridge can be an appliance with a broad set of applications. These applications shall be future projects goals.

An idea that can be added to future SMIDGE systems shall be that the fridge comes up with healthy recipes, depending on what the user stocks in it. The system should guide the user with vocal instructions, spoon by spoon, until the meal is completely prepared. Basically the system looks at what you have in the fridge, puts together a healthy, balanced meal and teaches you how to cook it, this interaction through its touchscreen monitor. With this function we shall have no more decompose vegetables in the drawer, less waste and a better diet.

Another new idea that can be implemented into future projects shall be the capability of taking pictures of what's inside your fridge using your cell phone. Cell phones that have multimedia messaging service or MMS can have an application that remotely takes a picture of their fridge's interior. The refrigerator comes installed with cameras to capture the image of all the items inside the fridge.

Upcoming SMIDGE projects shall let users clean their empty food containers across the freezer's bar-code reader and then reorder the items over the Web using the users preferred grocery store.

In this new world of "green-awareness" an application cannot be called smart if it does not implement "green-based technology". In order to preserve our planet and make a smart use of our energy a Smart Fridge shall be capable of maintaining its average temperature while regulating its power consumption from renewable-energy generators, such as solar panels or wind turbines. The fridge decides when to cool down, and when to consume power, based on how much additional power will be available. It shall be able to predict power deficiencies and be capable of adjusting its running periods so it uses as little power as possible during these times. The fridge shall make an efficient use of the available power supply. A green Smart Fridge shall be capable of regulating its inside temperature. It can lower the temperature a few degrees at night, still keeping the fridge's contents cold during the night but saving energy at the same time. By reducing the amount of electricity consumed through peak-demand periods we can avoid the need to build more power stations. Using less electricity is always preferable to generating more and is the easiest and faster way to reduce greenhouse gas emissions.

8. Summary

Working on the SMIDGE project has been a challenge for every member of this team. It has been a great experience to work as a whole during this first stage of the project that includes its definition, research and the design of it. It is a fact that this experience is the closest that we have been to a real life work situation, maybe similar to many that we will encounter in our future as engineers.

The first phase of the project was to find the definition of it. This was a fun area to play with our ideas and let our imaginations fly. Every member of the group came up with plenty brilliant ideas so that at the end of the day we had a table full of very tenting projects. All these brainstorming led us to different paths until we all agreed on this combination of software and hardware design that is SMIDGE, a new generation and a new concept of a smart fridge. SMIDGE is the smart fridge that allows you to access your food items inventory and make changes to it from any computer just by login into the web site. If no computer can be found or you just feel like getting the most use out of your phone there is also a phone application for it. SMIDGE represents a new and more fun generation of kitchen appliances.

Once the team agreed on the concept of the project the research phase started. At this point decisions had to be taken and details had to be looked very closely. I was not an easy task to plan the project within a financial budget and time constraints. The team decided to add the features we considered the most important to this first model of SMIDGE. Many other features can be added to future projects but based on time and finances these were the ones that fitted better with our desire to create an outstanding product.

The team obtained Infinite knowledge while working on the research phase of the project. A deep research process was followed for every software and hardware component used on the system. There were hardware comparisons, charts, statistics, it was our desire to choose the best and more financially accessible components. Working on the research help us getting a more abroad knowledge of wireless devices, development boards, bar code readers scanners, LCD displays, web applications, phone applications and web servers as well as programming languages. The knowledge obtain while working on this phase it will definitely be of a lot of help in future tasks. When working on this phase many new ideas were added to the initial design and some of the original ideas had to be eliminated from it based on our studies.

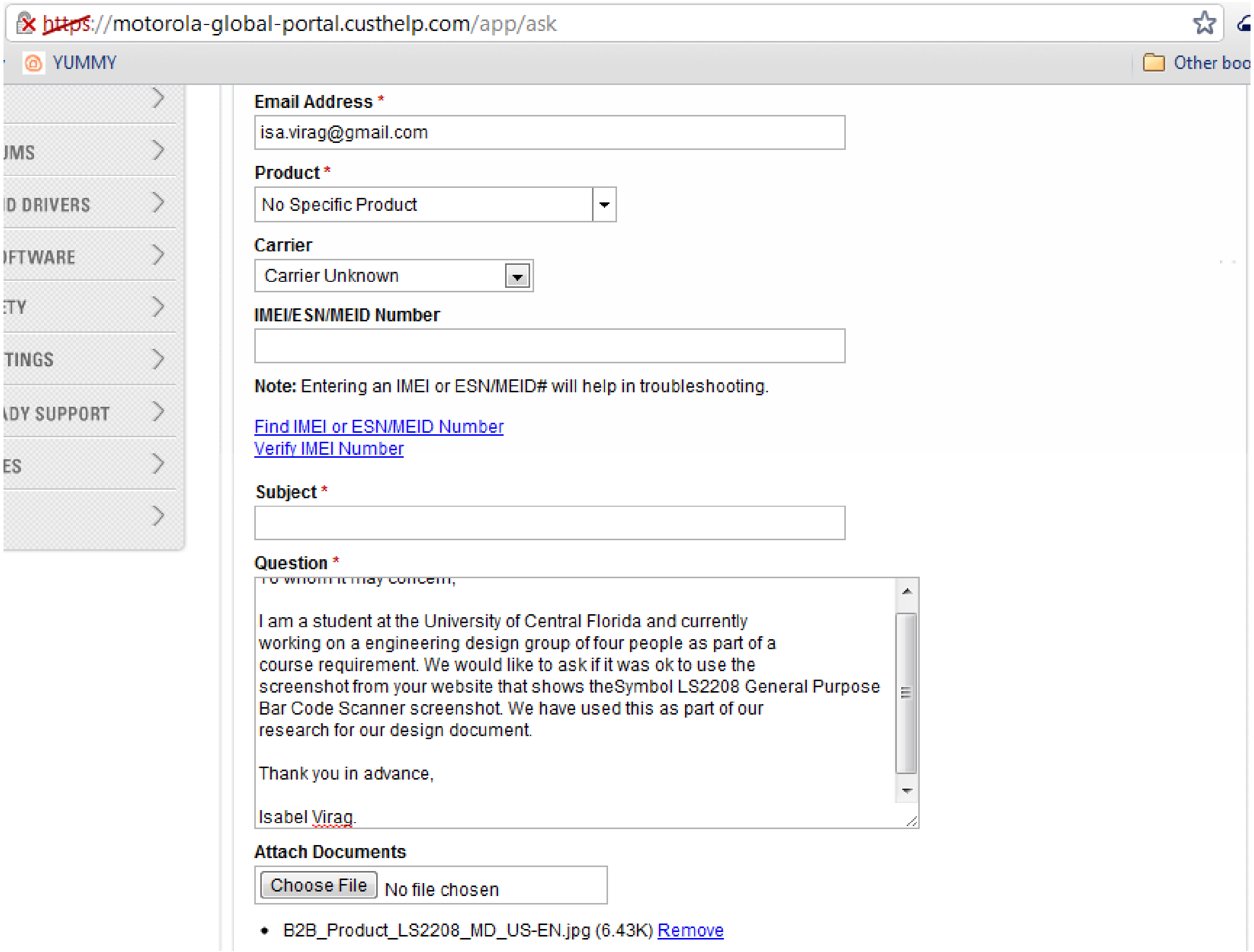
The team executed the design in the prototype and based on it is confident that once built the product shall satisfy our goals. Most likely there will be some slight variations from the design as documented, and hopefully some improvements to the features that we included in the design. But the time and effort already spent in the previous phases should keep these changes to a minimum.

It is safe to say that overall the team work has been remarkable. Goals were set every week and all the members worked hard to complete them and improve them. The work was well organized, we had weekly meetings in order to keep track of everyone’s work and had an early start on the design document. All the work done has paid off and we are looking forward to the next phase on our project and firmly believe that all the objectives and requirements will be met.

9. Appendices

9.1 Copyright permissions

The following screenshots are emails sent to manufacturers asking for copyright permissions of the figures used on our document.



Email Address *

isa.virag@gmail.com

Product *

No Specific Product

Carrier

Carrier Unknown

IMEI/ESN/MEID Number

Note: Entering an IMEI or ESN/MEID# will help in troubleshooting.

Find IMEI or ESN/MEID Number
Verify IMEI Number

Subject *

Question *

To whom it may concern,

I am a student at the University of Central Florida and currently working on a engineering design group of four people as part of a course requirement. We would like to ask if it was ok to use the screenshot from your website that shows theSymbol LS2208 General Purpose Bar Code Scanner screenshot. We have used this as part of our research for our design document.

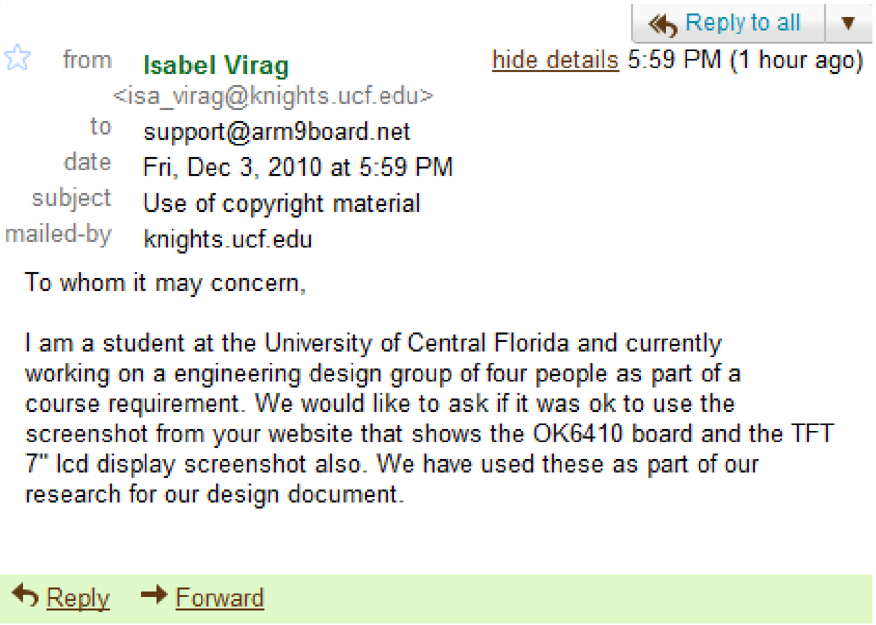
Thank you in advance,

Isabel Virag.

Attach Documents

Choose File No file chosen

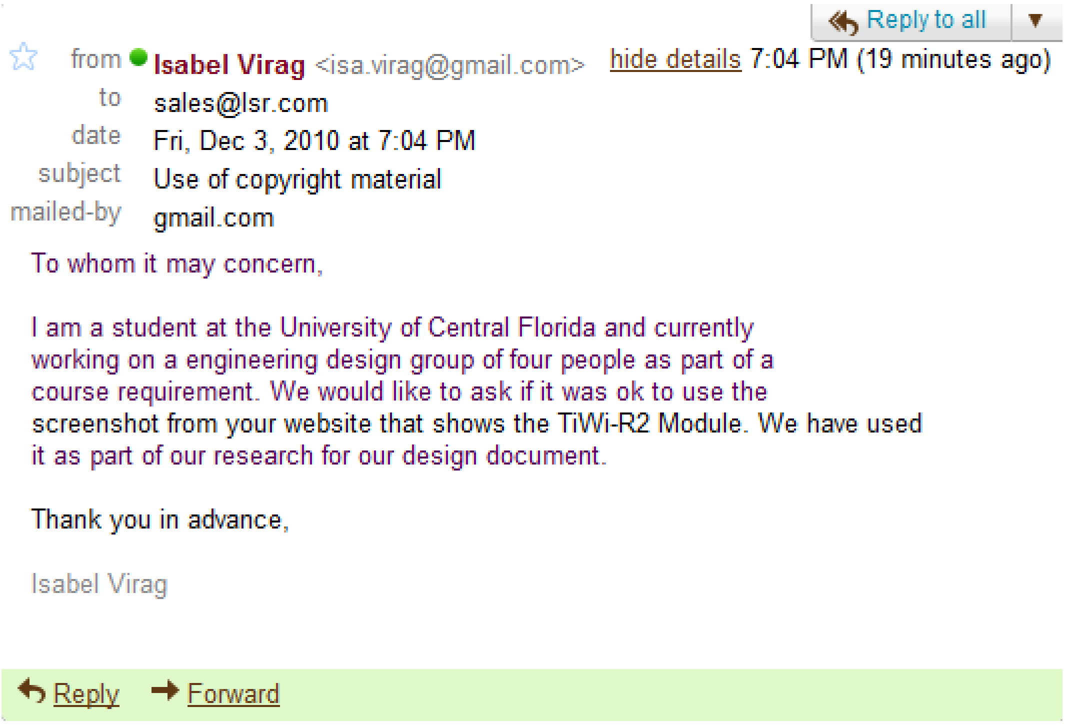
- B2B_Product_LS2208_MD_US-EN.jpg (6.43K) Remove



from Isabel Virag <isa_virag@knights.ucf.edu> 5:59 PM (1 hour ago)
to support@arm9board.net
date Fri, Dec 3, 2010 at 5:59 PM
subject Use of copyright material
mailed-by knights.ucf.edu

To whom it may concern,

I am a student at the University of Central Florida and currently working on a engineering design group of four people as part of a course requirement. We would like to ask if it was ok to use the screenshot from your website that shows the OK6410 board and the TFT 7" lcd display screenshot also. We have used these as part of our research for our design document.



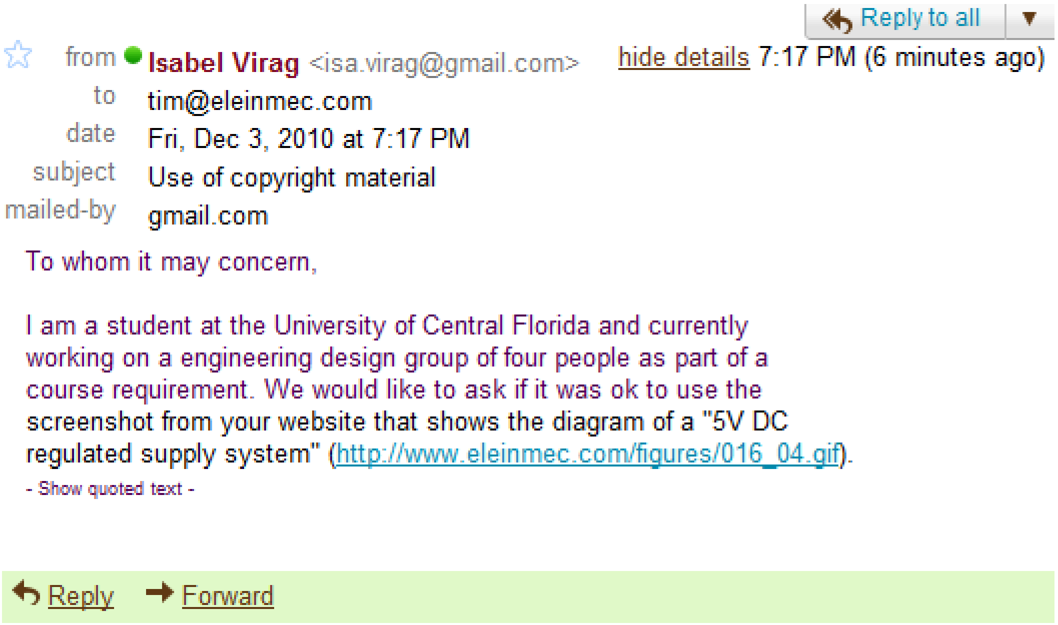
from Isabel Virag <isa.virag@gmail.com> 7:04 PM (19 minutes ago)
to sales@lsr.com
date Fri, Dec 3, 2010 at 7:04 PM
subject Use of copyright material
mailed-by gmail.com

To whom it may concern,

I am a student at the University of Central Florida and currently working on a engineering design group of four people as part of a course requirement. We would like to ask if it was ok to use the screenshot from your website that shows the TiWi-R2 Module. We have used it as part of our research for our design document.

Thank you in advance,

Isabel Virag

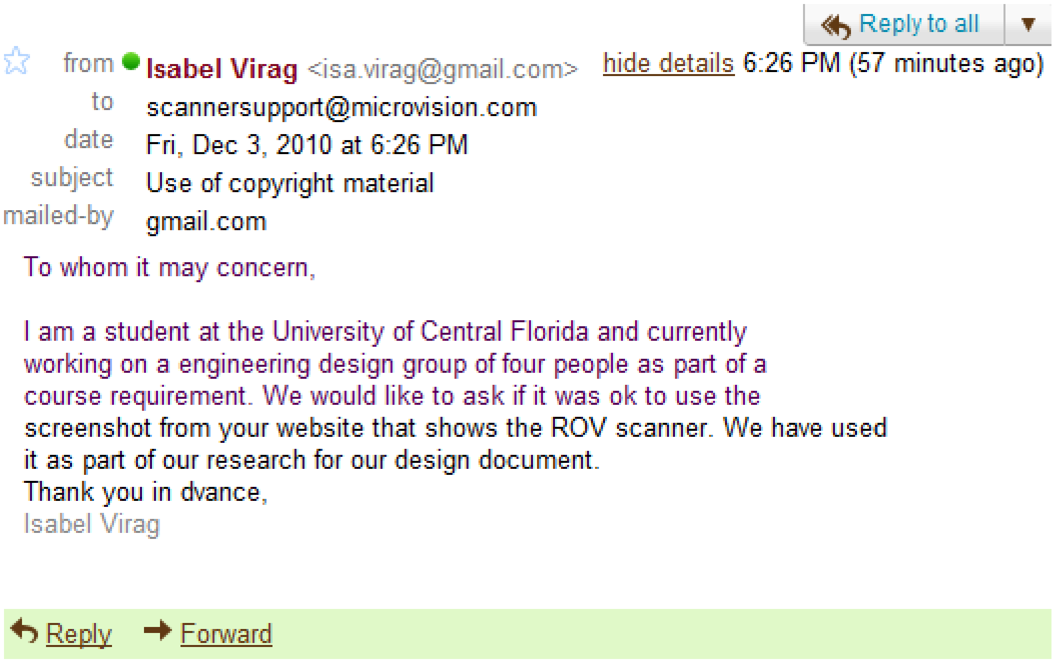


from Isabel Virag <isa.virag@gmail.com> 7:17 PM (6 minutes ago)
to tim@eleinmec.com
date Fri, Dec 3, 2010 at 7:17 PM
subject Use of copyright material
mailed-by gmail.com

To whom it may concern,

I am a student at the University of Central Florida and currently working on a engineering design group of four people as part of a course requirement. We would like to ask if it was ok to use the screenshot from your website that shows the diagram of a "5V DC regulated supply system" (http://www.eleinmec.com/figures/016_04.gif).

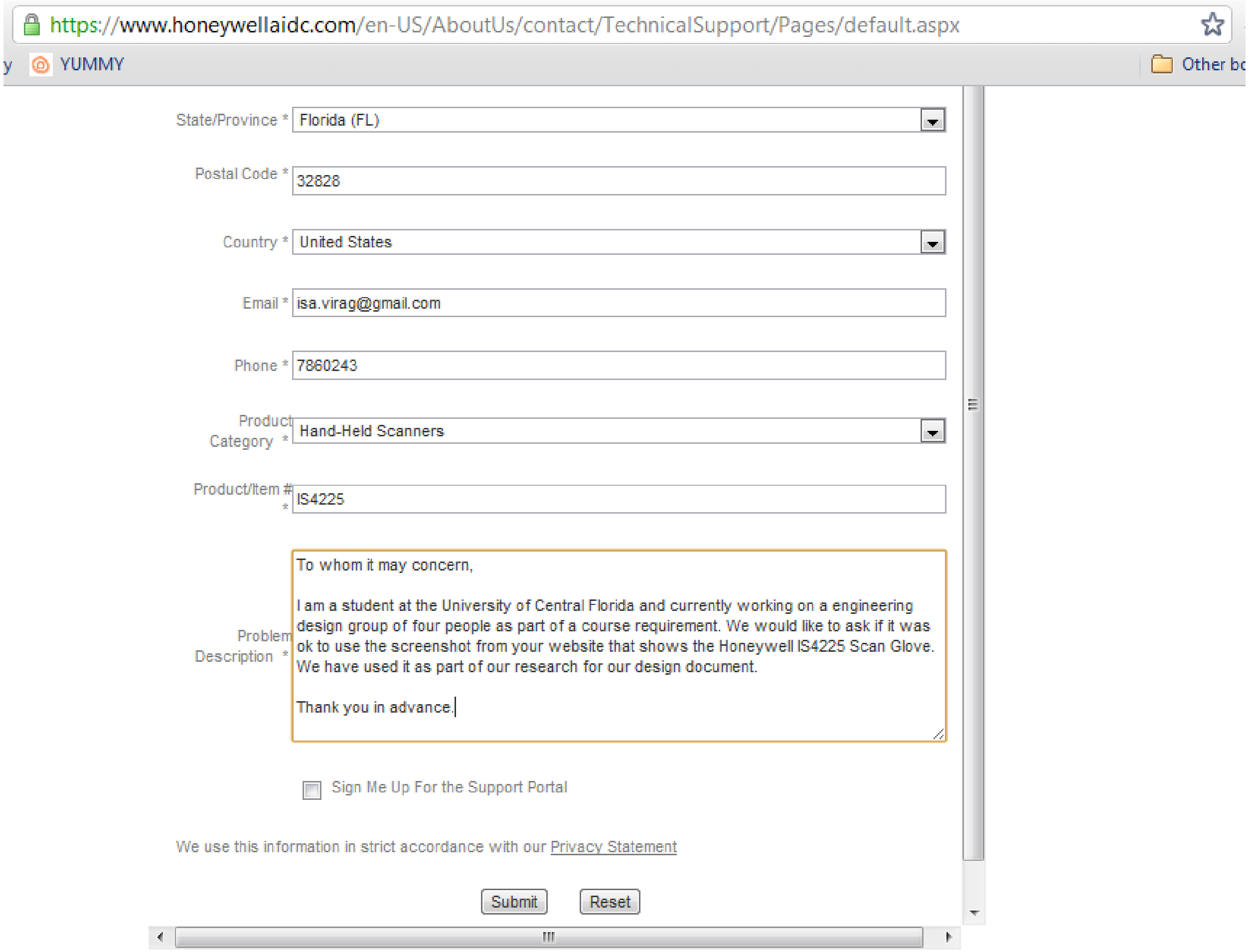
- Show quoted text -



from Isabel Virag <isa.virag@gmail.com> 6:26 PM (57 minutes ago)
to scannersupport@microvision.com
date Fri, Dec 3, 2010 at 6:26 PM
subject Use of copyright material
mailed-by gmail.com

To whom it may concern,

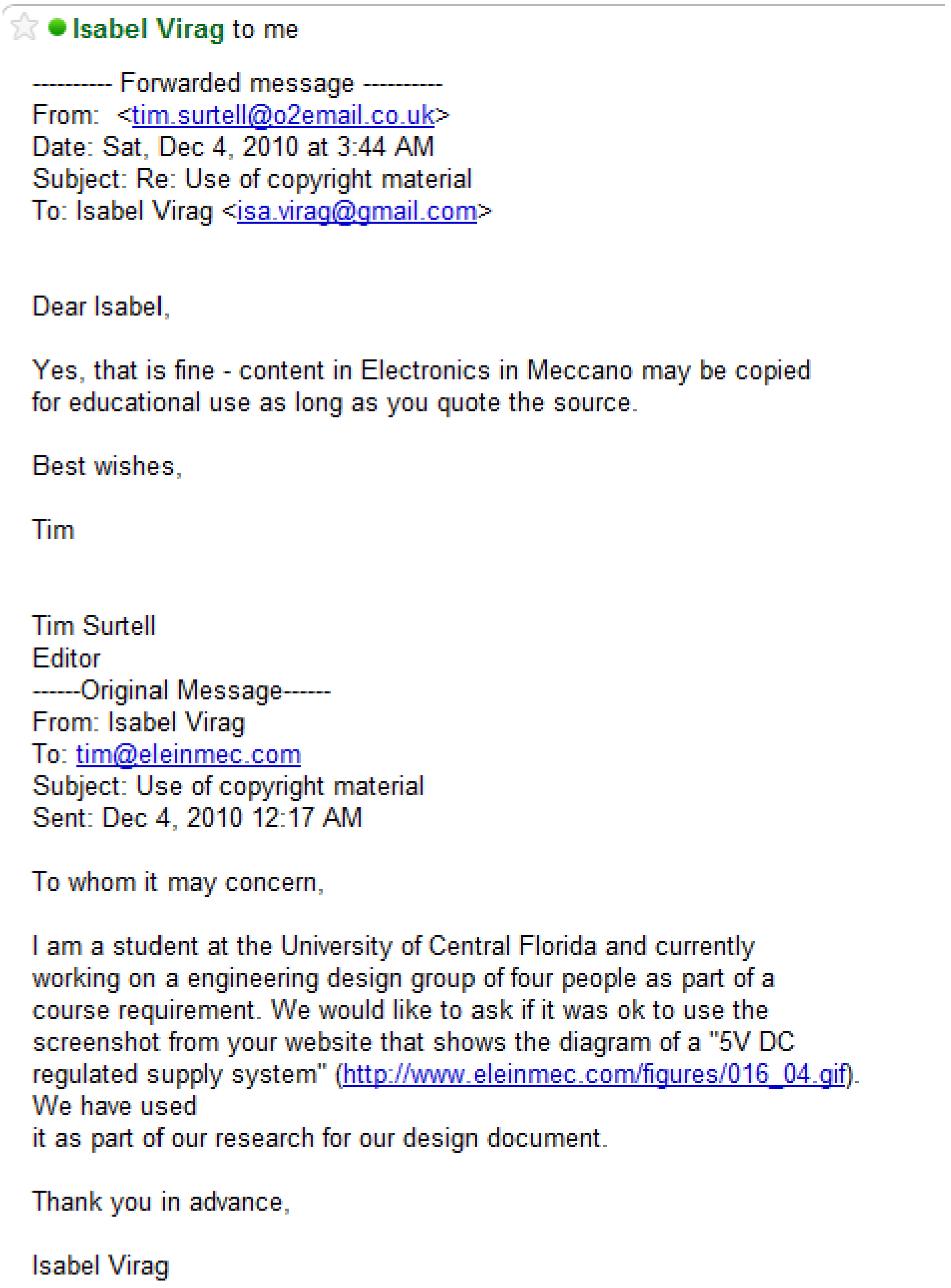
I am a student at the University of Central Florida and currently working on a engineering design group of four people as part of a course requirement. We would like to ask if it was ok to use the screenshot from your website that shows the ROV scanner. We have used it as part of our research for our design document.
Thank you in dvance,
Isabel Virag


https://www.honeywellaidc.com/en-US/AboutUs/contact/TechnicalSupport/Pages/default.aspx
YUMMY
Other bo

State/Province *	Florida (FL)
Postal Code *	32828
Country *	United States
Email *	isa.virag@gmail.com
Phone *	7860243
Product Category *	Hand-Held Scanners
Product/Item # *	IS4225
Problem Description *	To whom it may concern, I am a student at the University of Central Florida and currently working on a engineering design group of four people as part of a course requirement. We would like to ask if it was ok to use the screenshot from your website that shows the Honeywell IS4225 Scan Glove. We have used it as part of our research for our design document. Thank you in advance.

□ Sign Me Up For the Support Portal

We use this information in strict accordance with our Privacy Statement



Isabel Virag to me

---------- Forwarded message ----------
From: <tim.surtell@o2email.co.uk>
Date: Sat, Dec 4, 2010 at 3:44 AM
Subject: Re: Use of copyright material
To: Isabel Virag <isa.virag@gmail.com>

Dear Isabel,

Yes, that is fine - content in Electronics in Meccano may be copied
for educational use as long as you quote the source.

Best wishes,

Tim

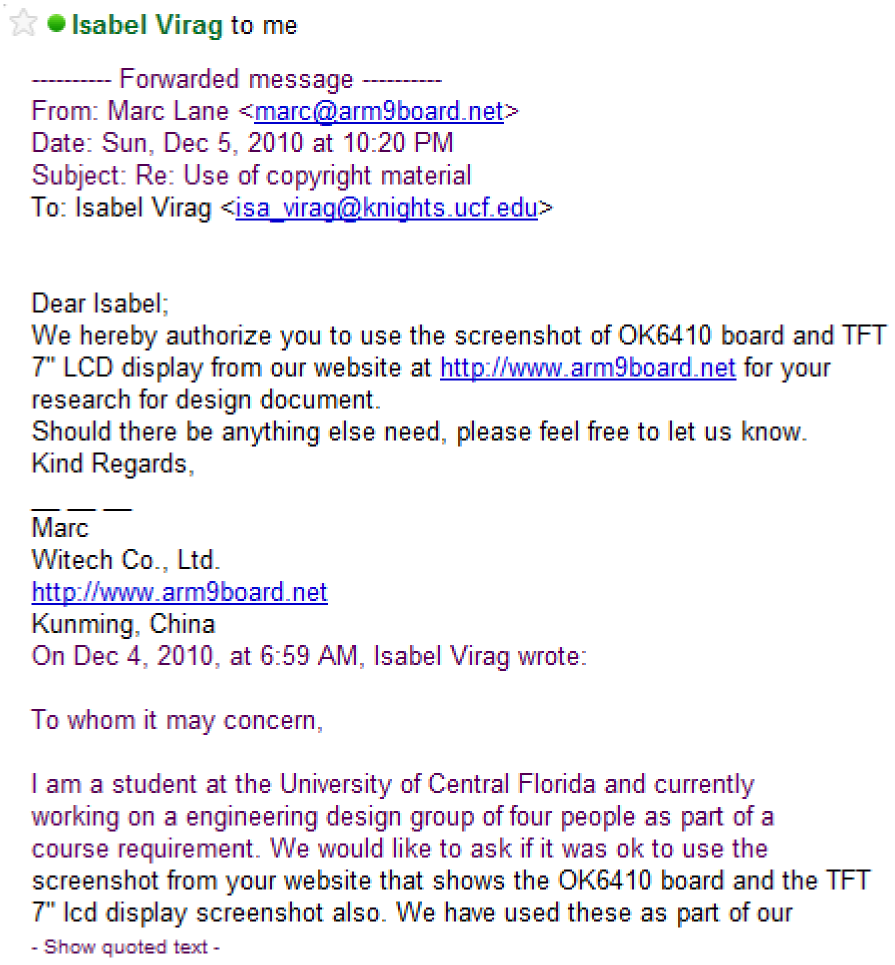
Tim Surtell
Editor
------Original Message------
From: Isabel Virag
To: tim@eleinmec.com
Subject: Use of copyright material
Sent: Dec 4, 2010 12:17 AM

To whom it may concern,

I am a student at the University of Central Florida and currently
working on a engineering design group of four people as part of a
course requirement. We would like to ask if it was ok to use the
screenshot from your website that shows the diagram of a "5V DC
regulated supply system" (http://www.eleinmec.com/figures/016_04.gif).
We have used
it as part of our research for our design document.

Thank you in advance,

Isabel Virag



☆ ● **Isabel Virag** to me

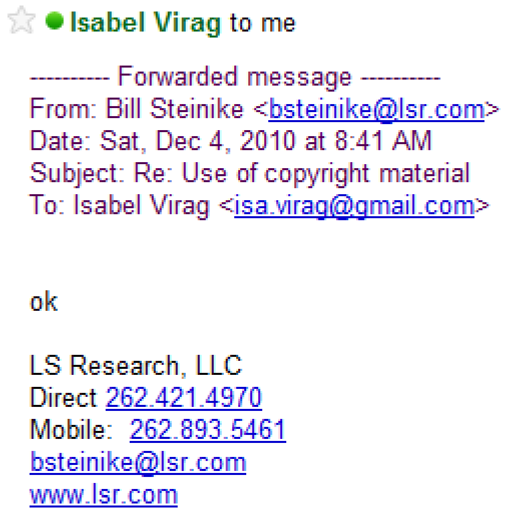
---------- Forwarded message ----------
From: Marc Lane <marc@arm9board.net>
Date: Sun, Dec 5, 2010 at 10:20 PM
Subject: Re: Use of copyright material
To: Isabel Virag <isa_virag@knights.ucf.edu>

Dear Isabel;
We hereby authorize you to use the screenshot of OK6410 board and TFT 7" LCD display from our website at http://www.arm9board.net for your research for design document.
Should there be anything else need, please feel free to let us know.
Kind Regards,

__ __ __
Marc
Witech Co., Ltd.
http://www.arm9board.net
Kunming, China
On Dec 4, 2010, at 6:59 AM, Isabel Virag wrote:

To whom it may concern,

I am a student at the University of Central Florida and currently working on a engineering design group of four people as part of a course requirement. We would like to ask if it was ok to use the screenshot from your website that shows the OK6410 board and the TFT 7" lcd display screenshot also. We have used these as part of our
- Show quoted text -

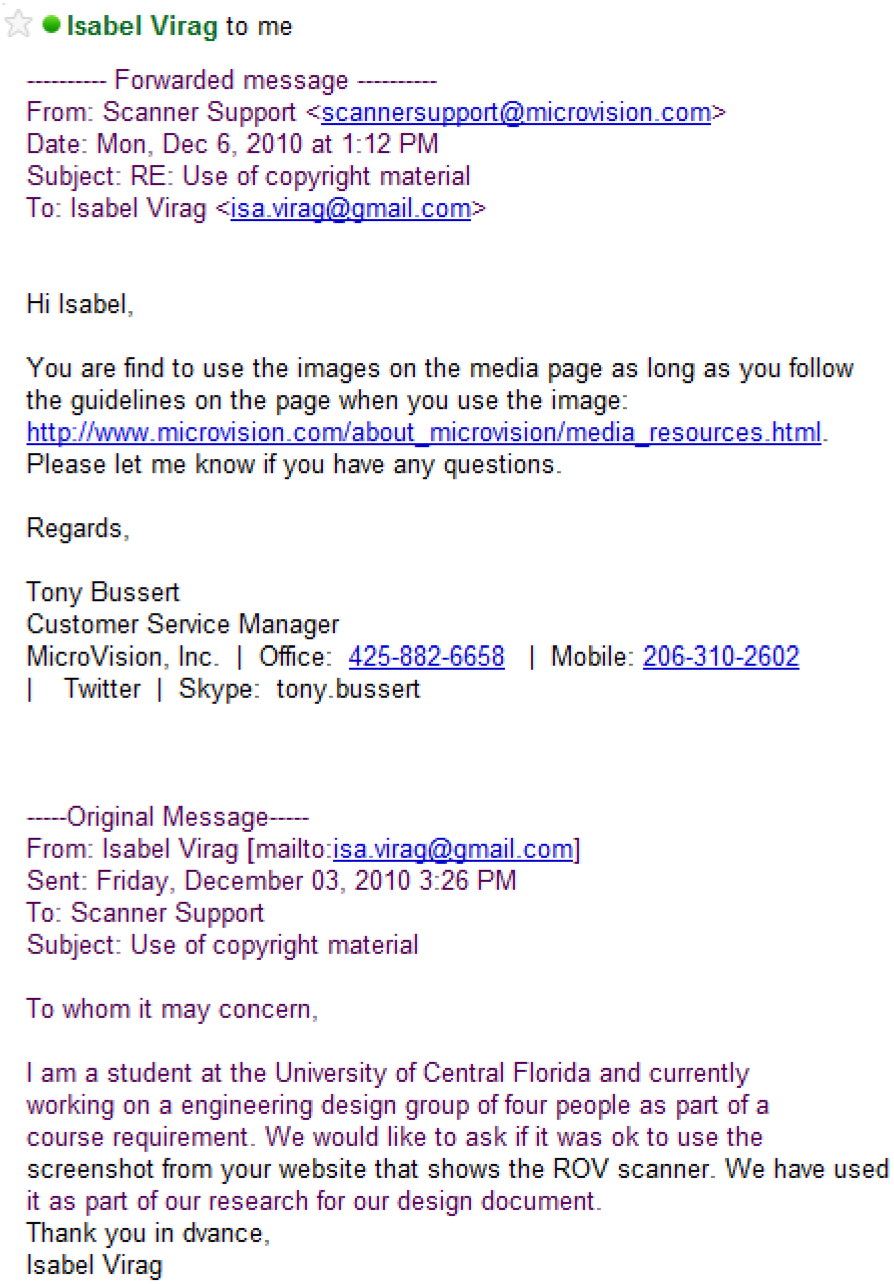


☆ ● **Isabel Virag** to me

---------- Forwarded message ----------
From: Bill Steinike <bsteinike@lsr.com>
Date: Sat, Dec 4, 2010 at 8:41 AM
Subject: Re: Use of copyright material
To: Isabel Virag <isa.virag@gmail.com>

ok

LS Research, LLC
Direct 262.421.4970
Mobile: 262.893.5461
bsteinike@lsr.com
www.lsr.com



Isabel Virag to me

---------- Forwarded message ----------
From: Scanner Support <scannersupport@microvision.com>
Date: Mon, Dec 6, 2010 at 1:12 PM
Subject: RE: Use of copyright material
To: Isabel Virag <isa.virag@gmail.com>

Hi Isabel,

You are find to use the images on the media page as long as you follow the guidelines on the page when you use the image: http://www.microvision.com/about_microvision/media_resources.html. Please let me know if you have any questions.

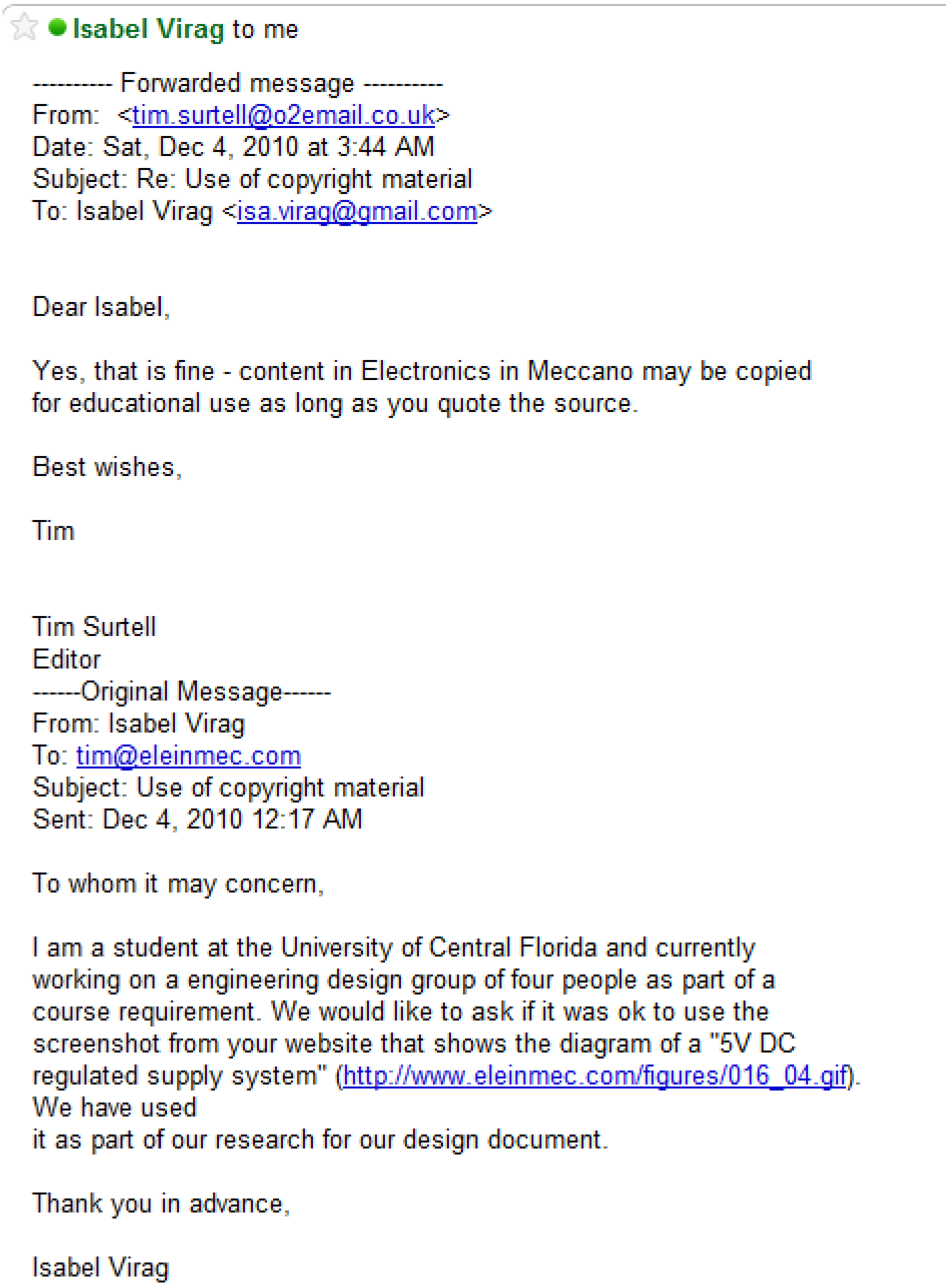
Regards,

Tony Bussert
Customer Service Manager
MicroVision, Inc. | Office: 425-882-6658 | Mobile: 206-310-2602
| Twitter | Skype: tony.bussert

-----Original Message-----
From: Isabel Virag [mailto:isa.virag@gmail.com]
Sent: Friday, December 03, 2010 3:26 PM
To: Scanner Support
Subject: Use of copyright material

To whom it may concern,

I am a student at the University of Central Florida and currently working on a engineering design group of four people as part of a course requirement. We would like to ask if it was ok to use the screenshot from your website that shows the ROV scanner. We have used it as part of our research for our design document.
Thank you in dvance,
Isabel Virag



☆ ● **Isabel Virag** to me

---------- Forwarded message ----------
From: <tim.surtell@o2email.co.uk>
Date: Sat, Dec 4, 2010 at 3:44 AM
Subject: Re: Use of copyright material
To: Isabel Virag <isa.virag@gmail.com>

Dear Isabel,

Yes, that is fine - content in Electronics in Meccano may be copied for educational use as long as you quote the source.

Best wishes,

Tim

Tim Surtell
Editor
------Original Message------
From: Isabel Virag
To: tim@eleinmec.com
Subject: Use of copyright material
Sent: Dec 4, 2010 12:17 AM

To whom it may concern,

I am a student at the University of Central Florida and currently working on a engineering design group of four people as part of a course requirement. We would like to ask if it was ok to use the screenshot from your website that shows the diagram of a "5V DC regulated supply system" (http://www.eleinmec.com/figures/016_04.gif).
We have used
it as part of our research for our design document.

Thank you in advance,

Isabel Virag

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9.3 Software

Eclipse. Free and open source software community (IBM). *Eclipse Public License*.

Pencil. Pascal Naidon. *GNU General Public License.*

Google App Engine. Google. *Software Service*.

Google Web Toolkit. Google. *Apache License 2.0*.

Microsoft Visio. Microsoft. *Proprietary EULA.*

Microsoft Word. Microsoft. *Proprietary commercial software.*

Adobe Photoshop. Adobe Systems. *Proprietary software.*

Adobe Illustrator. Adobe Systems. *Proprietary software.*