MOBILE FOOD PLANNING AND CONSERVATION SYSTEM

(FOOD TAGGING AND INVENTORY CONTROL)

By

Lim Sin Hong

A REPORT

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Abstract

The goal of the module of the system "Mobile Food Planning and Conservation System" which is dubbed "Food Tagging and Inventory Control" is to create an application that allows user to tag food items around the house to keep track of the inventory while saving information such as expiry date. Food wastage is a serious matter not just in Malaysia alone but the entire globe. In first world countries, there are people throwing away uneaten and leftover food in masses while on the other end, children of third world countries suffer from malnutrition. Therefore, the main objective of this project is to develop a solution to help reduce food wastage through proper inventory control which is based on aspects such as tracking of expiry date, controlled shopping and food management.

This project final deliverables is part of a mobile phone application.The application primary features are in the aspect of unique and special mobile technologies integration. The first feature of this application is food tagging which is concerned with using tagging technology to keep track of inventory of food items in the house which will also incorporate the implementation of a color coding scheme. The main function of the color code is to arrange food item in food storing locations such as fridge using a color scheme to represent the compartments that store a specific category of food. Another main feature is a geo-location based awareness function which included the function to create a location aware shopping list to notify users when they are near an ideal shopping location.

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HCI	Human-Computer Interaction
NFC	Near field communication
QR	Quick Response
URL	Uniform Resource Locator
RFID	Radio frequency identification
ATM	Automatic teller machine
GPS	Global Positioning System
API	Application Programming Interface
3D	Three-Dimensional
MVVM	Model-View-ViewModel
UI	User Interface
RUP	Rational Unified Process
IDE	Integrated Development Environment
WPF	Windows Presentation Foundation
XML	Extensible Markup Language

XAML	Extensible Application Markup Language
MVC	Model View Controller

Chapter 1 Introduction

1.1 Problem Statement

Food wastage is becoming a serious matter not only in Malaysia alone, but in the whole world. Everywhere we go, we see people throwing away unfinished food and bought too muchgrocerythat are just waiting to expire and be thrown away. Therefore, it is important that this issue is analyzed and solved quickly.

Besides that, most **consumers are actually unaware of how much and what type of food item they actually have** and therefore, tend to buy more of the same type of food during grocery shopping. This causes the amount of food in their household to stockpile and if not consumed quickly, most of it will just wind up wasted and thrown away.

To solve this issue, a system dubbed **Mobile Food Planning and Conservation System** is developed. This system aims to help consumers **reduce wastage of food through inventory management and controlled shopping**. The area of study of this system is a mobile phone application in the domain of Human Computer Interaction (HCI) which is specifically chosen to give consumers a convenient way to use the application anytime, anywhere since consumers have their smart phones with them wherever they go.

1.2 Motivation

The motivation behind this project is concerned with **reducing food wastage through inventory management and improving the efficiency of grocery shopping**. Through this project, we also aim to improve awareness of food availability in their house and efficient communication of this information to

the tenants. The people that will be able to benefit from this project are basically everyone. This can be justified because no matter who we are, we will need food as sustenance and since majority of consumers nowadays have access to smart phones, this system is actually viable. Therefore, by preventing food wastage, starting from the household level, we can ensure that the food security of the economy will be kept stable. Besides that, this system is geared towards providing a way towards better living quality by helping users save time to search for food they might or might not have. With just a simple touch of a few interfaces, users will be able to know where they kept their food, what food do they actually have and don't have, which is time efficient especially for people with long working hours who do not have much time for household management.

Besides, one of the other driving forces behind this project is to create a **user centered application for mobile phone** which will incorporate aspects of HCI for users to switch calmly and effortlessly between the system and other tasks without having to figure out how to use the system. This means that when users turn on the application for the first time, users can immediately figure out the functions and how to navigate the system without any guide or manual. In essence, the system aims to be largely unobtrusive in user's daily life where the system decides how to provide a contextually-relevant information such as meal plan of the day and the nearest shopping place for users at the appropriate time to support them while on the move.

1.3 Project Objective

The main objective of this project is to create an innovative solution to help reduce wasting of food. This is because food wastage is a rampant issue in current society. Everywhere, people can be seen throwing expired food which can actually prevented if they managed their meal and inventory well enough. Statistics shows that for every pound of beef wasted, almost 2500 to 5000 gallons of water are wasted yearly (Steve B., 2010). Therefore, it is a good idea to start reducing wastage. Therefore, this project aims to provide the way to a better environment as well and alsoto help people manage inventory better at the household level. This project will be able to help users to keep track of their groceries and where they kept their food for a more convenient way of life.

1.4 Project Scope

This project involves developing part of the application for Mobile Food Planning and Conservation System. The module that will be developed is **Food Tagging and Inventory Control** which will be the preprocessing part of the application. The core function of the module is to **identify and keep count of food on purchase** with storage location at the household level. Firstly, the module should be able to**tagfood items by using appropriate tagging technology** to store essential information such as expiry date into a generated code that can be printed out. The system must also be able to **control inventory of food** which means that when user buy new groceries, the system should be able to keep track of what the user has boughtand what should be bought so that there is no excess or shortage of food. Also, **a shopping list with geo-**

locationawareness will be included in the module to allow users to choose the most convenient place to do their shopping.

1.5 Impact, Significance and Contribution

First and foremost, this project's goal is to reduce food wastage through food management at the household level. Since food wastage is rampant nowadays, it is important that we take it into our own hands to help reduce the wastage. This is because when food is thrown away, it usually ends up in landfills. The problem with food wastes going to landfill is that organic product will break down to produce methane, a gas 25 times more potent than carbon dioxide. Therefore, this project will ultimately help towards preserving the environment by reducing emission of methane and other greenhouse gases from wasted food.

Besides, this project is also geared to help consumers keep track of their food items in their household. This is important because when consumers buy more thing than they need. It tends to lead to stockpiling storage behavior where older food item is pushed to the back of fridge or any storage compartment in place of newer items. This will cause the older items to be left in the back, waiting to expire. This project is geared to help consumers reduce this problem by introducing a mean of keeping track of where they keep a particular food item which means that even though it is pushed to the back, consumer will still have the awareness that the item is kept in there.

Lastly, this project also aims to contribute a mobile application which will provide a set of functionalities which will incorporate the interaction design of

HCI domain. Nowadays, when people download a new mobile application, it will take some time before they are actually able to figure out how to use the application. Therefore, this project will aim towards an end product which users will be able to use at a moment's glance. Besides, this project aims to contribute towards the aspect where the application will not interferes with users daily activities. This means that everything will be done automatically by the system and essential information will be displayed to user when a certain constraint is fulfilled to help users manage their food items easier.

In conclusion, with the help of the application, users will be able to manage their inventory while also preventing wasting for a more convenient household management besides helping users to save more in terms of food and monetary.

1.6 Background Information

This project will also cover the domain of mobile applications development. With the introduction of smart phones, our lives have become much easier since our phone is evidently already replacing personal computers. With the higher processing power available in phone nowadays, there will be no problem for powerful applications to run smoothly without delay. Therefore, it has come to the belief that there is a mobile phone application, or app, for everything that we can think of. In that sense however, food management applications do exist but with very limited functionalities. Therefore, it is our aim to create a food

management application that will improve the way technology is used in household management.

This project will also cover the domain of Human Computer Interaction (HCI) which is the study of planning and design of the interaction between human and computers. This is because the chosen platform for this project is for mobiles phones or more specifically smart phones. This allows users to be able to use the application at their convenience since smart phones is definitely more lightweight than laptops or even tablet computers. Therefore, it is important to develop this application so that it caters to the interaction between users and their smart phones. To this extent, the application is catered towards using some of the sensors only available in smart phones such as QR code scanners and near field communication (NFC) tags.

Chapter 2 Literature Review

2.1 Introduction

This review is conducted to find out the necessary requirements needed for the system. This is important since not much research have been done on this topic. Firstly, statistics on food wastage is given. Then, the review on food tagging which will include review of appropriate tagging technologies and the comparisons between them will be done. Also to be reviewed will be on security on tagging technology, human computer interaction ,color coding scheme to improve inventory control and the types of digital maps followed by reviews on inventory control and ways to measure food items. Lastly will be the review on existing software which has been on the market.

2.2 Food Wastage

Food waste has an environmental impact caused by the loss of natural resources used during production and the greenhouse gas emissions during its disposal. The fact that food is wasted when there are people that needs it means that there is a social impact. In anywhere around the world, food waste are commonly sent to landfill for disposal. The problem here is that when organic substance breaks down, it produces methane, a greenhouse gas 25 times deadlier than carbon dioxide (Love Food Hate Waste, n.d).

In Australia, landfill contributes to about 2 percent of its total greenhouse gas emission. It may not seem much, but to put it into perspective, for every ton of food wasted, 0.9 ton of carbon dioxide is produced. In Malaysia, 15000 tons of food waste is generated daily. This

amount of food is enough to feed 7.5 million people for a day. Of the food waste, 10 to 15 percent comprised of expired or unconsumed food. This figure brings us to a shocking 1500 to 2250 tons of food going expired daily. The worse is, at large banquets, for example, a 10 course Chinese dinner, 30% of the food actually go to waste (The Star, 2013).

According to Food and Agriculture Organization of the United Nations (FAO), it is estimated that a third of the global food production is either wasted or lost. This is a shocking 1.3 billion tons of food wasted every year. The global food consumption occupies 25 percent of all habitable land and nearly 70 % of the fresh water consumption (The Star, 2013). It also contributes to 80 percent of deforestation and 30 percent of greenhouse emissions which makes it the single largest factor of biodiversity lost and land-use change.

Based on the statistics given, it is high time that we wage a war against food wastage to prevent our natural resources being dried out. To this extend, the proposed system is useful to help reduce food wastage starting from the household level. This may not seem much, but as people adopt this system, food wastage will be reduced by a long shot.

2.2.1 Factors Contributing to Food Wastage in Household

According to Wharton, et al. (2012), the color coding scheme promotes healthier and more environmentally sustainable food practices by promoting efficient storing and purchasing of food. Also, he stated that there are three major factors and two

minor ones that result in expired food waste. The three major factors are:

- **Transparency:** An individual's forgetfulness or memory concerning food items they have placed in of taken out of fridge/pantry/cabinet. This means that people may forget that where they placed a food item and therefore, does not have the knowledge that they ever have that item.
- **Awareness Of Available Food:** An individual's knowledge of food item in the household. This is usually applicable to tenants of the household that are not directly involved in the shopping since they do not know what has been bought and what has not.
- **Misled/Incorrect Tacit Knowledge:** the tacit knowledge of an individual who knows if a food item is edible or not by the use of sight, smell or touch. This means that an individual may or may not be able to detect whether a food item is edible or not and therefore, sometimes chooses to ignore it instead.

  The two minor factors include:

  - **Unplanned Events: "**Spur of the moment" situations that led to cancelation of previously planned consumption of food that was purchased for that specific meal. This means that a change of plans causes an individual to be unable to consume food items that is bought specifically for that particular meal.

- **No Desire to Consume Leftover Food:** A person having cooked a large meal with the intentional goal of it lasting consecutive mealtimes, but does not resume desire to consume leftovers before they go off. This can be easily solved by planning ahead so that a person does not cook too large a meal and instead separating it into several small meals.

2.3 Food Tagging

The term food tagging in this context does not mean putting a price tag on food but instead, to "tag" the food in the system to record its information (price, expiry date, etc.) that can be printed out in the form of a tag to label a food so that the next time the code is scanned, users can immediately retrieve information such as date of purchase, expiry date and category.

Another function of food tagging is actually inventory control. This means that when user prints a QR code for the first time and sticks it on a food item, the item is considered to be a part of the inventory of the household and should be taken into account for any meal planning done by the system. If the user scans the QR code again, it means that the food item is removed from the inventory and is used for consumption, effectively eliminating its presence in the system. This is useful for users to keep track of their food items using just their mobile phones instead of the need to search the entire household to find a food item.

This function is actually important as fresh food such as meat do not have expiry date label attached. This sometimes may make it hard for users to remember the expiry date and the food will go to waste. Therefore, this function aims to help user by using tagging technology to store the expiry date and to be pasted on the food so that users only need to scan the code to know the expiry date of the food. This way, wastage can be reduced and it will be more convenient for the user.

2.3.1 Differences between Tagging Technologies

Mobile tagging is the category term for the creation and rendering of a two-dimensional bar code that is a link to an online experience, accessed through a mobile device. Each 2-D code, or tag, is encoded with specific information such as a Web URL, a phone number, or a person's contact information. Once a tag is scanned or photographed it creates the link to a specified webpage, dials a voice call, or downloads contact information. (Marshall 2012)

QR code, or Quick Response code, is a type of matrix barcode first designed for automotive industry. However, it has now become popular due to its fast readability and high storage capacity. QR code is able to store information as much as several dozen more information than conventional barcode. (Denso Wave, 2010)

Bar code is a machine readable representation of data. Original barcode systematically represents data by varying widths and spacing of parallel lines in 1-dimension. However, it has revolved into other geometric patterns in 2-dimension which is not unlike QR code but is still referred to as barcodes. (Learning Centre Barcode Concepts Barcode Technology, n.d)

Near field communication (NFC), uses electromagnetic waves to transfer data to and fro NFC tags from digital devices such as a smart phone. It is an offshoot of radio frequency identification (RFID) but only works within a closer proximity. There are four types of NFC tags that is type 1, type 2, type 3 and type 4 (How Near Field Communication Works, 2012). Many cell phones have been designed with near field communication (NFC) chips with the hopes that they will eventually be used as debit or credit cards for point of sale transactions. NFC enabled devices could then be held up to an ATM machine or cash register, waved, and a transaction completed

Tagging Technology\ Characteristic	Capacity of data	Resistance	Readability	Cost	Printout Size	Reading Speed
QR code	Up to 7089 characters	Up to 30% of code can be restored on	Readable from any angle	Generated for free	Small	Faster

		damage				
Bar code	Approximately 20 characters	Cannot be read if damaged	Directly in front	Generated for free	Becomes larger with more data stored	Fast
NFC	Up to 32kb	Cannot be read if damaged	Readable from anywhere within 10centimeters	Around 0.5 USD per tag	Small	Fastest

Table 2-1: Comparisons between tagging technologies (Denso Wave 2010)

From table 2.1, we can see that QR code is a better choice to be used for tagging. This is because of a few factors. For starters, it stores a lot more data compared to barcode with a smaller printout size. Although NFC can store more data and have a much faster communication speed, each tag comes at a cost of 10USD per tag which is very unlikely that users can afford in large quantities. Also, because of the nature of food storage, the tags may be easily damaged which means that QR code is a better choice as it is still readable even if damaged. Besides, QR code being readable from any angle is definitely a better choice compared to the barcode which can only be read from the front although NFC tags can be read anywhere within 10 centimeters. From this, we definitely can conclude that QR code is a better

choice to be used for tagging. However, a barcode scanner will also be required in the system to scan for processed food which is usually still using barcode technology.

2.3.2 Security of Tagging Technology

For QR code, it can be malicious in nature in the sense that when a user scans the code and clicks on the hyperlink provided by the code, it could easily redirect them to a website containing viruses and other malicious content. This can be solved by taking precautions whereby the users have to check the URL provided by the QR code before accessing the website. Besides, if users decided to store sensitive data in QR code for easy access, a third party can easily access the code using another code reader to retrieve the sensitive information. This can be solved by encrypting the data using an encryption scheme before the data is used to generate a QR code. This will make it much harder for unwanted personnel to access sensitive data, although it is not advised to store any sensitive data in QR code whether it is protected or not.

The security risks of NFC included eavesdropping, stealing of data, and opening devices to malicious software such as virus, Trojans and worms. As NFC technology is mainly used for electronic payment methods, the need for a fool proof encryption system is immense. Since RF waves are used to transfer data, it is highly possible for eavesdropping to occur during transaction to

gain access to sensitive information such as bank account number. The best way to prevent security with NFC enabled devices is to make sure that both devices is operating on an encrypted system. However, due to the nature of NFC tags, it is difficult for hackers to hack the system although it is also not 100% foolproof.

2.4 Shelf Life of Food

Types of food / Condition	**Poultry**	**Beef, Pork, Lamb, Veal**	**Sausage**	**Ground Meat & Poultry**	**Eggs**	**Canned Meat, Poultry & Fish**	**Bread**	**Fruits & Veggies**	**Dairy Products**
Raw, unopened	1-2 days	-	1-2 days	1-2 days	3-5 weeks	2 -5 years	-	Few days to couple weeks	Sour then throw, smell or taste a little
Cooked	3-4 days	3-5 days	3-4 days	3-4 days	-	-	-	-	
Precooked, after opening	3-4 days	-	3-4 days	-	-	3 - 4 days	2-3 days	-	

Table 2-2: Shelf Life of FoodSource:greatest.com

From the table above, it can be deduced most raw and unopened foods such as poultry, sausages and ground meat can last for only couple of days. On the other hand, canned food can last from two to five long years. Besides, various fruits and vegetables usually have a short shelf life and are suggested to be consumed as soon as possible after purchase.

Uncooked food after opened and cooked foods will last for 3 to 4 days since they will spoil due to the growth of bacteria if left uneaten even if it is kept in a refrigerator . It can also be deduced that whether dairy products are spoilt or not are easier to differentiate by just smelling or tasting them, if it is sour then it is spoiled. So, dairy products are not suitable for long term storage and need to be consumed within a week after purchase.

2.5 Type of UI Design Suitable For Mobile Applications

2.5.1 Minimalism

In this design, lesser is more. Glossy icons are replaced by simpler one color or text -based buttons with simple solid color combinations (Vukovic, 2012).. This way, the interface is easy to digest and does not get in the way. Prime example is the Metro design of Microsoft

Figure 2-1 Minimalism

2.5.2 Skeuomorphism

This approach relies on imitating the look and functionalities of traditional and familiar objects to make it more intuitive (Vukovic, 2012). Some may say imitating real world objects means that it is also imitating the limitations of the objects. However, due to touch-screen nature of smart phones, this approach gives an impression of touching real-world objects while appeals to the masses. This approach is popularized by Apple.

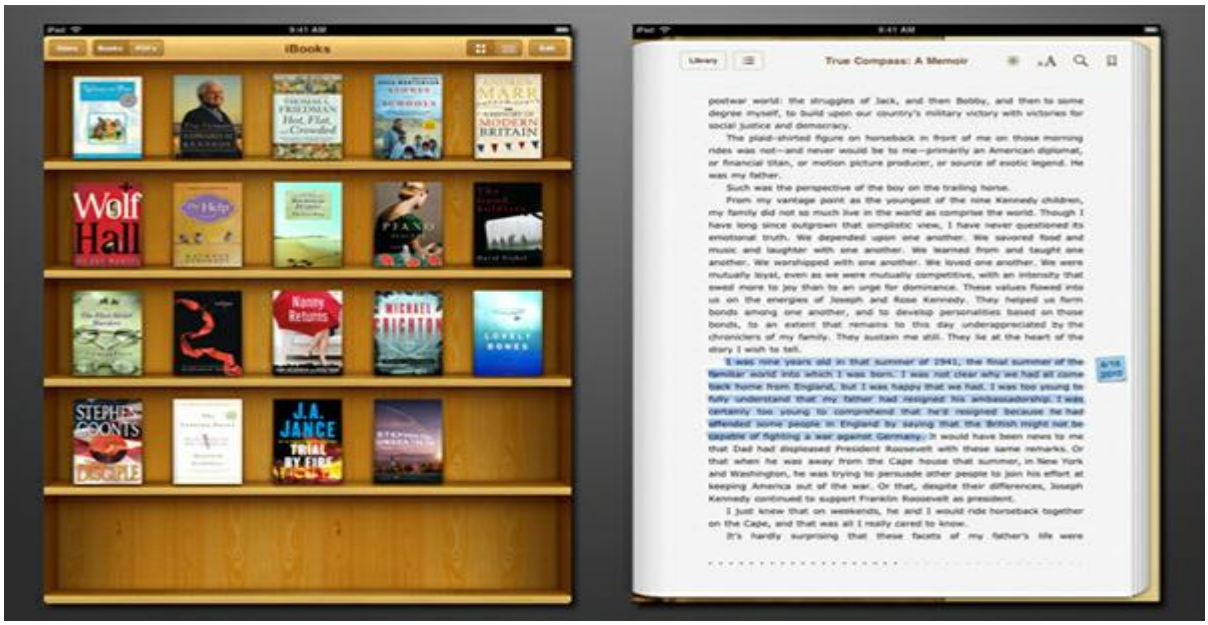


Figure 2-2 Skeuomorphism

2.5.3 Context Sensitive Navigation

This approach comes with the use of dynamic interface design and is a great way to not clutter the design of the interface (Vukovic, 2012). Basically, it is concerned with which design element should be shown at all times and which should only be shown in a certain situation. For example, Pinterest shows action buttons only when you hover over a pin.

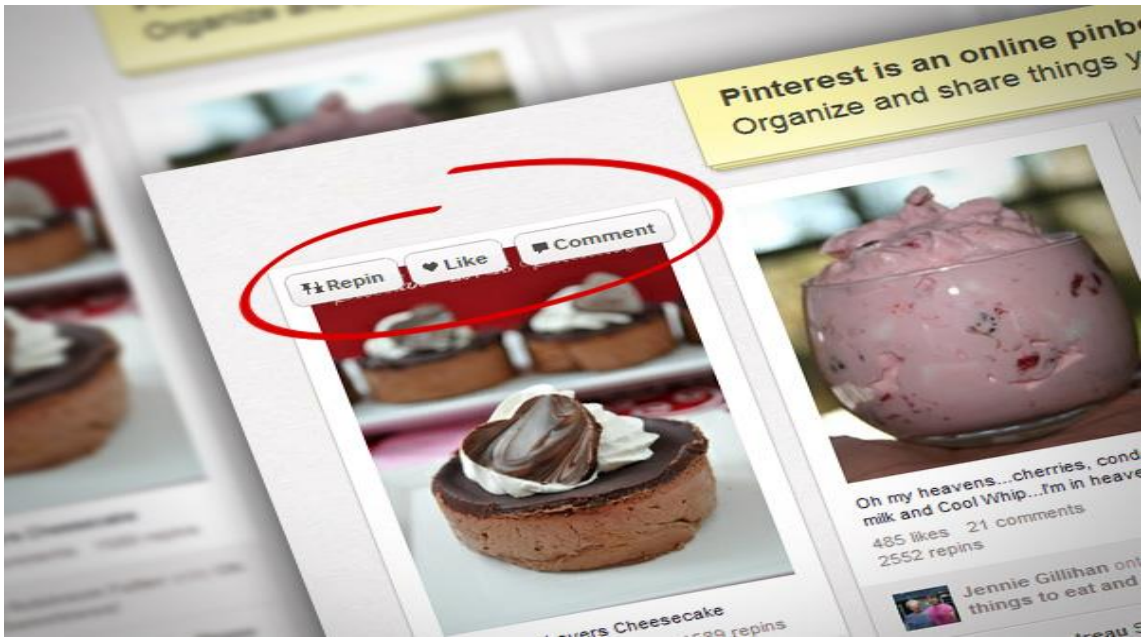


Figure 2-3 Context Sensitive Navigation

2.6 Color Coding Scheme For Food Grouping

2.6.1 Introduction to Color Coding Scheme

Wharton, et al. (2012) in his paper proposed a color coding scheme to group similar types of food together in the refrigerator to increase awareness of available food. The color coding scheme entailed using seven piece of colored opaque plastic that were matched to a corresponding food type in the refrigerator. The category included *Fruit and Vegetable Produce, Dairy, Condiments, Meat, Bread/Baked Goods, Drinks, and Leftovers*.

Users are allowed to match color to any food categories as they please. According to Wharton, et al. (2012), a ‘map’ of the configuration will be printed on a sheet of paper and glued to the door of the fridge so that users will be able to know which compartment corresponds to which type of food by following the ‘map’.

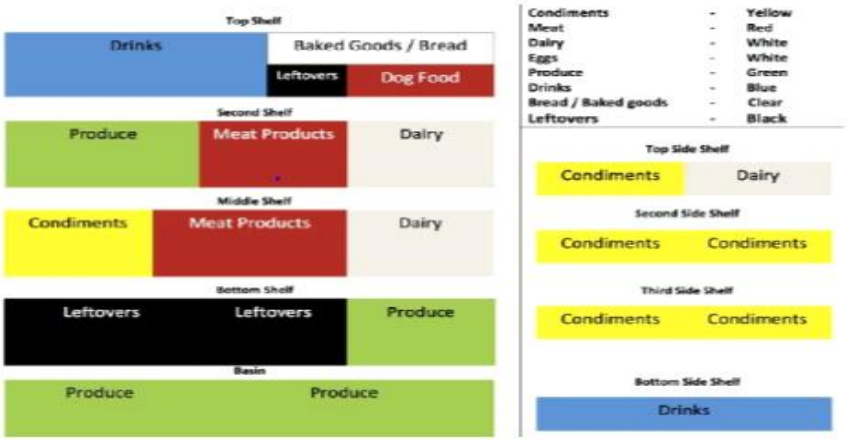


Figure 2-4 Example of Color Coded Map

There are a few improvements that can be applied to the scheme as proposed. Firstly, the scheme should not only be applied to refrigerator as there will be other locations where members of the household keep their food items. This may include cabinets, freezers and pantries. Although majority of food items may be kept in the fridge, there should also be a different scheme to be used for other storage places to increase awareness of food items. Secondly,

the food category proposed by Wharton, et al. (2012) can be extended to cater for other items of food. This is because there is some food items that cannot be categorized into any of the seven categories proposed. For example, the scheme can be extended to include items that are kept in cabinets such as canned food, cereals, instant beverages such as coffee or tea and instant food. With this improvisation, the color scheme can be extended to cover a larger spectrum of food items to increase awareness of food items around the house and not just in the refrigerator.

Not only that, the biggest improvement that can be applied to the color coding scheme is the possibility for technology integration. More specifically, the aim is to integrate this color coding scheme into a mobile application that can be easily accessed from the user smart phones. In further detail, it means that instead of gluing a paper 'map' to the door of the fridge, the color scheme can be stored in the smart phone instead. The scheme can be made so that it will display the list of items in a particular color area when interaction occurs. This will help user to be able to keep track of each of their food items in the household. Besides, this will provide a convenient way to "access" food storage area in the sense that users will be able to see what they have in store in the house even if they are not physically in the house through the smart phone. This will help to promote easier storing of food for

improved efficiency in household management as lesser time are spent looking for food in the fridge.

2.6.2 Relation Between Color Scheme and Increase of Awareness of Food Items in Household

Sharp, et al. (2007) stated that in HCI context, the cognitive processes running in our brain during daily activities included attention, goals, information presentation, perception and memory. However, what is important here is information presentation and perception. Information presentation means the way information is displayed will greatly influence how easy or difficult it is to appreciated a piece of information. In this context, by using a color coding scheme to categorize food, we have structured the information which is where the food is kept into a easily understandable format which will improve the way the information passes on to the users.

Perception refers to how information is acquired from the environment via the 5 senses and transformed into experiences of objects, events, sounds and taste. For sighted individuals, the most dominant sense is vision, followed by hearing and touch. Although Huchendorf, (2007) stated that color may or may not actually affect memory, it has been proven that color increases the awareness level of a person which in turn, will increase awareness

for the object the color is associated to. Besides that, Sharp, et al. (2007) stated that by using mnemonics, which is associating a color to an object of the same color, people will actually find it easier to remember the certain object. For example, for this project, we can associate meat with red and vegetables with green.

2.7 Food Measurement

Food measurement is separated into two ways of measuring which is weigh and measure (Weighing and Measuring, 2008)

Weigh: The preferred method to determine the quantity of dry ingredients using a scale. It can be determine in ounces, pounds, kilograms etc. (Weighing and Measuring, 2008)

Measure: A device such as a graduated container used for measuring. It can be determined in solid ounces, 1/2 cup, 1/4 cup etc. (Weighing and Measuring, 2008)

Usually, for dry ingredients, weighing is used while measuring is used for smaller quantity of dry ingredients or liquid. Therefore, using these concepts, a food measurement table is proposed.

Food Types	**Measurement**
Vegetables	**Pound(453.6 grams per pound)**
Fruits	**Pound(453.6 grams per pound)**
Meat	**Pound(453.6 grams per pound)**

Liquid Products	**Ounce (1/2 tablespoon or 3 teaspoon per ounce)**
Powdered products including sugar and salt	**Tablespoon(2 ounce per tablespoon)**
Dairy products such as butter, cheese (excluding eggs)	**Pound(453.6 grams per pound)**
Beverages	**Milliliters**
Canned food	**Can(1 can,1/2 can,1/4can)**
Bakery wares	**Pound(453.6 grams per pound)**

Table 2-3: Proposed Table for Food Measurement (Weighing and Measuring, 2008)

Table 2.3 clearly shows the unit for food measurement for most categories of food, if not all. The purpose of doing this food measurement is so that the system is able to accurately track the inventory of each food items that the user possesses. This is important as people will not consume everything that they bought immediately. For example, a user may only eat half a can of tuna. The system should be able to update and subtract the consumed portion from the user's inventory, thereby keeping the inventory updated. This can also be true for grocery shopping. For example, a user bought a pound of cabbage and he or she has a pound of cabbage at home. The system should be able to accurately update the user's inventory to 2 pounds of cabbage. Therefore, from the examples given, it is clear that food measurement is an essential part of this project

to make sure that food items can be managed properly with the correct unit of measurement.

2.8 Geo-Location Based Awareness Shopping List And Price Comparison

One of the many functions for Mobile Food Planning and Conservation System includes a shopping list with location awareness. Also included in the shopping list is the price comparison of the products that the users wanted to buy.

2.8.1 Geo-Location Based Awareness

Geo-location based awareness or location awareness, in this context, is to keep track of the location of the user using the functions of a GPS. With the incorporation of GPS into every smart phone available on the market today, users are able to easily find their path to any nearby destination be it a restaurant, shopping mall or any tourist destinations. Therefore, one of the aims of this project is to incorporate this technology into a digital shopping list. This means that when users create their shopping list, be it daily or weekly, the system will help users to find the places that sell a particular food product in the shopping list within a designated distance radius. This means that users will be able to choose any of the places proposed by the system to do their grocery shopping and the system will guide the user to the designated place using GPS.

2.8.2 Comparisons Between Types of Map For Geo-Location Awareness Capabilities

Nowadays, map sites are generally pretty similar. It is used to find locations, business listings, get directions and see images of places to visit. Despite all that, there are still some differences between the digital maps provided on the Internet. Here is the comparison between the three most famous map services which is Bing Maps by Microsoft, Google Maps by Google and Nokia Maps by Nokia. The categories which is tested will be map essentials which will be the details of the map when zoomed and panned in, street view which is the way the map represent data at street level, geo coding services which is the availability of the API of the map solutions, distance matrix which is the accuracy of the coordinates, 3D view which is the details of the map in 3 dimensional view and satellite imagery which represents the availability of satellite images for the maps.

	Google	Bing	Nokia
Map Essentials(Zoom,Panning,Tooltip)	10/10	10/10	9/10
Street View	Yes (Street View)	Yes (Streetside)	Yes (Nokia Drive)
Geo coding services	Yes	Yes	Yes
Distance Matrix	8/10	10/10	10/10
3D View	9/10	10/10	9/10

Satellite Imagery	Yes	Yes	Yes

Table 2-4 Comparison between Types of Digital Maps (Sanj, 2012)

From the table above, it is clear that there is no distinct advantage between each of the mapping solutions compared above. Although Nokia Maps might have a slight disadvantage in the map essentials and 3D view categories, in reality, the difference is almost miniscule. However, it is more prudent that each of the solutions above is properly tested using the same location as a constant to compare the usability. The images below provide a map of Cupertino, CA, America using each of the mapping solutions compared above.

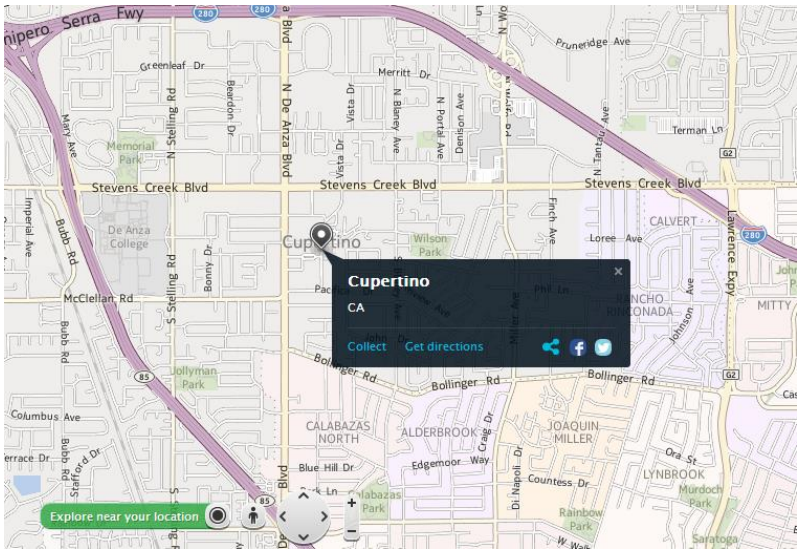


Figure 2-5 Nokia Maps

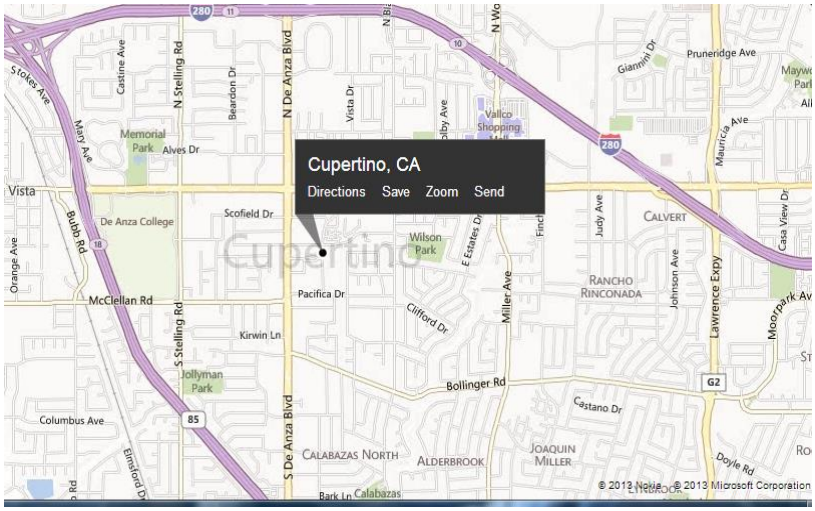


Figure 2-6 Bing Maps

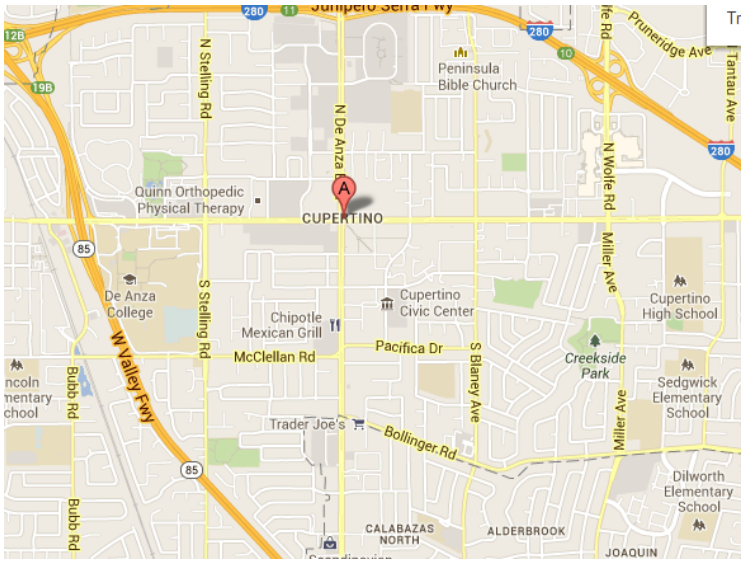


Figure 2-7 Google Maps

In a glance, it may seem that all 3 of the mapping solutions given are almost identical. However, on closer inspection, we can see that Nokia Maps is actually more detailed than the other two as the street names on each intersection is provided. It may not seem much, but this will be useful for users who are new in town and have no idea which street is which.

2.9 Review Of Existing Software

2.9.1 Food Planner

This application for Android devices works much like a day to day planner used to plane daily meals. It allows users to choose between breakfast, lunch and dinner and let users to choose between which recipe that the user wanted to cook. Recipe can be added either by user or imported from a few selected websites. Users also have the option to add ingredients from their recipes into their shopping list on the application. Not only that, this application has a feature to allow users to sync with other devices using an email. This application also allow user to keep track of their inventory and comes with a feature to integrate third party barcode scanner into the system. However, groceries that have been bought are not automatically added into the user's inventory and instead have to be manually added by the users. Besides that, this application will not notify users when users actually added items that they already have into the shopping list. This will actually cause food wastage which is undesirable. Also, the interface of this application may be too simplistic for some people who prefer more interactive interface.

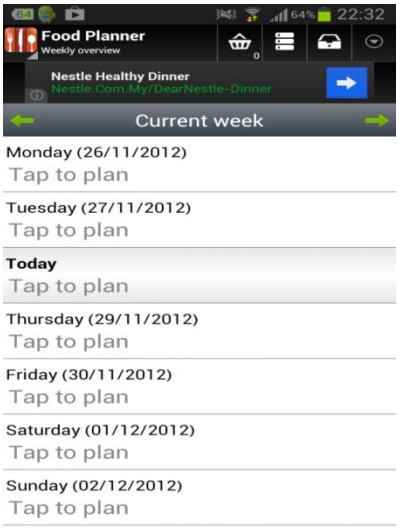


Figure 2-8Screenshot of Food Planner

2.9.2 myFood

This application for Android devices works much like a standard meal planner. Firstly, it allows users to sign in with their personal email and allow users can choose to view their recipes, food plans and shopping list. For each meal or recipe, the app will display the amount of calories, carbohydrates, proteins and fats which is helpful to promote a healthy diet. The application also come with a few pre-suggested recipes and the ingredients from the recipes can be imported into either an online shopping list which is stored in the cloud and can be viewed by other users or offline list which is a personal list. However, the applications have no way of keeping track of inventory which will lead to wastage. Besides, there is no way to cross off groceries from shopping list

unless the item is deleted which will cause confusion as the user will have no way of knowing whether they actually bought a particular ingredient. Also, users will have to key in everything manually, from recipes to ingredients other than groceries imported into shopping lists which will greatly cause inconvenience to users.

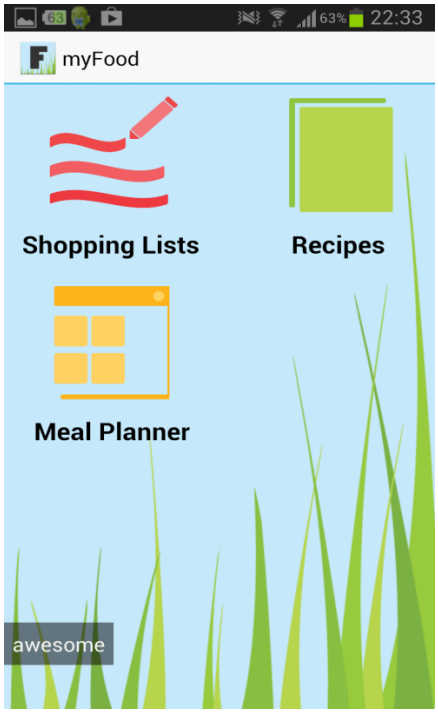


Figure 2-9 Screenshot of MyFood

2.9.3 Love Food Hate Waste

This application for Android devices is more of an application to prevent wastage rather than a standard meal planner. Firstly, it comes with a feature to enter how many people are eating to control the portion of food and to control the portion of ingredient that need to be bought. This application also comes with an interesting feature called the Recipe Blender where users select ingredient and random recipes will be suggested. This is actually a fun feature to keep the boredom of cooking the same thing everyday away. It also comes with a standard meal planner to allow users to plan what they wanted to eat on a daily basis and also a basic shopping list feature. However, this application, like Recipe, Menu and Cooking Planner, does not have a way to keep track of inventory. Besides, it does not have a way to import ingredients from recipes to the shopping list. From this, it can be seen that this application only aims to prevent wastage of food through portion control instead of inventory control which will actually help to save more and easier to be done.

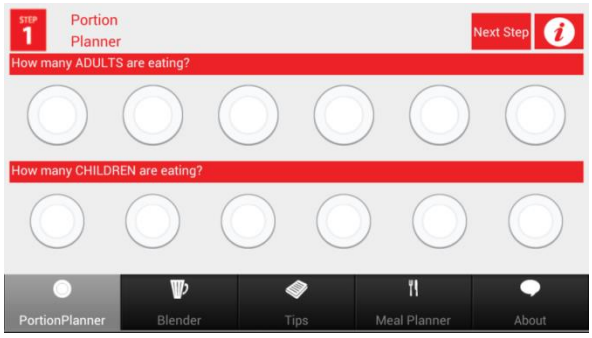


Figure 2-10 Screenshot of Love Food Hate Waste

2.9.4 Comparisons

Software\Features	Inventory Control	Color Coding Scheme For Storage Arrangement	Shopping List With Geo Location Awareness	Food Tagging	Food Measurement
Food Planner	Yes	No	No	No	No
myFood	No	No	No	No	No
Love Food Hate Waste	No	No	No	No	No

Table 2-5: Comparison between Existing Food Management Applications

From table above, we can clearly see that the proposed system, Mobile Food Planning and Conservation System clearly has an advantage over the other reviewed software. For the first category which is inventory control, it can be seen that both myFood and Love Food Hate Waste does not have such a feature. Even though Food Planner has this function, it is not optimal as it does not have food measuring to support it. Without color code scheme, users will have to spend a longer time looking for a particular food item if he or she forgets where the item is. Besides, without food measurement, inventory control will simply be the quantity of item the user has and we do not know how much of a particular ingredient is left and this will make it hard to keep track of the correct amount of food.

Besides, none of the reviewed applications have a geo location awareness function. This will make it hard for users to plan their shopping as there could be a lot of place where an item can be bought but with varying prices.

Not only that, we can see from table 2.5 that none of the reviewed system actually have a food tagging function. This is not optimal to the system as the function is needed for users to easily keep track of expiry date. Of course, products bought from supermarket usually have labels with expiration date on it but what about fresh food bought from market? Users may buy a chicken from the market and completely forget about it only to find it expired in a week. Therefore,

this function is needed so that users can keep track of the expiry date and will lessen the chance of food going to waste.

We can deduce from the result that most of the reviewed software has more or less the same functionalities. However, through this project, we aim to improve those basic functionalities while adding functions will help to increase the ease of usability and convenience for users such as integration of color code and food tagging which are not found in other software.

Chapter 3 Methodology and Tools

3.1 Architecture

3.1.1 System Architecture

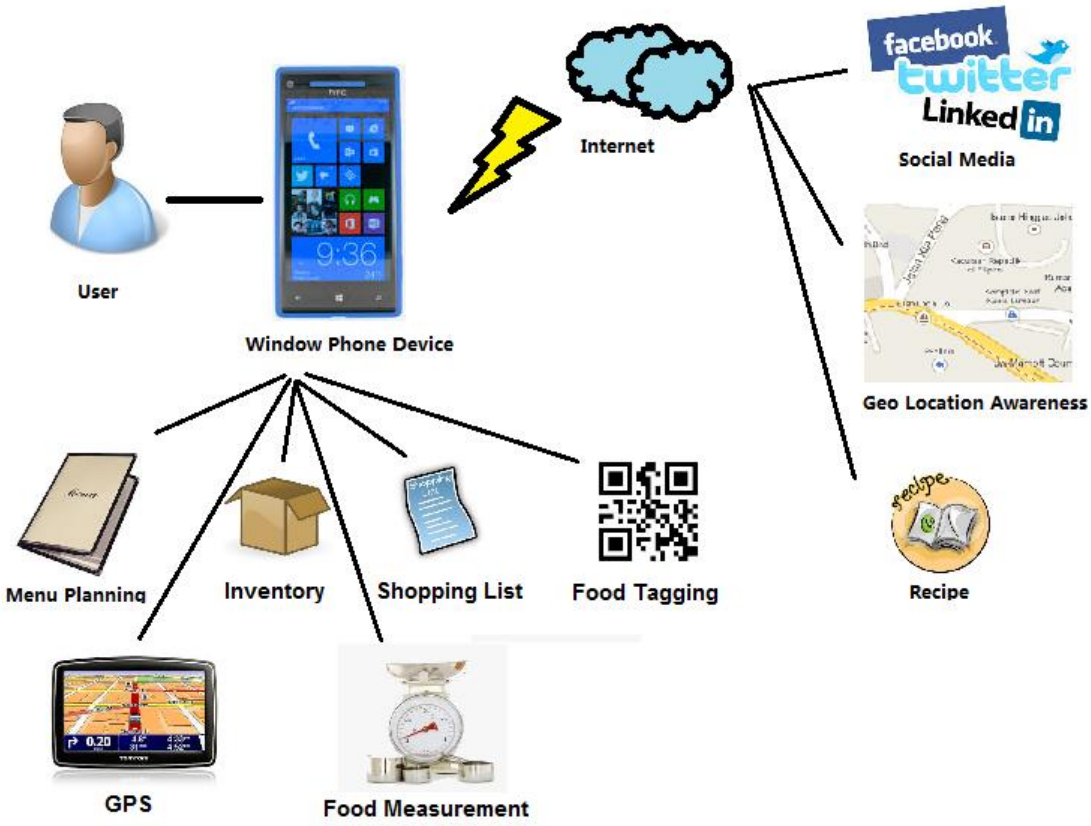


Figure 3-1 System Architecture for Food Tagging and Inventory Control

The system architecture for this project is proposed as above. Firstly, the mobile phone will need to be connected to the Internet to be able to access the GPS function to be used in the geo location awareness function. Other than that, food tagging and food measurement functions can be used even without Internet access so that users can use it at their own convenience without connecting to the Internet .

3.1.2 Model-View-ViewModel

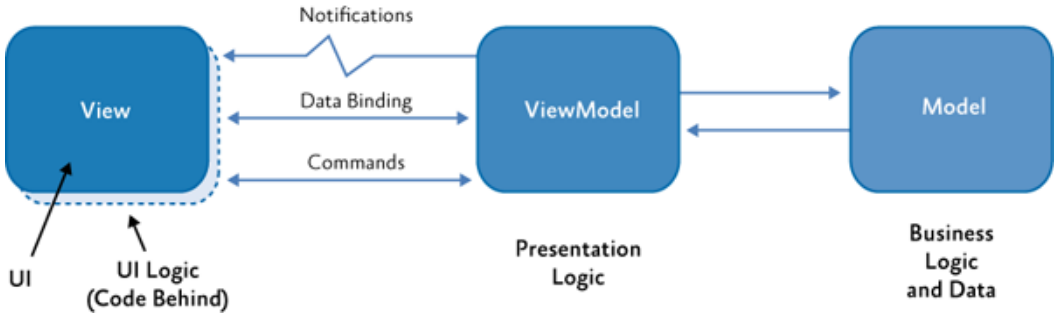


Figure 3-2 MVVM Model

The MVVM model is a software architecture pattern that originated from Microsoft. Largely based on the MVC pattern, MVVM is targeted at UI development platforms which support event driven programming. The MVVM model attempts to clearly separate the development of the UI from the business logic and behavior in an application (MSDN Magazine, 2009). MVVM can be said to be tailored specifically for WPF applications which is core to the development of this project as it is developed for the Windows Phone 8.

In MVVM, Model represents domain specific data or information that the application will be working with. It holds information, but does not typically handle behavior with the exception of data validation. The View is the only part of application the user interacts with. It is an interactive UI that represents the state of the ViewModel. In MVVM, the View is responsible for handling events to the ViewModel. The View Model is a specialized Controller that acts as data converter. It changes Model information to View information and passes commands from the View to the Model. In summary, the ViewModel sits behind the UI layer. It exposes data needed by a View (from a Model) and can be viewed as the source of data and actions for Views.

The reason that this particular architecture is chosen for this project is as follows (Addy Osmani, 2012)

- MVVM facilitates easier parallel development of a UI and the building blocks that powers it.
- Abstracts the View and thus reduces the quantity of business logic required in the code behind it.
- The ViewModel can be easier to unit test than event-driven code.

- The ViewModel (being more Model than View) can be tested without concerns of UI automation and interaction.

3.2 Software Model

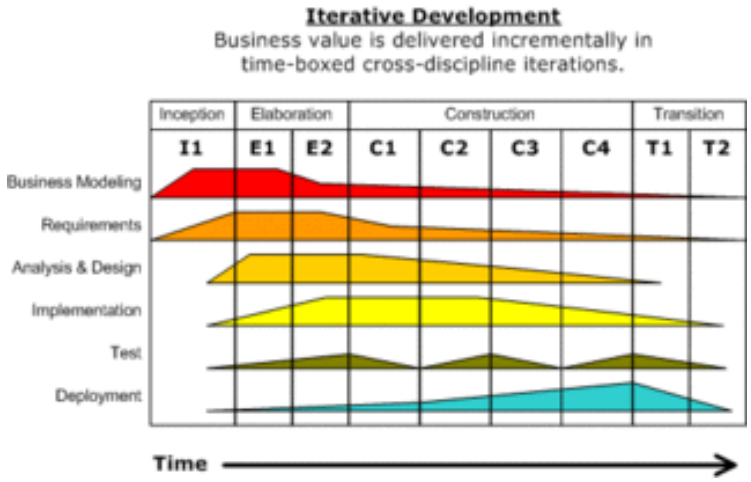


Figure 3-3 Rational Unified Process

The proposed software model to be used is the Rational Unified Process (RUP), also called iterative development. The reason this model is chosen is because there is it practically impossible to produce a set of stable requirements to be fulfilled by

this system. Therefore, it is important that a model that can easily incorporate changes to requirements is chosen. Besides, the project is planned to be implemented incrementally. This is because for each module, there will be different requirements which makes it easier if the project is incrementally developed. Below depicts each of the processes of RUP

3.2.1 Inception

This is the process where the business case for the system is established. This is where the problem statement and the objectives are defined. This is because the problems need to be understood before a solution is proposed. This means that at this stage, research on inventory control, tagging technology, geo location technology, and food measurement is done. This is to narrow down the choices of technology and algorithms that can be used. This is also where each and every of the modules proposed are documented in details to understand the reasoning behind each and every one of the module proposed.

3.2.2 Elaboration

At this stage, the system architecture is laid out and the problem domain is further broken down to understand it further. Besides that, a development plan is drawn out so that the prototype can be ready in time. This is where the

modules proposed are finalized before development begins and changes cannot be made anymore. The decided modules are food tagging, geo location aware shopping list and

3.2.3 Construction

This is the stage where implementation occurs. This means that this is where each of the modules proposed is developed and tested. The MVVM architecture is chosen for development as it allows for easier testing to minimize bugs in the system.

3.2.4 Transition

This is where each module of the system is deployed after being thoroughly tested to ensure minimization of bugs in the system. Before the deployment of the whole system, the modules will need to be integrated since some of the features are incomplete. For example, without the shopping list from the Food Planning Module, the geo location awareness function will be useless. Therefore, it is prudent that the integration is performed and the entire system is tested again.

3.3 Tools

3.3.1 Integrated Development Environment (IDE)

The IDE chosen to develop this project is Microsoft Visual Studio 2012. It is used to develop console and graphical user interface application along with Windows Form or WPF applications for all platforms supported by Microsoft specifically for this project Windows Phone 8. The reason this IDE is chosen because the project aim to develop an application for Windows Phone 8 and therefore, the IDE provided by Microsoft will be more suitable for development in this context.

3.3.2 Windows Phone 8 Development API

The application programming interface (API) provided for windows 8 development cover most of the area needed to create any type of Windows Phone 8 application possible. The API provided included basic programming uses such as fundamental types and date and time to complex functions such as multitasking and 3D graphics. The API that will most likely be used in this project included:

1) Media, Sounds and Pictures: This API included the functions for media capture such as photos and audios besides the functions to control the camera of the phone.
2) XML, Database and Serializations: This API gives the ability to do data binding for attributes in XML format through LINq while also allowing programs to perform serializations.

3) Maps, Location and Sensors: This API gives the ability to track the location of the phone through geo-location awareness while also giving access to the sensors of the phone such as accelerometer and gyroscope.
4) Controls and Animation(XAML): This API included the functions to draw polygons and create animations and elements for UI design while also giving the access to the maps to be used in GPS

3.3.3 Programming Language

The proposed programming language to be used in this project is C#. The reason that it is chosen because C# support rapid application development which is critical to this project as a prototype needs to be quickly delivered and is also synonymous with the software model chosen in section 3.2 which requires a rapid development approach. Besides, this is a fourth generation programming language which makes it easier to develop the system as the graphical user interface will be easily developed using form designer to fit the coding behind the system.

3.4 Implementation Issues and Challenges

First and foremost, one of the challenges of this project is the implementation of Model View ViewModel (MVVM) framework. This is because the model clearly separates the development of the user interface (UI) from the development of the

business logic or back end logic known as the model. This makes it difficult to connect the UI to the model of the system as we have to make use of the data binding functions of the Windows Form Presentation (WPF) to properly connect a model to the view. Besides, the MVVM model is one of the newer architecture frameworks that have been introduced and therefore, some time needed to be spent to explore the model as most mobile applications makes use of the Model View Controller (MVC) model instead of MVVM.

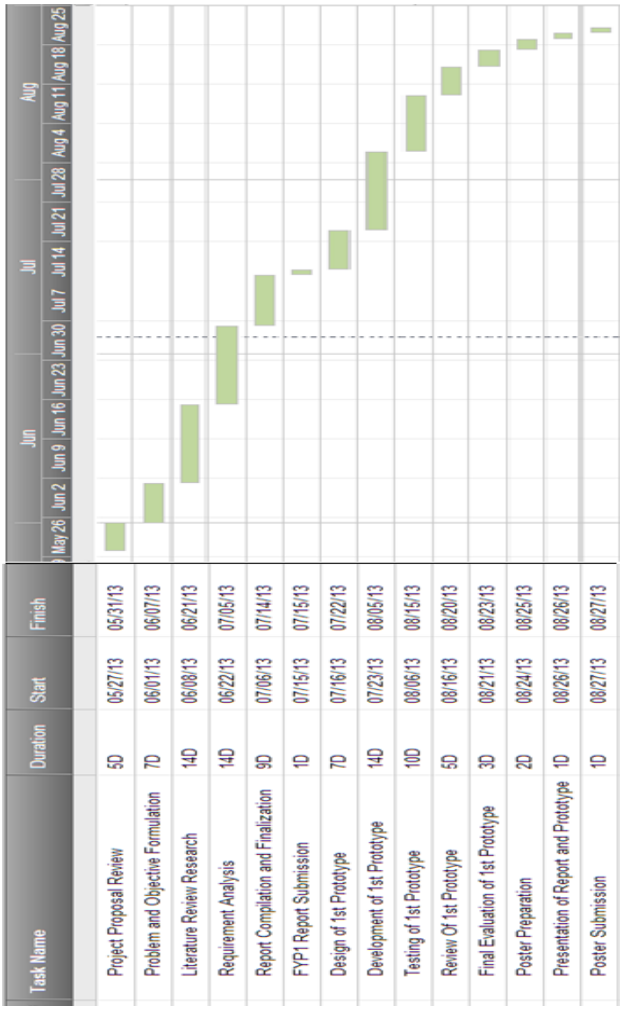
Besides that, the project requires the use of a real smart phone for testing. Although some of the functions can be tested in an emulator. There are some aspects that require the project to be tested on a real phone. Firstly, the feel of the system as in the fact that the feel of the system when it is tested using an emulator and a touch screen of a smart phone is vastly different. Therefore, the UI of the system needs to be catered so that it feels interactive in the smart phone at the hands of a user instead of the emulator. Besides, some of the functions may require the use of the sensors such as camera and accelerometer. These sensors will definitely not be available in the emulator and therefore, will require the use of a real phone to correctly test the function. Lastly, and perhaps the most important, is that a real phone is need to do benchmarking. This is because an emulator will be definitely run on a computer or laptop and therefore, will share its resources such as memory and

processing power. This may cause the performance to vastly differ in the emulator and the real thing because even though nowadays smart phone has higher processing power, it still cannot be compared to a personal computer and even a laptop. Therefore, a real phone is needed to test the performance and the system can be catered to run smoothly on the phone.

3.5 Timeline

3.5.1 Gantt Chart

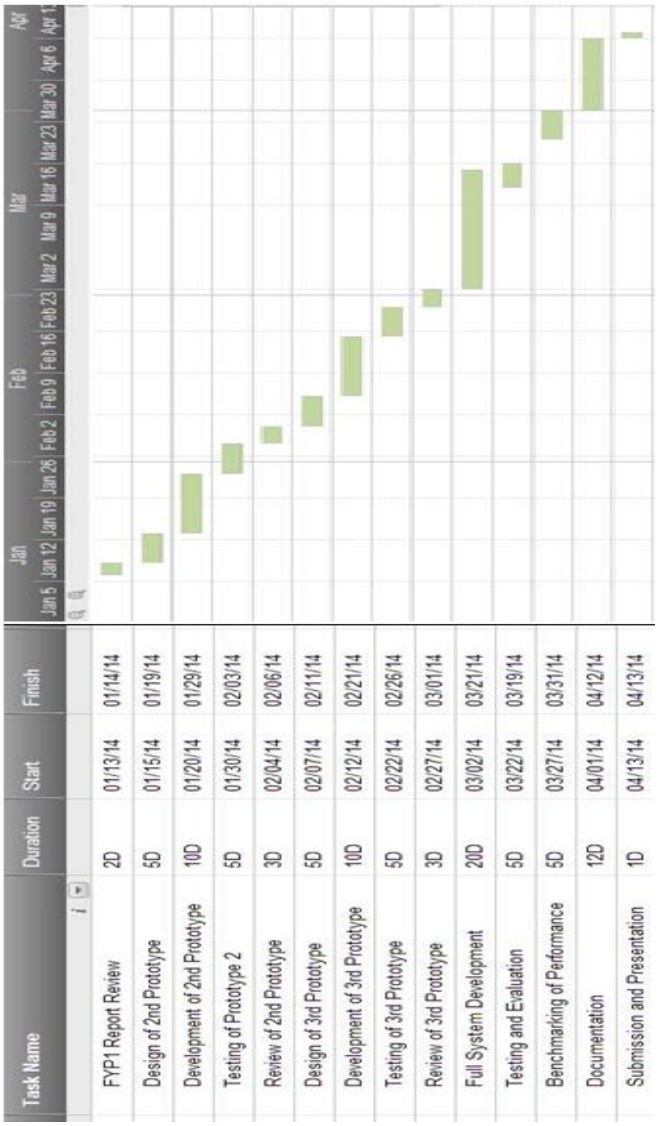
1) Project 1



Task Name	Duration	Start	Finish
Project Proposal Review	5D	05/27/13	05/31/13
Problem and Objective Formulation	7D	06/01/13	06/07/13
Literature Review Research	14D	06/08/13	06/21/13
Requirement Analysis	14D	06/22/13	07/05/13
Report Compilation and Finalization	9D	07/06/13	07/14/13
FYP1 Report Submission	1D	07/15/13	07/15/13
Design of 1st Prototype	7D	07/16/13	07/22/13
Development of 1st Prototype	14D	07/23/13	08/05/13
Testing of 1st Prototype	10D	08/06/13	08/15/13
Review Of 1st Prototype	5D	08/16/13	08/20/13
Final Evaluation of 1st Prototype	3D	08/21/13	08/23/13
Poster Preparation	2D	08/24/13	08/25/13
Presentation of Report and Prototype	1D	08/26/13	08/26/13
Poster Submission	1D	08/27/13	08/27/13

Figure 3-4 Gantt Chart for Project 1

2) Project 2



Task Name	Duration	Start	Finish
FYP1 Report Review	2D	01/13/14	01/14/14
Design of 2nd Prototype	5D	01/15/14	01/19/14
Development of 2nd Prototype	10D	01/20/14	01/29/14
Testing of Prototype 2	5D	01/30/14	02/03/14
Review of 2nd Prototype	3D	02/04/14	02/06/14
Design of 3rd Prototype	5D	02/07/14	02/11/14
Development of 3rd Prototype	10D	02/12/14	02/21/14
Testing of 3rd Prototype	5D	02/22/14	02/26/14
Review of 3rd Prototype	3D	02/27/14	03/01/14
Full System Development	20D	03/02/14	03/21/14
Testing and Evaluation	5D	03/22/14	03/19/14
Benchmarking of Performance	5D	03/27/14	03/31/14
Documentation	12D	04/01/14	04/12/14
Submission and Presentation	1D	04/13/14	04/13/14

Figure 3-5 Gantt chart for Project 2

3.6 Requirement Specifications

3.6.1 User Requirements

a) Use Case

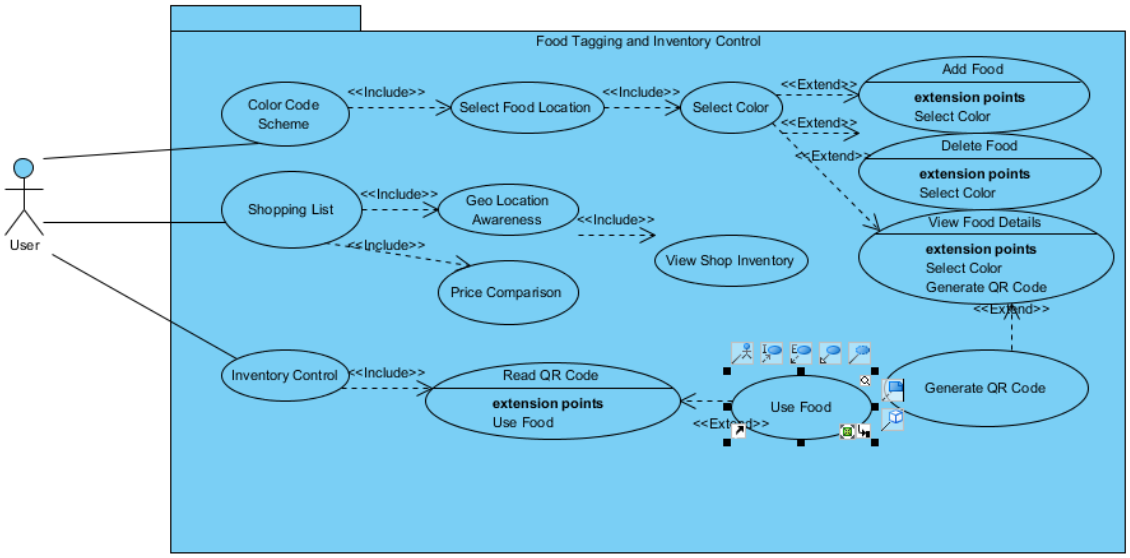


Figure 3-6 Main Use Case for Food Tagging and Inventory Control

b) Sequence Diagram

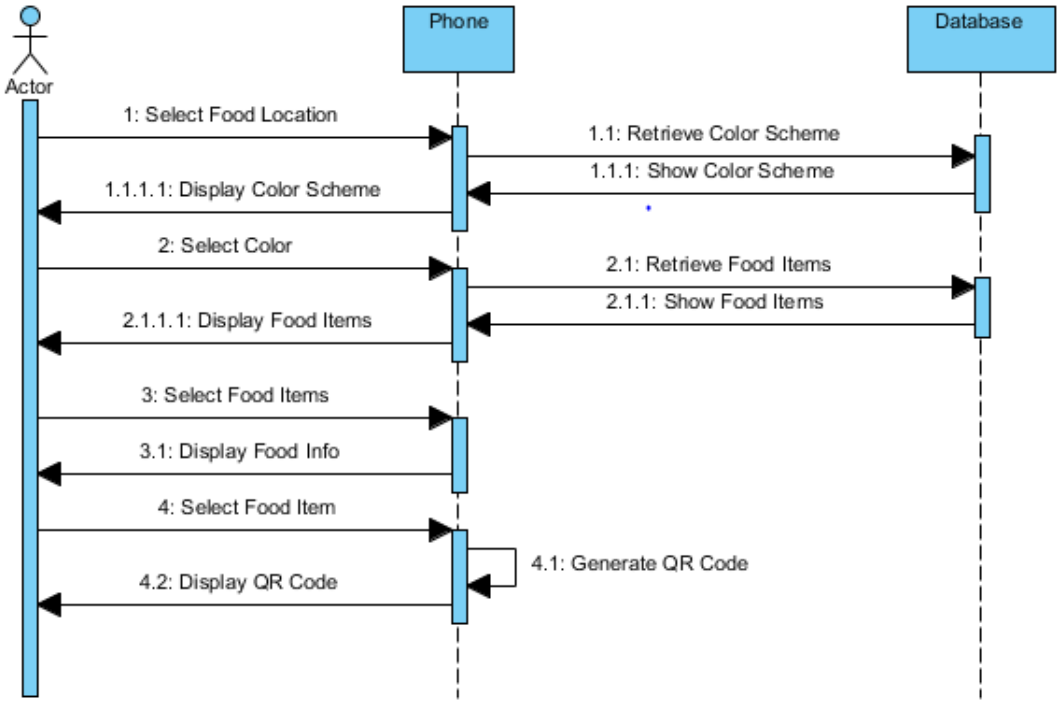


Figure 3-7 Sequence Diagram for Color Code Module

For Food Tagging, the user is first allowed to select any location where they have food stored. This will reveal the color code scheme for that particulate location for the user to see. After that, user will be able to choose any segment of the color code scheme to view the food item data that is inside that segment. The details of the food item such as

expiry date and quantity will be displayed to the user. Then, user will be able to generate a QR code using the details shown.

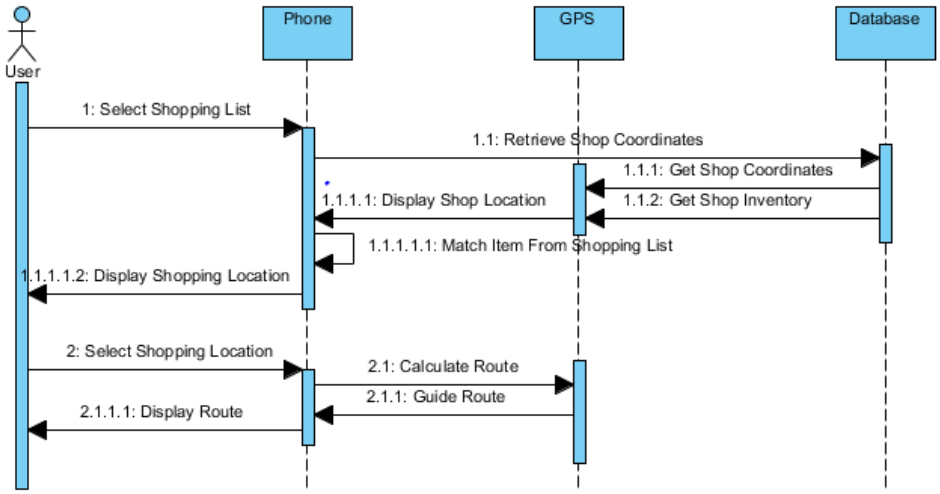


Figure 3-8 Sequence Diagram for Geo-Location Aware Shopping List

For this module, the system will check for any item entered in the shopping list and matches it with the locations of stores that will sell that particular item from the database. The system will then display a list of location that sells that particular item. User can then choose any location and the system will be able to guide the user to that location.

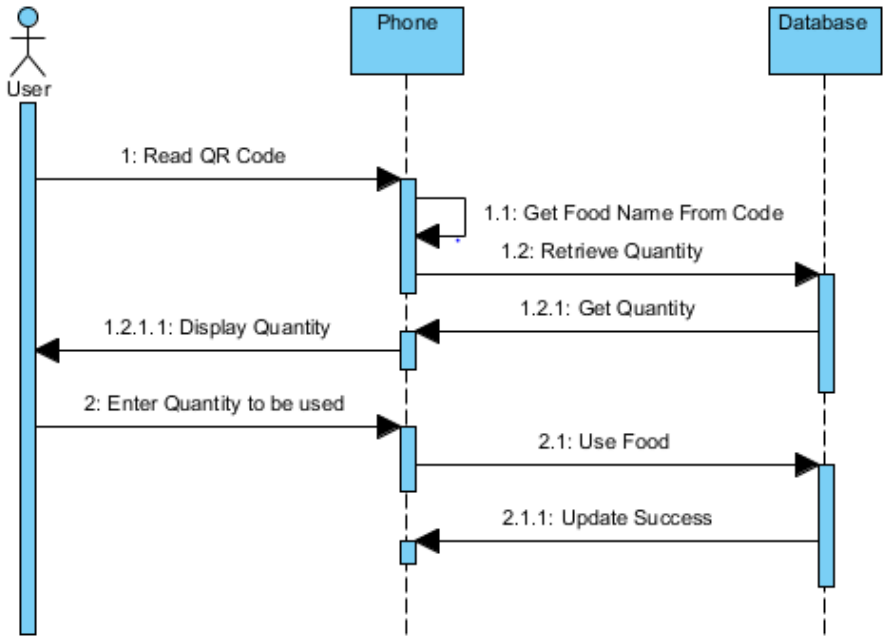


Figure 3-9 Sequence Diagram for Inventory Control

For this function, the system will continuously check in the background for any items that is about to expire. If it is about to expire, the system will display a message asking the user to consume the food quickly. To that extend, the system will allow user to select a list of recipes that uses the item that is about to expire as an ingredient.

c) Database Design

For the database, 2 separate schema will be needed to store the data as the data for Food Tagging and the data for Geo Location Aware Shopping List does not have any similarities with each other. The schema for both the module is shown below.

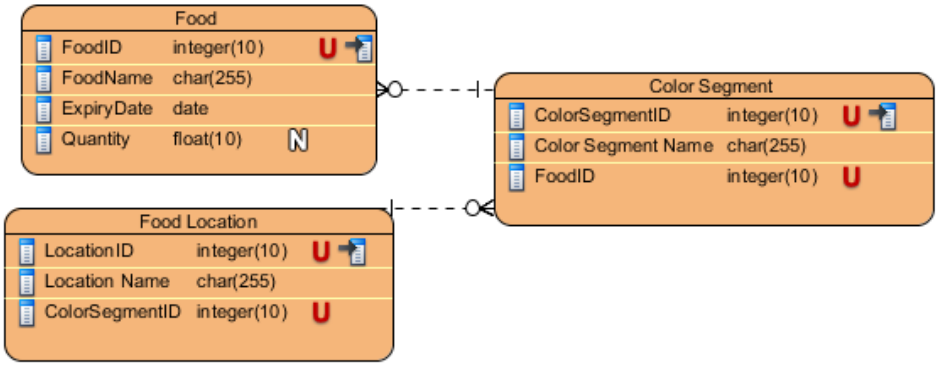


Figure 3-10 Database Schema for Food Tagging

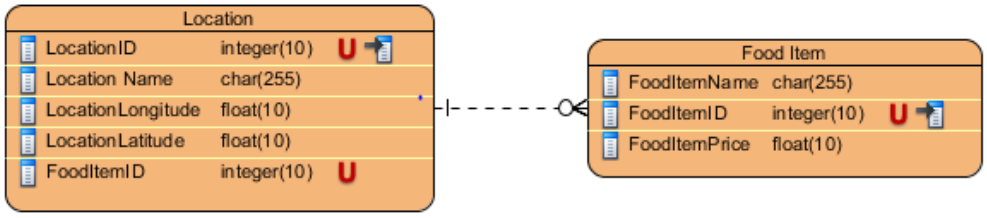


Figure 3-11 Database Schema for Shopping List

3.6.2 Design and Verification Plan

The testing for this project will be conducted using use case testing where the input of the program will be matched with the output of the program for each of the use case in the program.

Use Case ID	1
Title	Food Tagging
Pre-Condition	The app is in the main menu
Test Steps	1. Click on Food Tagging button
Expected Results	Color code scheme is displayed
Results	Pass

Use Case ID	2
Title	Select Color
Pre-Condition	Click on any color in the selected food location
Test Steps	1. Select any color
Expected Results	For select color, the list of food in that color is displayed.
Results	Pass

Use Case ID	3
Title	Add Food
Pre-Condition	Clicked on any color button
Test Steps	1. Add new food with name, expiry date and quantity
Expected Results	New food is added
Results	Pass

Use Case ID	4
Title	Delete Food
Pre-Condition	Clicked on any color button

Test Steps	1. Click on delete button beside food item
Expected Results	Food item is deleted
Results	Pass

Use Case ID	5
Title	View Food Details
Pre-Condition	Clicked on any color button
Test Steps	1. Press on any food item button
Expected Results	Food item details is shown
Results	Pass

Use Case ID	6
Title	QR Code generator
Pre-Condition	Clicked on any food details
Test Steps	1. Clicked on the generate QR code button
Expected Results	QR code is generated
Results	Pass

Use Case ID	7
Title	Shopping List
Pre-Condition	The app is in the main menu
Test Steps	1. Click on the shopping list button
Expected Results	The shopping list page is displayed
Results	Pass

Use Case ID	8
Title	Geo location awareness
Pre-Condition	Clicked on search button in Shopping List
Test Steps	1. Wait for list of shopping location to be displayed
Expected Results	List of shopping location is displayed

Results	Pass

Use Case ID	9
Title	Inventory Control
Pre-Condition	The app is in the main menu
Test Steps	1. Click Inventory Control button
Expected Results	The camera is displayed
Results	Pass

Use Case ID	10
Title	Read QR Code
Pre-Condition	Inventory Control button is clicked
Test Steps	1. Focus QR Code 2. Read QR Code 3. Move to Use Food
Expected Results	QR code successfully read
Results	Pass

Use Case ID	11
Title	Use Food
Pre-Condition	QR Code successfully read
Test Steps	1. Enter quantity of food to be used
Expected Results	Quantity entered is subtracted from current quantity and database is updated
Results	Pass

3.6.3 Screenshots with Explanations

Figure 3-12 Main Menu

Figure 3-13 Color Code Scheme

In figure 3-23, the color code scheme is shown. The purpose of the color scheme is to segment the fridge according to the compartments so that each category of food can only be stored in a specific compartment. This has been shown to reduce food wastage as it increases awareness of food items in the fridge. When user clicks on any of the button, it will be directed to the page according to the category of the food being selected.

Figure 3-14 Meat Compartment of the Color Code Scheme

Figure 3-24 is the result after user clicked on the Meat section of the color code scheme. As shown above, the information are arranged according to alphabetical order and the information of the food are shown. The 4 buttons on the application bar are the bottom of the screen are the functions to generate QR code, add food, scan food from barcode, and delete food.

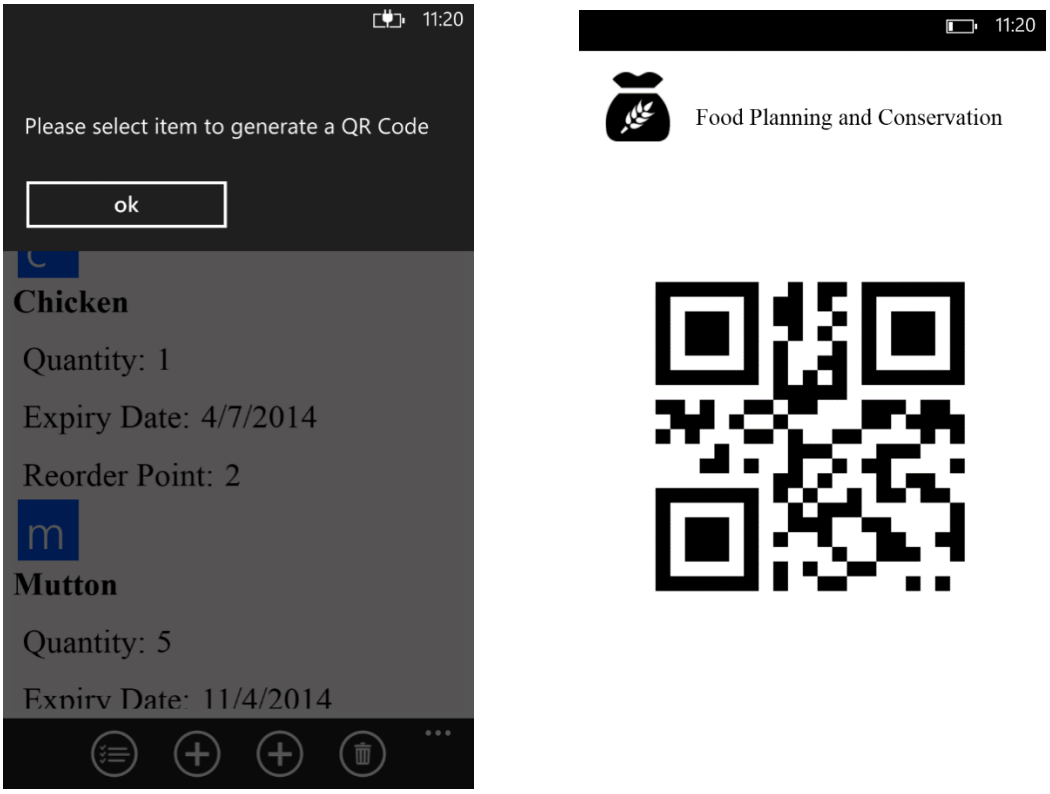


Figure 3-15 Generating QR Code and the subsequent result

In figure 3-25, after the generate QR code button is pressed, a message box will ask user to select a food to generate a QR code. After the message box is removed, user can click on any food item to generate a QR code as shown. The function of the QR code is for user to keep track of inventory as will be explained further below on the inventory control section.

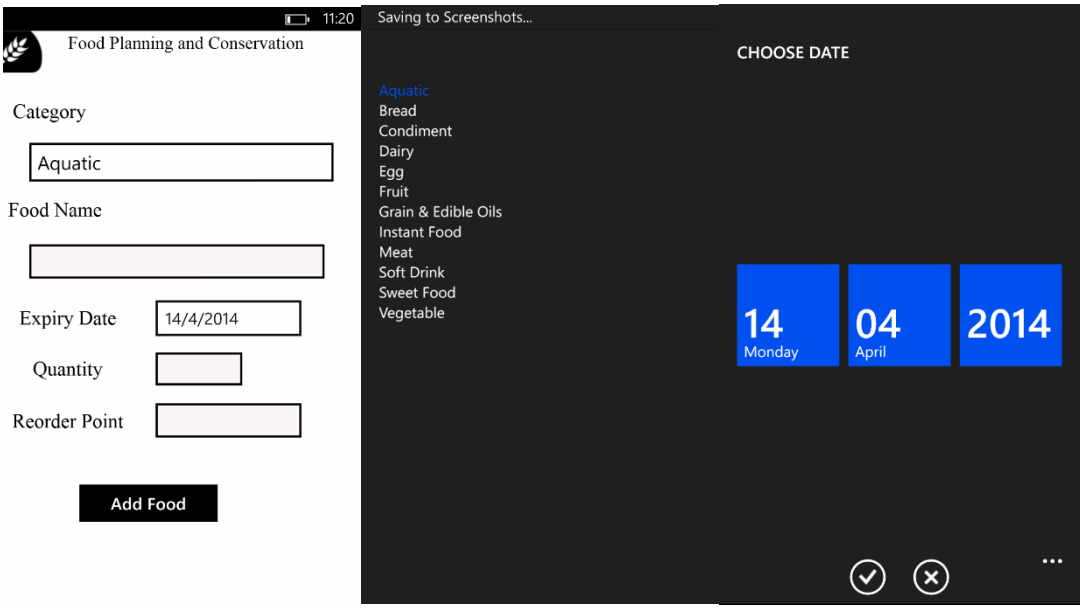


Figure 3-16 Add Food page

In figure 3-26, the screen on the left is shown when user clicks on the add food button. In this page, user can select the category of food that they wanted to add it to. Besides that, a date picker asset is used to allow user to easily select their expiry date. The other informations that have to be entered include quantity and reorder point. When the Add Food button is clicked, the food is added into the database and will be shown in the subsequent category chosen.

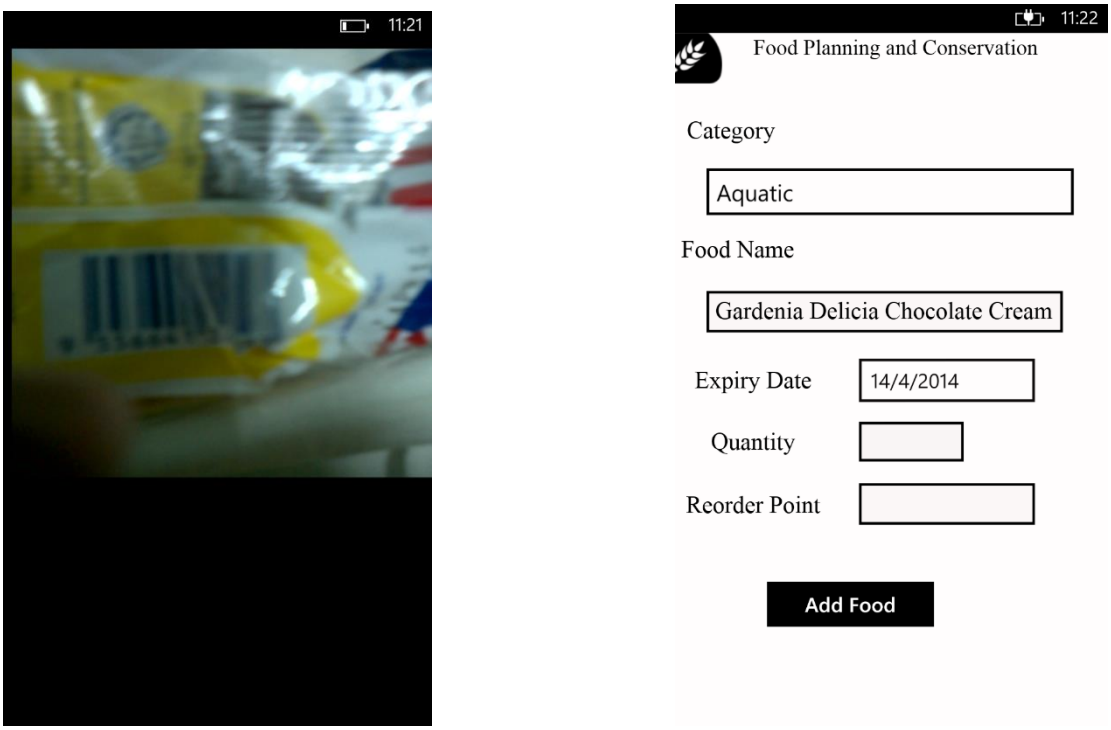


Figure 3-17 Add Food from Barcode

In figure 3-27, the camera is brought up when the add food from barcode button is pressed in the page shown in figure 3-24. When a barcode is successfully read, the phone will retrieve its name from the database and show it on the page as shown on the right. This is to speed up the process of entering information of food for convenience purposes.

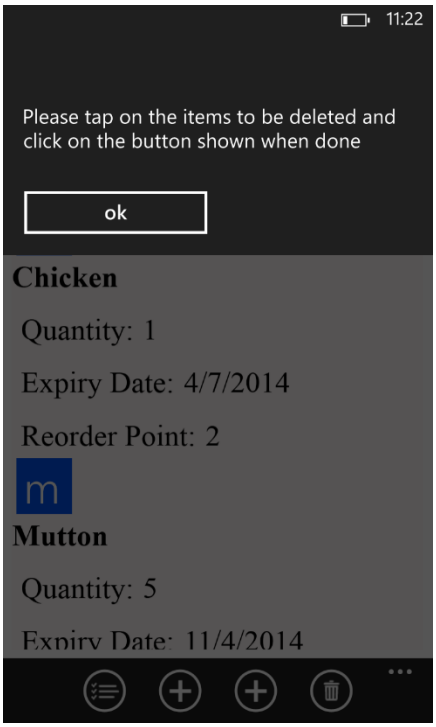


Figure 3-18 Deleting Food

The message box shown in figure 3-28 is the result of pressing the delete food button. After the message box is removed by clicking the OK button, user can tap on any food item shown and the food item will be deleted from the database.

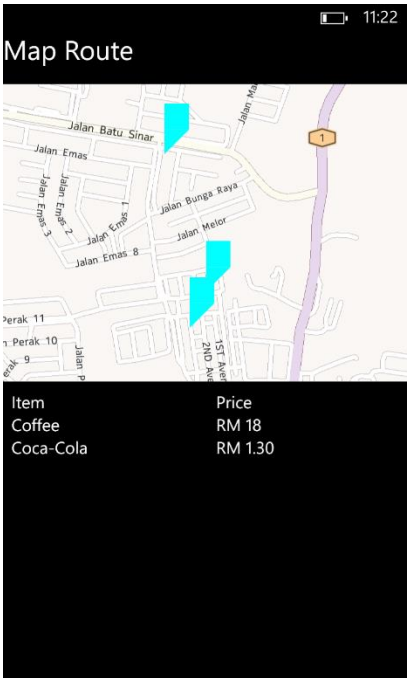


Figure 3-19 Geo Location Aware Shopping List

In figure 3-29, the geo location aware shopping list will be brought up when user clicks on the search button in the shopping list. The purpose of the shopping list is to provide convenient location for users to do their shopping.

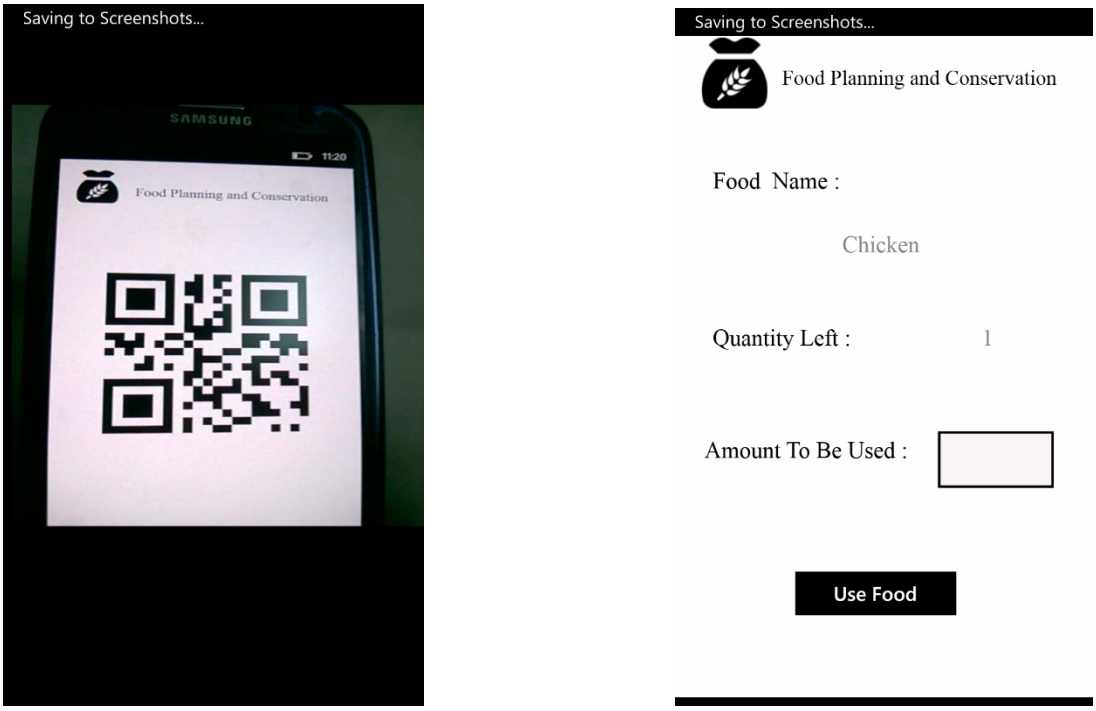


Figure 3-20 Inventory Control

Figure 3-30 shows the inventory control module, when a QR code that is generated using this application is scanned, the data in the code will be retrieved and shown on the page on the right. The current quantity of the item will be shown and the amount to be used will be keyed in by the user. When the Use Food button is pressed, the app will subtract the current quantity of the food with the entered quantity and update the value in the database.

Chapter 4 Conclusion

In conclusion, food wastage is getting serious by the day. Since food wastage is no small matter and running rampant, it is high time that actions are taken to ensure it does not spread further before it affects and destroys the environment. Therefore, the motivation behind 'Mobile Food Planning and Conservation System' is to reduce food wastage through inventory control and controlled shopping.

Throughout the project, some of the constraints for the application was discovered. One of the problem is that there will still be human interaction when adding or deleting food. However, through the use of tagging technologies, we have greatly reduce the manual input need and was able to increase the speed when entering inventory. Besides, the shopping locations in the geo-location aware shopping list will need to be stored in the database beforehand as the functionalities of a GPS does not cover which business a particular location is. Not only that, for the QR code generator, a new QR code will need to be generated every time a new type of food item is introduced into the system. However, the QR code that is already generated can be reused in the inventory control module.

Some of the proposed future improvements for this project may include functions that allow users to add in their own shopping list and its inventory for next time use as the app itself will not be able to keep track of all the shops in a particular area. Besides, in the future, the app shall be allowed to show the current discounts of a particular shopping center such as Tesco or Giant. Also included as part of future improvement will be the choice to customize the color

code scheme either through drag and drop operations or the introduction of new templates based on refrigerator model in the market.

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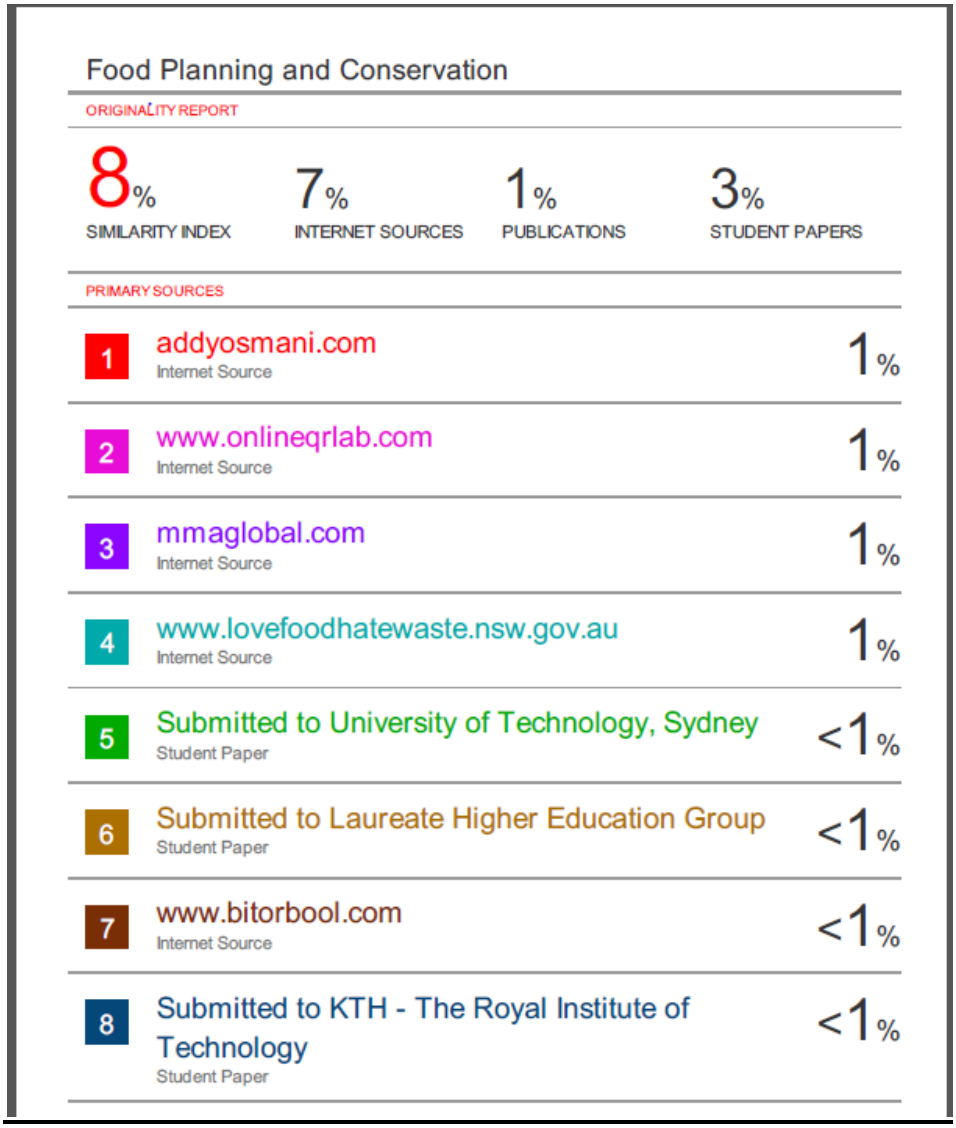
Appendix A



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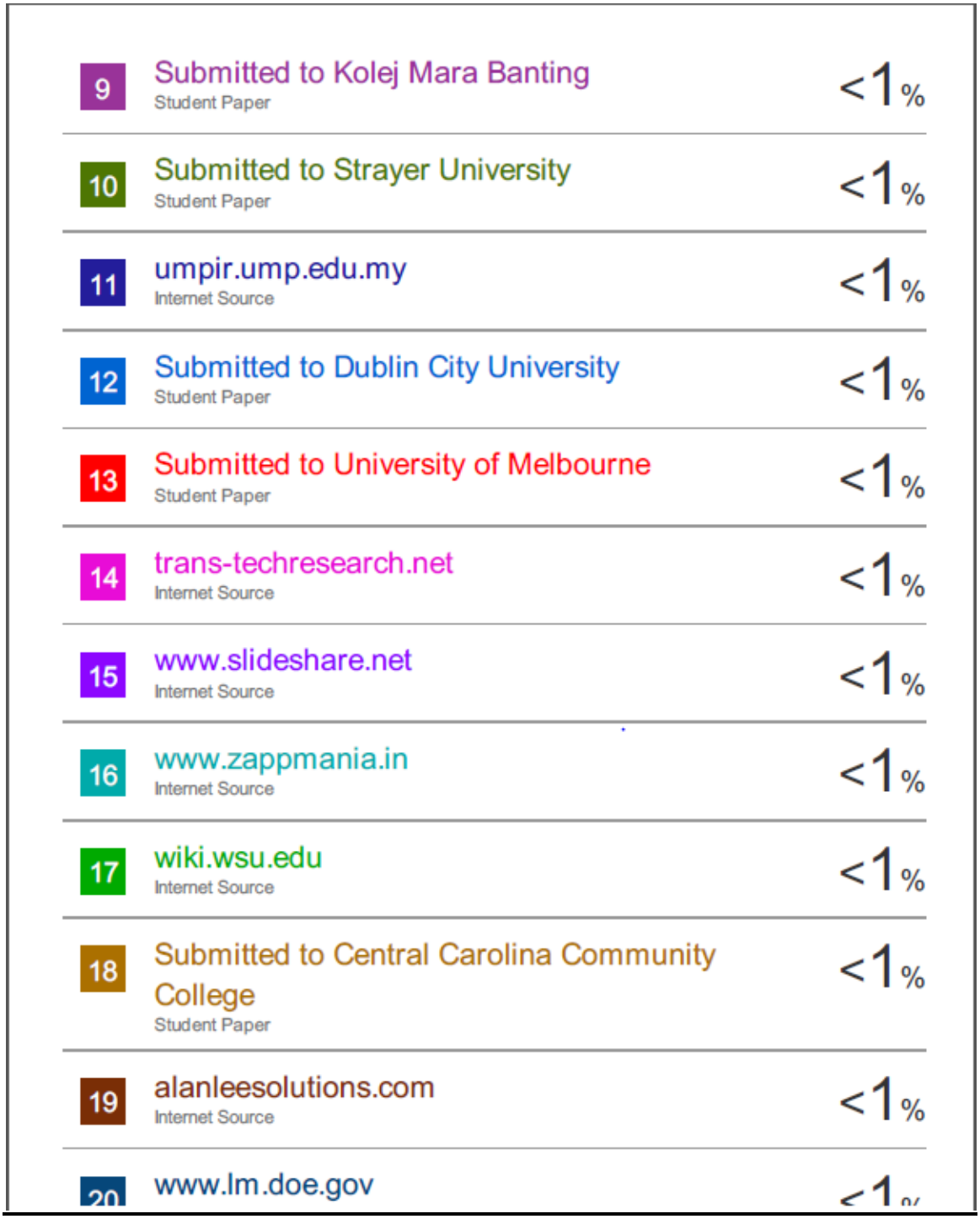

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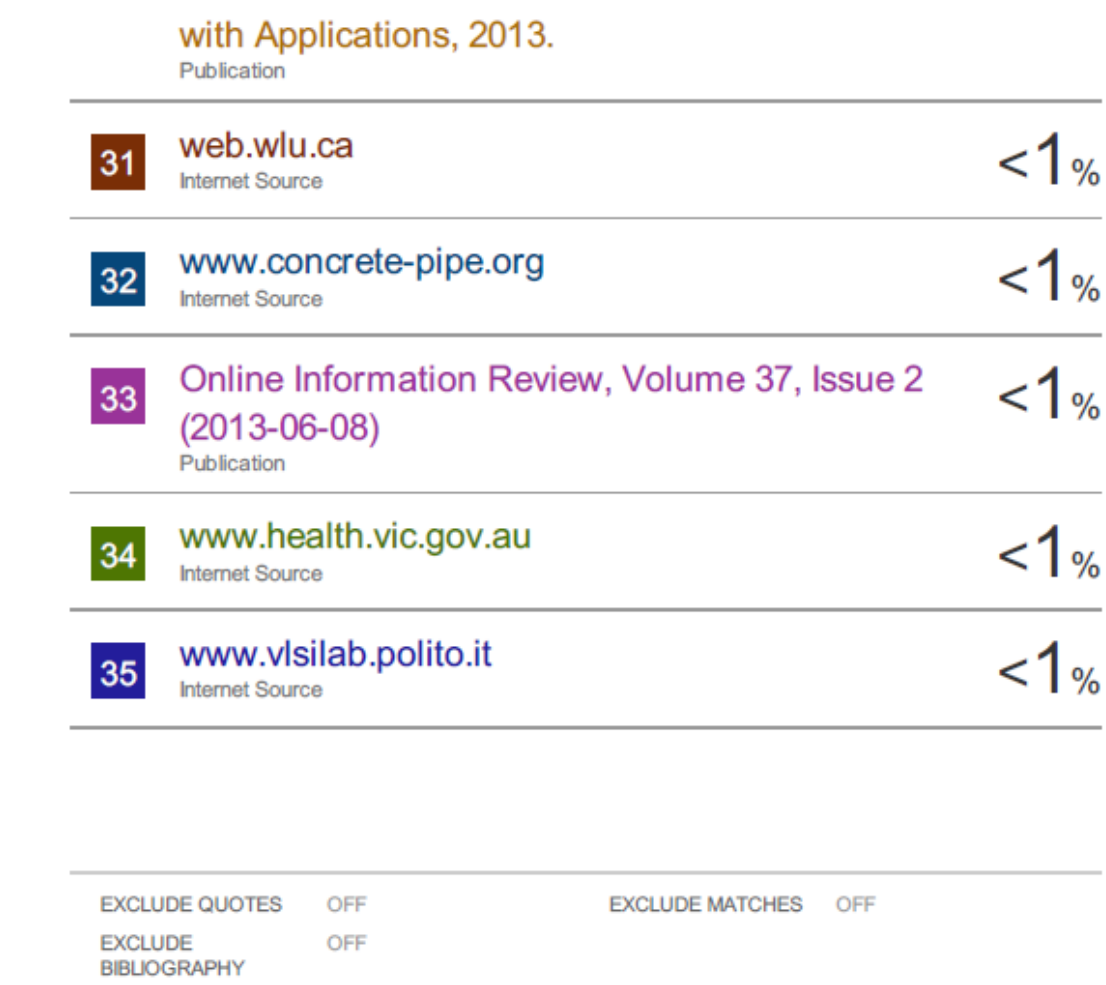
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