Designing Interactive Digital Tools to Support Families Reducing Food Waste

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Abstract

Food waste - the avoidable loss of edible products - has social, economic and environmental impacts. In the poorer nations food security is an issue while in the richer nations, the higher the national GDP, the higher the per capita food waste. Over half the food wasted in Europe occurs in the domestic/consumer section with the majority of that going for composting which produces excess greenhouses gasses. This study targets the home user with a mobile device application called ‘FeastMe’ that is aimed at reducing this domestic waste. FeastMe is designed to integrate a pre-existing supermarket, BYOD, self-scan POS system with a novel, multi-user, ‘family sync’, database driven storage system and a recipe module.

The methodology used was to examine previous works in this sector and note their shortcomings. These were then addressed in the application design. A barcode scanning, Android app was developed using a standard, iterative design cycle process using paper prototypes and user feedback prior to building with the Ionic framework. The application backend was also built using Ionic, linking a Google Firestore/Firebase data storage with the recipe module and the Android app. All communication between these components was using Javascript (or a derivative such as JSON, Typescript, AngularJS) to/from REST APIs via TSL HTTPS links.

The number of participants in the study were 15. The prototype was evaluated by a number of user questionnaires. Statistical analysis of the results found a wholly positive response as to whether the prototype could help reduce wastage. This study showed that a barcode scanning app could be utilised to reduce shared household food waste.

Keywords: Prototype, Food Waste, Recipe, BYOD, Ionic, Firestore, Firebase, Typescript, Angular JS
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Contents

1. Introduction .................................................. 10
1.1 Background .................................................. 10
1.2 Literature Review .......................................... 10
1.3 Terms and Scope ........................................... 12
1.4 Current situation ........................................... 12
1.5 Research Questions ........................................ 14
1.6 Strategy ....................................................... 15
1.7 Application Requirements Analysis ....................... 15
1.8 Overview of the application architecture ................. 16
2. Background and Related Work ............................... 17
2.1 Introduction .................................................. 17
2.2 Food Wastage Impacts ...................................... 17
2.3 Causes of consumer food wastage ........................... 18
2.4 Preventing and Recovering Food Wastage .................. 19
2.5 Social Recipes in Reducing Food Waste .................... 20
2.6 Technologies for Reducing Food Wastage .................. 20
2.6.1 A ‘Traditional’ web based approach: Love Food Hate Waste .... 21
2.6.2 A ‘Traditional’ web based approach: FoodSharing.de .......... 22
2.6.3 Smartphone: Fridge Pal .................................. 23
2.6.4 Leftover Swap ............................................. 24
2.6.5 EatChaFood ............................................... 25
2.6.6 ZmartFri Technology ..................................... 26
2.6.7 Fridge-Cam ............................................... 27
2.6.8 Internet of Things Food Inventory Management Study ........ 28
2.6.9 Food Waste Diary ........................................ 28
2.7 Overcoming the Short Comings of Existing Applications . 29
2.8 Self-Service Technologies (SSTs) ......................... 30
2.8.1 Bring Your Own Device (BYOD) ......................... 30
2.9 App technology ................................................ 32
2.9.1 Android .................................................... 32
2.10 Analysis of Barcodes ........................................ 32
2.10.1 GS1 ....................................................... 33
2.10.2 GS1 Databar ............................................... 34
2.11 Usage of Barcode for FeastMe application ................. 34
2.12 Mobile Devices: Native/Hybrid Apps and Barcode Implementation ... 35
3. Methodology ..................................................... 36
3.1 Identify needs/Establish requirements ...................... 36
3.2 Functional requirement collection ........................... 37
3.2.1 Focus group strategy ..................................... 37
3.3 Design of the First User Interview .......................... 37
3.4 Users proposed requirements ................................ 37
3.5 Functional Requirements ..................................... 38
3.5.1 Functional Requirements .................................. 38
3.6 Data Collection ................................................ 39
3.6.1 Questionnaires ............................................ 39
3.7 Designing of the Prototype Review Questionnaire ......... 39
3.8 Open ended interviews ........................................ 39
3.9 User Group Selection ........................................ 40
3.10 Fours “Us” - Usability, Utility, UX and UI ............ 40
3.11 Developing a prototype .................................... 41
3.12 Paper prototype ............................................ 41
  3.12.1 Paper prototype v.1 .................................... 41
  3.12.2 Paper prototype v.2 .................................... 41
3.13 Developed App Prototype .................................. 42
  3.13.1 Developed App Prototype (v.1) ....................... 42
  3.13.2 Developed App Prototype (Final Version) ........ 42
3.14 Scientific Approach vs Inductive Approach .......... 42
3.15 Analytical Methods ........................................ 42
4. Development of the Prototype ............................ 43
  4.1 Paper Prototype ............................................ 43
  4.2 FeastMe Mobile App Prototype .......................... 44
  4.3 Mobile Application Features .............................. 44
  4.4 Implementation ........................................... 44
    4.4.1 The Presentation Layer – Ionic Framework ........ 44
    4.4.2 The Presentation Layer - Angular JS ................ 45
    4.4.3 The Presentation Layer - Apache Cordova ......... 45
    4.4.4 The Business Layer - Typescript (TS) ............ 46
  4.5 Major APIs ................................................ 46
    4.5.1 Firebase API .......................................... 46
    4.5.2 QR Code API .......................................... 46
    4.5.3 Google Custom Search Engine ....................... 46
  4.6 Android Architecture ...................................... 47
  4.7 App System Architecture ................................ 48
    4.7.1 Use Case Diagram Description ....................... 49
  4.8 Family Tree & Your Cart Features ...................... 51
  4.9 Recipe Search Results .................................... 52
  4.10 Architecture of Recipe module .......................... 53
  4.11 Developed App Prototype (Final Version) ............ 54
  5. Results ................................................... 59
    5.1 Types of Statistical Analysis Performed .............. 59
    5.2 Demographic Data ........................................ 59
    5.3 Cronbach’s Alpha Reliability Test Results .......... 59
  5.4 Prototype Review Questionnaire ......................... 60
    5.4.1 Interface Design Characteristics .................... 61
    5.4.2 Short Answer Questions .............................. 74
    5.4.3 Prototype Tools ...................................... 78
  5.5 Application Module Views from Interviews ............ 84
  6. Discussion ................................................ 85
    6.1 Introduction ............................................ 85
      6.1.1 Your Cart Module .................................... 85
        6.1.1.1 Module UI & UX ................................ 85
        6.1.1.2 Future work .................................... 85
      6.1.2 Recipes Module ...................................... 86
        6.1.2.1 Future work .................................... 86
6.1.3 Family Sync Module .............................................. 86
  6.1.3.1 Future work .................................................. 86
6.1.4 Help Module ...................................................... 87
  6.1.4.1 Future work .................................................. 87
6.2 The Application Modules as a Whole .................................. 87
6.3 Cross platform extensibility .......................................... 88
  6.3.1 Data storage .................................................... 88
6.4 Recipes ..................................................................... 88
6.5 Overall project management ........................................... 89
6.6 Answering the Research Questions ..................................... 89
  6.6.1 RQ1: Could a smart(er) best before managing and notification system help to reduce food waste? ...................... 89
  6.6.2 RQ2: Would an integrated recipe search engine inside the application help? ................................................................. 90
  6.6.3 RQ3: The purchase of duplicate and/or excessive foodstuffs lead to waste. Most families already have a shopping strategy with shared shopping list. Could this be enhanced and extended into a multiple occupancy household by way of a sharing and synchronizing application? .................. 90

7. Summary ..................................................................... 91
  7.1 Conclusion .............................................................. 91
  7.1.1 The FeastMe Application Approach .............................. 91
  7.2 Limitations ................................................................ 92
  7.3 Future Work ............................................................ 93

Appendix A .................................................................... 104
  a) Prototype Review Questionnaire ...................................... 104
Appendix B .................................................................... 109
  b) Project Briefing .......................................................... 109
Appendix C .................................................................... 110
  c) Open Ended Interview Questions .................................... 110
Appendix D .................................................................... 111
  d) FeastMe.apk File and Demo Barcode Links .......................... 111
  e) XSS Error .................................................................. 112
List of Figures

1.1 A typical Swedish language recipe search result for “pasta spenat” presented in the recipe rich card format at the Google search engine. 13

1.2 A Swedish language search for a recipe that included “Vin” produces an erroneous product listing for a bottle of wine instead of a recipe card. 14

2.1 Two examples the inverted pyramid Food Recovery Hierarchy infographic from either side of The Atlantic. The European Union Zero Waste Project [73] (top) and the United States Environmental Protection Agency [74] (bottom). 19

2.2 Screenshot of the recipe finder page on the Love Food Hate Waste website demonstrating its ability to provide a recipe (middle panel) from an ingredients list (right panel). 21

2.3 FoodSharing.de website frontend displaying menu driven access to their various projects/site options. 22

2.4 iPhone Screenshots taken from the 2013 FridgePal app showing home inventory (left); shopping list (middle) and product entry screen (right). 23

2.5 Android screenshots of the LeftoverSwap Interface showing the geocentric ‘leftovers available near me’ (left) and feedback for other users entry (right). 24

2.6 EatChaFood Smartphone screenshots showing: color coded fridge display/home screen (far left); matching color coded database detail (middle left); fridge organizer (middle right) and recipe suggestions (right). 25

2.7 ZmartFri Technology Interface for Fridges – smartphone food management app (left) and using the app to determine fridge contents (right). 26

2.8 FridgeCam Interface/screenshots: Android screenshot (left); iPhone screenshot (middle) and the WiFi enabled camera for placing inside the user’s fridge (right). 27

2.9 Food Waste Diary Android screenshots showing the multi-level user data entry screens required to record all food wasted. 28

2.10 Typical Bring Your Own Device Interfaces for Scan and Shop: Android based barcode input (left) and SmartScan perishable groceries input (right). 30

2.11 Existing ICA smartphone data passing through POS terminal to store/central database [black icons] (left) is duplicated into the newly proposed FeastMe application [blue icons] (right) via the BYOD device when checking out of the supermarket. 31

2.12 Example of a typical 1D barcode generated using the Free Online Barcode Generator [118]. 32

2.13 Example of a typical 2D Barcode generated using the QR Code Generator [120]. 33

2.14 Example of the extended GS1 Databar barcode format displaying the GTIN and Expiry Date functionality that makes this new format ideal for use by FeastMe. 34

3.1 Typical Interaction Design Lifecycle from Rogers et al [135]. 36
4.1 Example of a FeastMe app paper prototype during the conceptual
design stage .......................................................... 43
4.2 The multitier system architecture of an Android application ....... 47
4.3 Complete internal working principle of the FeastMe mobile application.. 48
4.4 Use Case diagram of FeastMe app ........................................ 50
4.5 Sequence Diagram of the Family tree and Your cart module ......... 52
4.6 Architecture of recipe search module .................................... 53
4.7 Homepage of FeastMe app .................................................. 54
4.8 Dashboard menu of FeastMe app .......................................... 55
4.9 Your Cart menu of FeastMe app ............................................ 55
4.10 Displays the customize menu ............................................. 56
4.11 The recipe feature of the app .............................................. 57
4.12 Example search results of ginger ingredient keyword ................. 57
4.13 The family tree feature of the app ........................................ 58
4.14 A new member is added to the family .................................... 58
5.1 Cronabach’s Alpha and Gutman’s Lamda Values ....................... 59
5.2 Majority of users feel they have control of the interface ............... 61
5.3 Majority of users found the language within the app understandable . 63
5.4 Majority of users found the internal navigation simple to use .......... 64
5.5 Majority of users found the UI layout easy to use ....................... 66
5.6 Majority of users found the app navigation easy to use. Focused group
study, interviews and testing of the app were also conducted in the
university library. The data was collected irrespective of the age group
and gender. The participants were students at the university .......... 69
5.7 Majority of users found no problem with the app response speed ... 70
5.8 No users specified a problem finding a particular feature in the app . 72
5.9 All users reported that they understood the action of each tool within
the app ........................................................................ 78
5.10 All participants felt that the tool button labels were applicable ...... 80
5.11 Majority of users felt that the purpose of each tool could be easily
discerned if not obvious .................................................. 81
5.12 All users were aware of what tool they were using at any point ...... 83
5.13 Overall rating of the app module/features ................................ 84
## List of Tables

2.1 Table summarizing the identified pros and cons of the smartphone apps investigated as presented in this chapter. The major problem identified by the app designers themselves is that of ‘data entry burdensome’ and we seek to overcome that with FeastMe. .......................... 29
3.1 Functional Requirements of the FeastMe user app. .................. 38
5.1 Frequency distribution results from question 1 .................... 61
5.2 Represents the descriptive statistics of the variable .............. 62
5.3 Frequency distribution results from question 2 .................... 62
5.4 Represents the descriptive statistics of the variable .............. 63
5.5 Frequency distribution results from question 3 .................... 64
5.6 Represents the descriptive statistics of the variable .............. 65
5.7 Frequency distribution results from question 4 .................... 65
5.8 Represents the descriptive statistics of the variable .............. 66
5.9 Frequency distribution results from question 5 .................... 67
5.10 Represents the descriptive statistics of the variable .......... 68
5.11 Frequency distribution results from question 6 .................. 68
5.12 Represents the descriptive statistics of the variable .......... 69
5.13 Frequency distribution results from question 7 .................. 70
5.14 Represents the descriptive statistics of the variable .......... 71
5.15 Frequency distribution results from question 8 .................. 72
5.16 Represents the descriptive statistics of the variable .......... 73
5.17 Answers presentation results from question 1 ................. 74
5.19 Answers presentation results from question 2 ................. 75
5.21 Answers presentation results from question 3 ................. 76
5.23 Frequency distribution results from question 4 ................. 77
5.25 Frequency distribution results from question 1 ................. 78
5.26 Represents the descriptive statistics of the variable .......... 79
5.27 Frequency distribution results from question 2 ................. 79
5.28 Represents the descriptive statistics of the variable .......... 80
5.29 Frequency distribution results from question 3 ................. 81
5.30 Represents the descriptive statistics of the variable .......... 82
5.31 Frequency distribution results from question 4 ................. 82
5.32 Represents the descriptive statistics of the variable .......... 83
List of Abbreviation Terms

1. **USDA:** United States department of Agriculture
2. **API:** Application program interface
3. **GTIN:** Global Trade Item Number
4. **WRAP:** Waste and Resource Action Program
5. **GDP:** Gross Domestic Product
6. **BYOD:** Bring Your Own Device
7. **SSTs:** Self-service technologies
8. **XSS:** Cross-site scripting
1. Introduction

In this chapter we will examine the problem of Food Waste, particularly in the domestic sector. After discussing the background and the existing literature. From there we will define the terms and scope of this project, discuss the current situation and identify perceived need therein that we would seek to remedy.

1.1 Background

Domestic consumers are increasingly becoming aware of food waste issues and their ability to have an active role in reducing it. The majority of Europeans point to individual responsibility when it comes to reducing food waste, with 63% saying that better food-related practices in terms of planning and shopping would help [1]. However, despite the concern consumers express, the level of food waste continues to be very high. Estimates report annual European and North American food waste across the supply chain as between 95-115 Kg per capita [2–4]. In Sweden alone, 674,000 tons of food waste are created annually at the household level approximating to 72kg per person [5]. With the increase in disposable incomes, urbanization and the corresponding changes in demographics and lifestyle, the amount of waste in the household will continue to grow over time [6].

Within the supply chain there are opportunities to reduce waste at every level from producer to consumer via processor and retailer. Retailers, for example, have launched programs and initiatives to not only reduce their own waste but to educate and assist their customers in reducing theirs too [7]. However, the greatest proportion of waste across the chain still occurs at the household level (53%).

1.2 Literature Review

Studies have confirmed that consumer behaviour and its modification can therefore have the greatest impact on food waste reduction [8–11]. Individuals possess different beliefs, attitudes and behaviours in all aspects of their lives and that includes food waste [12].

These are also affected by other personal and external influences or factors – for example an individual may have a positive attitude to reducing food waste but a busy schedule means that they do not have enough time to properly evaluate how to deal with a date expired grocery item and simply discard it [8].
Other instances of personal factors increasing food waste are:

1. Living alone [11–13]: Living alone increases food waste and waste in general. The main reason is that people tend to shop more products than they need and, in most cases, if people are living alone more food go to waste. For example Jörissen et al [14] in a two site study found that single occupancy households wasted, on average, 224 grams of food per week. That fell significantly to just over 100 grams per week for two, three and four person occupancy and just under 100 for more than four.

2. Being the cook of the family [13]: People with a passion for cooking need more self-control and planning if their enthusiasm is not to lead to greater food waste. Generally, people who like cooking most of the time tend to buy more products and cook complicated recipes that need a lot of ingredients. Where a smaller number of basic ingredients are used for all meals it has been shown that this decreases food waste due to more frequent purchasing of standard ingredients and an ability to easily incorporate leftovers [15].

3. Being young [16–18]: Being young is great for you and your lifestyle but not for food waste. The spontaneity and the selection of specific foods drives the household produce more waste. Young people tend to eat mostly fresh foods. On some occasions young people eat cooked food from a previous day. As a matter of fact, more food waste produced in households.

4. Not knowing much food labels [9]: If you are not knowing much about food labels you probably don’t know about the ingredients inside the product. Many ingredients inside products are blamed for huge environmental destruction such as palm oil. Another reason is that food labels inform the consumer about the best before date. If the consumer is not familiar to look for this information, it is more likely this product to become waste if this date is passed. Examples of product-specific external factors are packages that are difficult to empty [19], large packages [13] and data labels on products that are most suggestive of food safety concerns [20]. Finally, poor shopping planning and buying more than is needed [21] are typical examples of food-related behavioural factors directly increasing food waste.

Recently, two systematic reviews [10,22] have highlighted the importance of having a better understanding of how food-related behavioural factors contribute to household food waste. Increasing our knowledge of such behavioural factors would be not only of theoretical interest, given the paucity of systematic research on this specific issue (see for exceptions [21] and [23]) but also of practical importance. There have been a number of previous attempts to utilize Information Technology (IT) to combat the problem of food waste. These include pure web based applications such as Foodsharing.de [24]; hardware driven concepts such as the Zigbee sMART FRIdge [25]; mobile device based geocentric leftover food sharing as seen in Leftover Swap [26,27]; household based sharing (EatChaFood) [26] and mobile app shopping list compilers [28]. The many pros and cons of these previous works are fully discussed in Chapter 2. Many suffer from user input fatigue – however one has a limited barcode input. Some furnish recipe suggestions.
1. Introduction

The supermarket sector has been an early adopter of IT specifically using barcodes at Point of Sale (POS) to handle both stock control and customer payments. These have been extended by the inclusion of Self-Service Technologies (SST) and Bring Your Own Device (BYOD) functionalities. Given that smartphone ownership in Sweden is in excess of 94% [29] then leveraging this BYOD is a viable possibility.

Accordingly the author has proposed a prototype application –’FeastMe’- the application mostly focuses on best before date reminder for the products/items purchased by the users. Assuming that the attributes such as product name, product type and best before dates are embedded in the barcodes (GS1 Databar explained in chapter 2), the FeastMe app would extract those attributes and save in the application. The app would then remind its user about the items close it its best before dates. The users can also manually set the reminders as per their desire. Time critical recipe suggestions can also be searched in the recipe feature in the application for the users on how to utilize food items nearing their best before dates. The data extracted is saved in Google Firebase database in real-time.

1.3 Terms and Scope

This study will examine reducing consumer Food Waste in a Swedish multi-occupancy house. Specifically, we will investigate if the provision of a barcode scanning, mobile device app will encourage users to use more of their perishable food stocks and thus reduce their household Food Waste.

As a solo investigation the scope of the study has to be constrained due to time limitations. We have therefore identified that it will be limited to developing an application featuring a database driven back end and a prototype mobile app. This app will provide a ‘proof of concept’ that the proposed solution will work but will not, at this time, be integrated with a third party POS/BYOD system.

1.4 Current situation

Previous studies have shown that considering food waste is often the last stage of decision-making in the food provisioning process and is less intimately connected with other routine food-related behaviors that are part of this process, such as shopping, stocking up, or cooking [10,20,30,31]. These food-related behaviors are, therefore, be important in explaining household food waste. Based on Stefan et al [21] we conclude that planning and shopping routines explain most of the variance in food waste, with the latter having a larger influence.

At the purchase stage consumers often rely on food shopping routines and admit to regularly buying more food than needed or food products they never use, thereby increasing food waste. By contrast, planning routines such as checking the inventory level, making shopping lists or planning meals in advance help consumers to limit food waste [32–34].

Within the home itself, the random and non-systematic placing of food items results in food becoming easily lost and often expiring before being used; in addition, the low visibility of food items in the refrigerator, particularly of those located towards
the back, also resulted in food waste [5]. A form of notification to the consumer prior to the expiry date would be of benefit here.

Another suggested remedy to reduce waste is to educate consumers not to throw away left overs or near/post expired foods but to (re)use them instead [2]. Many consumers are not used to ‘cooking from scratch’ and here some sort of recipe suggestion utilizing products known to be available within the household would be of benefit.

However, searching for suitable recipes online is not as easy as you might think, especially when considering cultural specificity. Food consumption, recipes and preferences vary between nations [35] making finding a localized recipe difficult. 0.3% of website content is in Swedish while 60% is in English making Swedish content harder to find [36]. While 80% of the Swedish population have English as a second language, much of the English content is in US English and uses their US/Imperial measurements (Oz/pint) rather than the Swedish metric (gram/litre) [37,38]. Localization in a search of a recipe raise more challenges to the consumer who tries to find a recipe to cook using the available ingredients. As a matter of fact, general results about food recipes could become a fruitless exercise and in the end the user will cook an easy recipe without using all the available ingredients which, in turns, could lead to increased food waste.

Google is the highest used search engine in Sweden with a 96% market share [39]. It has the ability to present recipe search results in ‘recipe rich cards’ [40]. In addition there exists the ability to form your own Custom Search using their API. Using this relevant keyword(s) such as ingredient or recipe name may be searched on and it brings results of Swedish items only. Figure 1.1 shows a typical result for the search on for spinach and pasta (“pasta spenat”). Such search results can save time and effort of the user to identify the individual items and their details. The keyword/recipe rich card search feature is discussed in detail in chapter 4. The above search result may contain a thumbnail of the recipes, their star-based rating, short description, calories and cooking time. However, results do not indicate the true validity of the recipe to the user. In order to decide on the recipe, the user needs to further examine cook time, star rating, and short description.

More complex search like examine only the calories, or the rating, or the cooking time would not bring the desired results in a try to utilize all the available ingredients. Additionally, there is a possibility for the recipe rich card format to present the wrong data as there are some items that are not recipes which still get listed as if they were. Such as in Figure 1.2, it can be clearly seen that an individual bottle of wine is presented in the recipe search results for wine. This erroneous result detracts
from the usefulness of the application.

![Image of a Swedish language search for a recipe that included “Vin” produces an erroneous product listing for a bottle of wine instead of a recipe card.](image)

**Fig. 1.2:** A Swedish language search for a recipe that included “Vin” produces an erroneous product listing for a bottle of wine instead of a recipe card.

Finally, waste across the food supply chain has implicit environmental impacts on land use, energy use, water consumption and ecosystems while generating greenhouse gasses [41]. The greenhouse gas generation from the industry is further amplified by food waste that goes to landfill – each ton of food-based landfill adds an extra 250kg of CO2e [42] to that already provided within the production and transport sectors [43]. As a third the food waste occurs in the household then any reduction there would have a positive impact on the environment and global warming reduction targets.

### 1.5 Research Questions

Given the introduction and problem domain described previously, this research raises the following research questions (RQs) for investigation:

1. Could a smart(er) best before managing and notification system help to reduce food waste?
2. Would an integrated recipe search engine inside the application help?
3. The purchase of duplicate and/or excessive foodstuffs lead to waste. Most families already have a shopping strategy with shared shopping list. Could this be enhanced and extended into a multiple occupancy household by way of a sharing and synchronizing application?

It may be anticipated that if consumers are provided with a reminder about a product that is close to the best before the date of use it will motivate them to use the item rather than let it go to waste. This study will investigate, test, evaluate and draw conclusions based on this. The study will be based on the Swedish market and providing culturally related recipes accordingly. One of Sweden’s largest supermarket chain ICA [44] has developed a smart phone shopping application for both iOS and Android [45]. The main goal of this thesis is to develop a similar application taking inspiration from ICA app in order to develop additional features that could be integrated in the existing app in the future like to include a multi-user (i.e. household or family) group with the ability to sync across all devices, recipe search engine based on application data and custom alert reminders for every user.
1.6 Strategy

In order to investigate the Research Questions we will follow an iterative approach utilizing questionnaires, interviews analyses. The initial stage will be to formulate the primary functionalities, design, intended user experience and the potential value of the prototype. This will be done by researching previous works, the available technologies and their integration, and an iterative design stage.

Next feedback on the primary design is needed. Here a study group of testers will be recruited from students at LNU. Their numbers needs to be great enough to be statistically relevant but not so big that the project becomes too large for a single investigator to handle. Accordingly the minimum number suitable would be the five suggested by Nielsen [46] – in actuality fifteen testers were recruited. Results will be obtained by way of three questionnaires – two are of closed-ended Likert scale [47] construction the third is of open-ended text answers which may evoke feedback on items that the author originally failed to consider/include but which users deem important.

The final phase will involve statistical analysis using Microsoft Excel in the first instance and then Frequency, t-test, cronbachs alpha, median, standard deviation and average, should more involved analysis be needed (discussed in Chapter 5). These will provide valuable information about whether or not this application could be a good tool in the fight to reduce food waste in order to promote a cleaner future for us and our children.

The first research questionnaire tests the utility and usability [48] of the prototype in the hands of users. Does it provide the features that they need and can they access these in a timely and easy manner? This is done using Likert scales.

The second questionnaire is in the form of short answer questions and allows users to give subjective feedback on areas where they felt that the application was good, bad or indifferent. For example: was it lacking in any way? What was their overall impression?

The final questions are again Likert scales asking the testers about the usability of the feature the satisfaction of the usage and their opinion about the sharing feature.

1.7 Application Requirements Analysis

Requirements Analysis process involves matching the needs of the end user to the application and creating, or modifying, elements within the application in order to do so. Primarily a list of Functional Requirements (i.e. the features and functions that the application should perform) is obtained from users – in this case by discussion with the Professor and peers in one on one discussions. The non-functional requirements (i.e. system abilities) can be constructed from these. (See section 3.8).

From both sets of requirements the initial designs for the prototype application can be constructed and then iterated upon following feedback from test users (See section 4).
1.8 Overview of the application architecture

The application architecture essentially consists of a cloud database driven backend with a mobile device application front end.

A cloud based storage system offers the advantages of scalability and guaranteed uptime over a more traditional hardware/data center based option. There are many competitors offering Cloud solutions of varying complexity but, for the mobile application developer lacking hard core coding skills, Google Firestore/Firebase provides a simple, entry level (Freemium) product. It provides a REST API, turnkey authorization, real time online/offline multi-user data sync and other options suitable for small prototyping projects such as this. There is a trade of in that the user/project data is being entrusted/shared with a third party (Google) and that may not be appropriate for larger/commercial applications [49,50].

Just over 99% of the current mobile device operating system market is split between the Apple iOS (24.82%) and Google Android (74.6%) [51]. It is therefore ideal if any new mobile application can be designed and tested for both. while development platforms cater for this we have, in this instance, chosen to base the design only on Android. The motivation for this is simply financial – at the time of writing Apple charge commercial developer’s fees to access the resources needed to deploy test applications for their OS. All Android development resources are free.

The overall architecture of the prototype application is presented in the section 4.
2. Background and Related Work

2.1 Introduction

Food waste is a global problem. Many studies have been conducted examining trends in, and factors affecting food waste at national [52,53] and international levels [54,55]. Several psychological factors are associated with food waste [23,56]. Reduction of food waste not only contributes to improving food security but may also contribute to improved global economic and environmental health [57]. Many technical solutions have been proposed to reduce food waste [58,59] or use in it a beneficial manner [60,61].

There are existing studies examining technological solutions to the food waste problem. We will examine these to identify both their good points and shortcomings. Appreciating those will help us to start developing the proposed FeastMe application with an eye on overcoming their weaknesses while benefiting from their strengths.

2.2 Food Wastage Impacts

Food waste has a negative impact on the world environment and economy. Up to a third of all food produced is lost in the farming, processing, retail and supply chains [62,63]. A further third of this total loss occurs in the final (consumer) stages [64]. In the United States, 55 million tons of food is wasted annually, which is 29% of their annual production [65]. Poor management wastes large amounts of food as in India where 30% of food is wasted every year because of the lack of refrigerated facilities [66].

High waste management costs are involved including operational costs, transportation costs and in some cases separation costs. It has been shown that greater environmental and economic savings can be made by preventing avoidable food waste rather than recycling [67]. Therefore, large amounts of food are being wasted at the world level. Numerous studies have been conducted to investigate food waste behaviour and the social impact of food waste [62,68,69,70]. As food waste increases, so does the rate of hunger. In some least developed countries, such as Nigeria and India, people suffer from undernourishment problems. From 2014 to 2016, an under nutrition rate of 23.2 per cent was observed [63]. Economic imbalances are also observed in developed countries, and 14% of food insecurity was observed in the United States [63]. Food waste thus leads to economic, environmental and social issues that may be controlled using different strategies in terms of technology, engineering and social awareness.
2.3 Causes of consumer food wastage

As previously stated consumers can account for a third of the total supply chain food wastage - eighty percent of that amount has been classified as ‘avoidable’ [64]. Some of the fundamental factors of consumer food wastage are highlighted by Grandhi and Singh [71]. These include:

- Perishable food is wasted due to over-purchasing/failing to consume before expiry.

- Poor food storage/rotation practices: Consumers do not want to see their fridge empty, therefore they put non-perishable food in the fridge effectively hiding perishable items from view – these then expire and get wasted.

- Poor and ineffective packaging of food items.

- Pricing/marketing practices: It is cheaper to purchase bulk volume of food items rather than the smaller quantity desired often leading to the waste of the remainder.

- Over ordering/preparing: In the developed countries we frequently prepare too much food for a meal dispose of the leftovers or, when eating out, are presented with more food than we can comfortably stomach.
2.4 Preventing and Recovering Food Wastage

Food waste has become one of the most talked and researched topics worldwide. Researchers are focused on finding methods and techniques to overcome or reduce the food wastage using technology, education or socio-economic methods. Waste management in general utilizes a hierarchy of methods ranging from the most preferred to least preferred e.g. the European Waste Framework Directive (WFD) [72]. This hierarchy has been incorporated into many countries’ food waste governance often as a pyramid:

Fig. 2.1: Two examples the inverted pyramid Food Recovery Hierarchy infographic from either side of The Atlantic. The European Union Zero Waste Project [73] (top) and the United States Environmental Protection Agency [74] (bottom).
There are also many food production firms and community organizations who have summarised this into “Prevent, Recover, Recycle”. Prevention: reducing at the source; optimizing processing; adapting production to needs. Recovery: redistributing food to people who need and/or want it. Recycling: feeding animals; using scraps for industrial production, energy, or compost) [75,76]. This includes feeding around 25 animal breeds and using the scrap items for production and energy of the industry [76].

2.5 Social Recipes in Reducing Food Waste

Lim et al [77] identified a Social Recipe as one where ingredients available from different households are combined into one or more dishes, which are suggested to a group of users. The perspective is to collectively prevent food waste by encouraging collaboration and food sharing. Apart from this altruistic aim, the social recipes concept is expected to incentivize people to share, cook, learn and enjoy food together [78]. Examples of good practices in terms of social innovation, technological eco-innovation and organizational eco-innovation are The Last Minute Market Business model, Italy [79]; Brixton Community Fridge, UK [80]; www.foodsharing.de [81]; Food-Keeper App [82] and Last Minute sotto casa APP [83].

Larger households whether a mix of related and unrelated adults, young and old are found to waste larger quantities of food than smaller ones (singles or couples) who are more focused in term of their cost and weights. Targeting these larger groups which can more easily share and coordinate with others would enable a greater prevention of wastage [84].

In Europe, a reduction of food wastage from the consumer side would be expected to influence a rise in the per capita Gross Domestic Product (GDP) [85]. According to The World Health Organization [86] a main strategy for influencing food wastage is altering the purchasing behaviour of people. However, this is complex in nature [86].

2.6 Technologies for Reducing Food Wastage

Our proposal is for a food waste solution aimed at the domestic end consumer. It is important to examine existing solutions and attempt to identify their strengths and weaknesses which we will do in the following subsections. Firstly, we will look at two static web-based solutions. One is a purely educational and informational site while the other, originating from within social media (Facebook), has migrated to a web-based format albeit supported by smaller, local, social media bubbles.
2. Background and Related Work

2.6.1 A ‘Traditional’ web based approach: Love Food Hate Waste

Love Food Hate Waste" (LFHW) is a web based campaign/influencer specifically aimed at reducing UK consumer food waste. It was launched by the UK program “Waste and Resource Action Program" (WRAP) in the year 2007 [4,88]. It aims to raise awareness of the economic and environmental costs of domestic food waste by providing users with detailed advice on food storage, expiry dates, portion control and recipes. while it claims that UK consumers are now saving over 5 billion GB pounds (61.7 billion SEK) and reducing CO2 by 5 million tonnes per annum compared to 2007 it also points out that they are still throwing away 4.5 million tonnes of edible food [88,89].

LFHW has spread from the UK to other English speaking countries including Canada, New Zealand and Australia [90–92] – all wealthy countries with a high GDP which correlates with higher food losses [93]. The current strategy of LFHW is a localised, behaviour-centric, public education one while this has short term impact with consumers it decreases over time without reinforcement [94]. The static, web-based interface would thus greatly benefit from a related, easily portable smartphone app as a reminder/prompt to users.

Fig. 2.2: Screenshot of the recipe finder page on the Love Food Hate Waste website demonstrating its ability to provide a recipe (middle panel) from an ingredients list (right panel).
2.6.2 A ‘Traditional’ web based approach: FoodSharing.de

Foodsharing.de is a German website that enables all sectors in the food supply chain (farmers, processors, retailers and consumers) to minimize waste by simply offering and collecting surplus food. Participation is free and there is no payment involved in collections. It evolved from the www.tastethewaste.com website via a Facebook collaborative (group) page. It was found that the Facebook layout was inefficient in that their display algorithm would often prioritize older posts that it felt important and thus push newer posts down the list and ‘off screen’. In addition, searching by nearby location was not possible.

Accordingly the current web based format was created including a searchable map [95]. There are around 17,000 active users who are using this web application to share food information around 1,800 food providers.

As with LeftOverSwap (below) researchers noted that sharing/accepting food with strangers required a greater degree of trust/comfort than many people possess. They noted that this may be overcome using a social media page alongside the web application – that way users can become familiar with their peers and overcome the trust issue. The developers launched localised Facebook group pages to overcome the trust issue and these are now backed up with by casual, locally based/administered WhatsApp groups [24].

However the model still relies on implicit co-operation between independent members which can sometimes break down resulting in frustration and loss of members [81].
2.6.3 Smartphone: Fridge Pal

Fig. 2.4: iPhone Screenshots taken from the 2013 FridgePal app showing home inventory (left); shopping list (middle) and product entry screen (right).

Fridge Pal was a 2013 iOS only smartphone application released under the ‘Freemium’ [96] business model. Targeting individual consumers, it contained several useful features – shopping lists that could be updated, annotated and copied; limited barcode inputs; push notifications for expiry reminders and inventory analysis. Farr-Wharton et al [28] highlighted a number of user reported difficulties with the app as listed in Table 2.1 (below). Data entry fatigue was a prime problem. Fridge Pal is now defunct and no longer available through the Apple iTunes Store.
2.6.4 Leftover Swap

![Image](image-url)

**Fig. 2.5**: Android screenshots of the LeftoverSwap Interface showing the geocentric ‘left-overs available near me’ (left) and feedback for other users entry (right).

**Leftover Swap** was also launched in 2013 but aimed at USA Android platforms. Using a geocentric database users would post details of their leftover meals, surplus takeaways and so on. Nearby members could then reserve and collect these items. Facebook and Twitter [27] accounts were launched to help promote the social connectivity of the application.

The application is no longer available. Users noted a reluctance to accept leftover meals ‘from strangers’ as accepting food is depends on trust while donating food depends on comfort. [28].
2.6.5 EatChaFood

![EatChaFood screenshots](image)

**Fig. 2.6:** EatChaFood Smartphone screenshots showing: color coded fridge display/home screen (far left); matching color coded database detail (middle left); fridge organizer (middle right) and recipe suggestions (right).

**EatChaFood** was created in attempt to combine the benefits of FridgePal and LeftOverSwap by allowing an entire household (whether family or shared (student) house) to create a shared food inventory and find recipes based on the inventory items. This was thought likely to overcome the sharing reluctances found in Leftover Swap by limiting the sharing to a known social group. EatChaFood did not progress beyond the prototype stage as it was developed in connection with academic research into reducing domestic food waste. [26] However the author did make a number of findings that are relevant to FeastMe:

- Date entry, update and removal needs to be as simple as possible
- Best before dates need to be manually adjustable as some items have a long shelf life until opened whereupon they may need to be consumed quickly.
- Managing food on a mobile device in a different location to the food itself was thought to be practical.
- The food incorporated into the application needs to include all stores and not just the fridge. This is important if relevant recipes are to be suggested.
- In the shared student household the trust/comfort aspect of sharing food, even with a housemate, was still a problem.
2.6.6 ZmartFri Technology

Fig. 2.7: ZmartFri Technology Interface for Fridges – smartphone food management app (left) and using the app to determine fridge contents (right).

The ZmartFRI (Zigbee sMART FRIdge) project [25] was an attempt to apply a human/computer interface to a standard fridge. It relied on each and every product placed in the fridge being marked with an RFID [97] tag that was then read by a Zigbee [98] enabled controller. The Zigbee network would then update a central record which would be used to generate shopping lists, inventories and notifications of food expiry.

The project was aimed more at researching the Human Computer Interactions involved in the concept rather than exploring the inherent technology and it did not get past the prototype stage.

Major shortcomings in this project were the need to (1) tag every product purchased with an individual RFID card and update the central record with the product details matched to the card number (data entry fatigue) and (2) utilizing the Zigbee technology. Both these requirements may be overcome using current smartphone technology.
2. Background and Related Work

2.6.7 Fridge-Cam

The Smarter FridgeCam is a commercially available IoT product [99] that links a WiFi camera inside your fridge to a smartphone app [100,101] and/or Apple Siri or Amazon Alexa. It is not to be confused with the identically named prototype produced by the same lab responsible for EatChaFood (above) [102] or the earlier Augmented Reality (AR) experiment by Bonanni et al [103].

FridgeCam operates by photographing the fridge contents as you shut the door – the user then must draw around each food item on their smartphone screen, identify it and give it an expiry date. There is a degree of Machine Learning/AR built in such that the application may start to ‘recognise’ foodstuffs after a degree of manual ‘teaching’ input by the user which was found to be time consuming [104]. Similarly there is a barcode scanner which is only available for a single UK based supermarket’s codes [104].

Once operating FridgeCam can run inventories, create shopping lists and push notifications to the user that items are near expiry date and/or need replenishing. User reviews are quite mixed with many complaining that the WiFi technology was not mature and inoperative [104,105]. The retail price has dropped from GBP £149.99 at launch in 2019 to GBP £33.99 indicating that the product is not succeeding in the marketplace [106].
2.6.8 Internet of Things Food Inventory Management Study

A temporally parallel, but otherwise independent investigation to this study at LNU that was along similar themes is “Exploring a New Way of Food Inventory Management in Households Using Modern Technologies to Reduce Food Waste” by K. Abdiju [107]. The author identified that data input fatigue was a major disincentive to overcoming domestic food waste and set out to determine if the input load could be reduced by way of an IoT device.

A Raspberry Pi powered IoT device was placed in a fridge and would, in a manner similar to Fridge-Cam and ZmartFri (above) create/update a food expiry inventory by the user scanning product barcodes when they placed new products in the fridge. The fridge inventory was to be manually depleted by users subsequently making a manual entry on their smartphone/personal devices at the point of consumption/disposal. A household shopping list would also be maintained for access by all users.

Abdiju identified that, despite the use of the IoT device for input, data entry was still the major demotivator to system users. In addition the fixed scanning device attached to the fridge makes no allowances for dry/pantry/store cupboard types of food – while these are not necessarily huge contributors to overall food waste their presence in the house is required to provide a useful output from any recipe module.

2.6.9 Food Waste Diary

Fig. 2.9: Food Waste Diary Android screenshots showing the multi-level user data entry screens required to record all food wasted.

The Food Waste Diary [108] was an Android/iOS application which aimed to reduce food waste by allowing users to record the food that they threw away. As such it was merely an app based version of a paper food diary [109]. One of the intents behind the app was to encourage users to reflect on their food waste while they were entering the data. This application also allowed the record of reasons for disposal and type of food. It also allows the optional section to note down the price of the food item by comments and pictures of food.

843 users downloaded and used the application and the results were presented by the
authors in 2015 before removing the application from circulation. As use of the app was anonymous their report admits to suffering from a lack of qualitative data from the users [110].

2.7 Overcoming the Short Comings of Existing Applications

Table 2.1 (below) summarises the pros and cons of the previously investigated applications/technologies.

<table>
<thead>
<tr>
<th>Name</th>
<th>FridgePal</th>
<th>LeftOverSwap</th>
<th>EatChaFood</th>
<th>ZSmartFri</th>
<th>FridgeCam</th>
<th>FoodKeeper</th>
<th>IoT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Creator/owner</td>
<td>USDA</td>
<td>iOS*</td>
<td>x (limited)</td>
<td>2.2 (30)</td>
<td>3.5 (27)</td>
<td>2.7 (100)</td>
<td>4.0 (129)</td>
</tr>
<tr>
<td>iOS*</td>
<td>x</td>
<td>x (limited)</td>
<td>2.2 (30)</td>
<td>2.7 (100)</td>
<td>4.0 (129)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Android*</td>
<td>x (limited)</td>
<td>x (limited)</td>
<td>2.2 (30)</td>
<td>2.7 (100)</td>
<td>4.0 (129)</td>
<td></td>
<td></td>
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<tr>
<td>Features</td>
<td></td>
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<tr>
<td>Multi-user</td>
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<tr>
<td>Barcode scan in</td>
<td>x (limited)</td>
<td>x (limited)</td>
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<tr>
<td>Barcode scan out</td>
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<tr>
<td>Recall alerts</td>
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<tr>
<td>Inventory</td>
<td>x</td>
<td>x</td>
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<tr>
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<td>x</td>
<td>x</td>
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<tr>
<td>Highlights near expiry</td>
<td>x</td>
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<tr>
<td>IoT</td>
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<tr>
<td>Noted problems</td>
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<td>Notifications fail</td>
<td></td>
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<tr>
<td>Consistent bugs</td>
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<tr>
<td>Data editing difficult</td>
<td>x</td>
<td>x</td>
<td>x</td>
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<td></td>
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<tr>
<td>Wrong food expiry</td>
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<tr>
<td>Data entry burdensome</td>
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<td>x</td>
<td>x</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Food sharing comfort</td>
<td>x</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>*Customer reviews from Apple and Google app stores. Average rating followed by number of reviews in brackets</td>
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</tbody>
</table>

**Tab. 2.1:** Table summarizing the identified pros and cons of the smartphone apps investigated as presented in this chapter. The major problem identified by the app designers themselves is that of ‘data entry burdensome’ and we seek to overcome that with FeastMe.

The major user-reported shortcoming of the applications is burdensome data entry which makes users lose interest in using the app on a daily basis. This may be overcome by utilizing the barcode scanning ability of the self-service/BYOD type apps for both data input and consumption.

User reviews of the two currently available apps show a low tolerance of technical glitches but an appreciation of the ability of the apps to ‘repurpose’ food purchased for one meal into a recipe for another.

Accordingly our proposed application should seek to provide easy user input/data output coupled with the ability to recommend alternative recipes where required.
2.8 Self-Service Technologies (SSTs)

Self-service technologies (SSTs) can be defined as technology-based solutions that allow a customer to produce a service without the direct involvement of a service employee. Companies may achieve improved productivity and service quality while cutting costs through successful implementation of SST solutions [111]. Internationally several supermarket chains have introduced ‘self-scan’ systems whereby a customer uses a shop provided, handheld scanner to scan product barcodes as they place them in their trolley. The scanner listing is then downloaded into a Point of Sale (POS) terminal which creates the customer invoice and, after payment, decrements the store product inventory/database. Examples are the French Carrefour and Intermarche [112], Swedish ICA [45] and UK Tesco [113].

2.8.1 Bring Your Own Device (BYOD)

BYOD allows users to access services using an app on their personal smartphone or other device. Applications exist for self-service shopping such as Scandit [114] and ShopScanGo [115]. Though these apps the user just has to scan the barcode present on the products as they shop with their phones and then proceed to the self-checkout kiosk for payment via the merchant’s own Point of Sale (POS) system. This saves the customer from having to queue and unload/repack their shopping at the normal checkout while enabling the merchant to save on staffing costs. Two of the previously mentioned supermarkets (ICA and Tesco) have extended their in-house self scan technology to BYOD applications for iOS [51,52] and Android [53,54]. Both companies have further enhanced the customer experience by enabling in-app payments from their own in store banking facilities thus removing one step from the checkout flow.
Our proposed application would seek to extend this SST/BYOD functionality by duplicating the existing ICA POS data into the FeastMe app for the end user – thus reducing the data entry overload of previous apps. These data would then be exported to the FeastMe datastore after editing by the user whereupon they would be available to all users.

**Fig. 2.11:** Existing ICA smartphone data passing through POS terminal to store/central database [black icons] (left) is duplicated into the newly proposed FeastMe application [blue icons] (right) via the BYOD device when checking out of the supermarket.

One drawback of this proposal is that the proprietary ICA application software is not available to this project therefore it will have to be mocked up within our prototype – this will be by way of a ‘Your Cart’ module.
2. Background and Related Work

2.9 App technology

It is proposed that we develop our smartphone app on an Android platform and that it includes some form of barcode scanning functionality to ease the previously highlighted problems with burdensome data entry.

2.9.1 Android

Currently there are two major players in the smartphone operating system market – Android (Google) and iOS (Apple) with 75% and 25% market shares respectively [52]. This section discusses the technologies used in designing the app system and also discusses the literature survey for the topics of barcode technology applications. We start with the work done in barcode technology, then in the mobile applications using barcode technology followed by food waste applications and smart home technology. This project utilizes various technologies and tools. The developed app is Android based and uses Barcode technology. The app architecture is discussed in detail in chapter 4. Android platform has been chosen for this project, primarily for the open-source nature of the platform as well as the ease of development and deployment with the extensive supports provided on the official Android website and major developers’ forums, such as the Stack Overflow website.

2.10 Analysis of Barcodes

Barcodes are optical machine-readable labels used to store information about the item they are attached to. Originally patented in 1952 by Woodland Silver [116]. Other than light industrial uses there was little adoption until 1973 when they were incorporated into the development of the Universal Product Code (UPC) by the US grocery supply chain industry. Growth in the use of UPC barcodes was then exponential throughout all supply chains with the original US de facto standard later becoming an ISO de jure [117]. These original barcodes are known as one dimensional (1D) consists of a single, horizontal row of bars and are ubiquitous throughout the world.

Fig. 2.12: Example of a typical 1D barcode generated using the Free Online Barcode Generator [118].
The most commonly used 1D barcodes are European Article Number (EAN-13, EAN-8), Universal Product Code (UPC-A, UPC-E), Code128, Interleaved Two or Five (ITF-14) and Code39 [121]. 2D barcodes (commonly genericized as QR codes) are more complex and carry/store a greater amount of data than a 1D barcode as data can be stored in both horizontal and vertical directions. The most common examples are QR codes, Data Matrix, Aztec, MaxiCode, DotCode and PDF417 [118].

![Example of a typical 2D Barcode](image)

**Fig. 2.13:** Example of a typical 2D Barcode generated using the QR Code Generator [120].

### 2.10.1 GS1

GS1 is the non-profit barcodes standards setting organization and has around 112 local member organizations and 1.5 million user companies [121]. By standardizing and coordinating barcode issuing it ensures that all industry barcodes remain readable throughout (and beyond) individual supply chains. GS1 estimates that in excess of six million barcodes are scanned daily. Obtaining a barcode is a seven step process [122]. In order to create a barcode using a Global Trade Item Number (GTIN) [123] companies first have to obtain a globally unique company ID number from GS1. Using that as a prefix they can then build their own, unique barcodes.
2.10.2 GS1 Databar

GS1 Databar is an extended version of the original 1D barcode and can hold up to 74 characters of data. This allows it to store combinations of product serial numbers, lot numbers, expiration dates, production dates, packaging dates, best-before dates, weights, measurements, quantity, country of origin, country of processing, and price per unit of measure along with a GTIN [124,125].

![Example of the extended GS1 Databar barcode format displaying the GTIN and Expiry Date functionality that makes this new format ideal for use by FeastMe](image)

This abundance of data makes the GS1 Databar invaluable in supply chain monitoring – particularly within the fresh produce industry [126]. The data is also readable by any suitably equipped scanning device – such as the proposed FeastMe smartphone app. Once read the data needs to be matched against the database that holds the relevant product information for it to be of any use.

2.11 Usage of Barcode for FeastMe application

As stated, the GS1 Databar is the industry standard barcode for perishable groceries. However, for ease of use during the prototyping of the FeastMe app we have used 2D Barcodes of the Data Matrix type. Such barcodes can easily be created using generic software to carry variable data loads as needed without the necessity of complying with the GS1 Databar generating and deployment legal requirements. Furthermore it allows us to use a simulated store inventory database reducing the prototyping workload.
2. Background and Related Work

2.12 Mobile Devices: Native/Hybrid Apps and Barcode Implementation

Ignoring the very minor players in the mobile device market we are left with two Operating Systems – the Apple iOS with a 25% share and Google Android with 75% [52]. While both are UNIX based their programs/coding are not interchangeable. In order to harness all the available features of either platform a developer thus has to code a different (Native) application for both. Such apps have the advantage of being futureproof within the OS ecosystem, extensible and can harness the full range of User Interface (UI) widgets and hooks. To that end both OS have published UI guides/expectations [127,128] and dedicated Software Development Kits (SDK) [129,130].

To circumvent the need to design twice developers have the option of building a cross platform (Hybrid) application. This is, essentially, core code written in HTML5/CSS3/Javascript with an external wrapper for each OS that allows a limited integration with its widgets/hooks. The wrappers are provided within cross platform developing frameworks such as the Open Source Ionic and Cordova/PhoneGap [131–133]. All have built in and third party plugins to extend cross platform functionality.

As stated Hybrid applications may not fully integrate with the host OS and, in respect of this project, an example would be that the Ionic plugin for barcode scanning cannot currently handle the GS1 style of barcode. Most other types of barcode can be scanned [134].

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As stated Hybrid applications may not fully integrate with the host OS and, in respect of this project, an example would be that the Ionic plugin for barcode scanning cannot currently handle the GS1 style of barcode. Most other types of barcode can be scanned [133].
3. Methodology

To the end user the FeastMe project will be delivered via a smartphone app. Users will be unaware of the actual technologies utilized ‘under the bonnet’ of the app as they interact with it via the User Interface (UI). Those technologies will be examined in the next chapter, here we will look at developing a prototype for the UI and investigating the User Experience (UX) while utilizing the app.

We followed a typical Human Computer Interaction (HCI) Design Lifecycle as illustrated below.

![Typical Interaction Design Lifecycle from Rogers et al [135]](image)

**Fig. 3.1:** Typical Interaction Design Lifecycle from Rogers et al [135]

3.1 Identify needs/Establish requirements

We have identified several research questions in Chapter 1 (Section 1.3). To examine RQ1\(^1\) two interview sessions were conducted with a user group. The purpose of these sessions was to identify the needs and requirements from the users that they felt important if the app was to be useful to them in saving food waste. This user centered design from the get-go helps identify unforeseen problems in the app while also obtaining feedback on the RQ.

An initial user group of eight volunteers consisting of fellow students from Linnaeus University was established. As all the users came from similar educational backgrounds it was understood that this could introduce bias due to their similar skill sets and knowledge of the problem domain. However, for the initial prototyping of the project it was felt that the tradeoff between bias and rapid, iterative design updates was justified. A broader user study would then be required were this project to be extended beyond the scope of this thesis.

A primary interview session was conducted with the user group which resulted in a set of functional requirements. These were incorporated into a paper prototype (v.1) which was then evaluated in a second user session. This session provided both useful feedback and further/amended functional requirements. The prototype was redesigned (v.2) and subject to a series of iterations with the users until no additional suggestions were forthcoming.

\(^1\) (Could a smart(er) best before managing and notification system help to reduce food waste?)
3. Methodology

3.2 Functional requirement collection

3.2.1 Focus group strategy

To collect data and meet the requirements for development of the application, a focus group strategy was implemented. This strategy collects qualitative data from a series of interviews with the focus group (which may be individual face-to-face or group sessions). In this way the reactions of the users to the project concept can be gauged and a set of initial FRs quickly drawn up.

3.3 Design of the First User Interview

The first one-on-one interview session was conducted with participants to gather the functional requirements for the app development. This is an important stage as the functional requirements and responses of the participants are gathered that form the basis and purpose of the design and application development. Interview sessions were conducted with participants during the trial of the developed app to provide insights and feedback of the app prototype.

3.4 Users proposed requirements

A number of suggestions were proposed by the participants. During the first round, participants suggested the following requirements.

- Not too many notifications, pop-ups and reminders.
- User has the right to select which items to be notified about.
- Also, date/time of the reminder required item can be selected by the user (manually adjusted)
- User friendly app. (Usability- user friendly and easy to use are often quoted but the overall technical term for them is usability.)
- Delete (selected) items from the list (no reminder required for) customization.

Once the Functional requirement were set, the next step was to develop a paper prototype according the expectations which could be tested with the participants for feedback and further changes if required.

At the end of the 2nd round the user had highlighted some additional requirements for the app

- Perishable items-the user scans the barcode and later manually enters the data/time to be notified
- Multiple items can be customized/deleted at the same time
- Multiple customized item- Summary and not multiple popups/reminders
• Product type Segregation- Fruits, Vegetables, Dairy products etc.

• Trashed item can be recovered.

From the above stated points, it was concluded that the users wanted an app that would be user-friendly, not too complicated and above all would be helpful in reminding/notifying them about the products purchased/stored are not wasted and are used before time. The requirements were concluded as functional and non-functional.

3.5 Functional Requirements

3.5.1 Functional Requirements

Functional requirements of the application are the requirements a user can perform on the dashboard of the application. These are the requirements of the application user can access.

<table>
<thead>
<tr>
<th>Requirements</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>User can sign up</td>
<td>Core</td>
</tr>
<tr>
<td>User can logout</td>
<td>Core</td>
</tr>
<tr>
<td>User can invite other members</td>
<td>Intermediate</td>
</tr>
<tr>
<td>User can checkout</td>
<td>Core</td>
</tr>
<tr>
<td>User can check the cart</td>
<td>Core</td>
</tr>
<tr>
<td>User can delete items</td>
<td>Core</td>
</tr>
<tr>
<td>User can add items</td>
<td>Core</td>
</tr>
<tr>
<td>User can receive notifications</td>
<td>Core</td>
</tr>
<tr>
<td>User can search recipe</td>
<td>Core</td>
</tr>
<tr>
<td>User can make family tree</td>
<td>Intermediate</td>
</tr>
<tr>
<td>User can add unlimited items</td>
<td>Core</td>
</tr>
</tbody>
</table>

Tab. 3.1:  Functional Requirements of the FeastMe user app.
3. Methodology

3.6 Data Collection

Data collection for this study was by way of a Prototype Review Questionnaire and a series of Open Ended Interviews with the members of a User Group. The questionnaire were filled in by the participants after the testing of the app prototype to get their feedback.

3.6.1 Questionnaires

Questionnaires are one of the most popular research methods for collecting user data [136]. They can be distributed to few or many participants simultaneously through different channels such as social media, email addresses and so on. Questions can be open ended (e.g. full text replies) or closed e.g. Likert scales, yes/no answers. When compared to oral interviews, the questionnaire is more time-effective, low cost and a direct answer may be received. The data collected from the questionnaire can be processed and analyzed manually or using software.

- What is considered missing in the application?
- What features are expected to be in the app?
- How a user responds to the application features.

3.7 Designing of the Prototype Review Questionnaire

The questionnaire used in this study was based on an original designed by J.M. Curran [137]. It incorporates an ethical statement with guidelines that included the purpose of the study, procedures, participant’s confidentiality and rights were included at the beginning of the questionnaire. The designed questionnaire can be found in Appendix A.

Participants were asked about the questions used after the first iteration of the questionnaire and all indicated that the questions were easy to understand and answerable by the users. The questionnaire thus remained unaltered in subsequent iterations.

3.8 Open ended interviews

Open-ended interviews are type of interviews that are not based on a yes or no answer. In open-ended interviews, statements are required in response to a question. Open-ended questions were asked with the participants in the initial stage of the study as well as at the end of the testing phase of the developed version of the FeastMe app prototype to meet the requirements of the participants. Regular interviews were organized. Open ended questions can be found in Appendix C. Interview feedbacks can be seen in chapter 7.
3.9 User Group Selection

The questionnaire was conducted in the city of Sweden in Kalmar. The city was chosen for practical and monetary reasons as this thesis was written in this city. The questionnaire was given to participants in the library of the university and was solved in front of the person doing the research. A random and diverse group of participants of various ages and backgrounds selected to study and complete the questionnaire.

3.10 Fours “Us” - Usability, Utility, UX and UI

Interaction design has three, often confused, terms: Usability, User Experience (UX), and User Interface (UI). Jakob Nielsen and Don Norman pioneered the definition and use of the terms and – for clarity - it is best to work with their own, current definitions [49].

Usability and Utility are quality attributes of the entire application/system judged by the users themselves. Both are defined in terms of five quality components: learnability, efficiency, memorability, errors and satisfaction. In general, it is found that:

- Utility – does it give the user the features they need?
- Usability – are these features simple and pleasant to use?
- Combined these two give an idea of how Useful a product will be for users - does it do what they want, and can they get it to do what they want?

User Experience (UX) covers all aspects of using the app – it should meet the users’ expectations easily, without fuss and, ideally, be “a joy to use” [138].

The User Interface (UI) is, essentially, a subset of UX and is very important as it provides the link between the user and the device/product/app in use – a poor UI can lead to a poor UX but a good UI does not necessarily mean a good UX. Nowadays UI is often, confusingly, taken to just mean a Graphical User Interface (GUI) as found on computational devices including smartphones.

Affordances are an important part of the UI and contribute to the ultimate UX. Each object within the UI should be designed such that users can easily perceive its function. The term was coined by Gibson [139] and Norman later introduced their application to computing [140].
3. Methodology

3.11 Developing a prototype

Prototyping is the third, iterative step in the design cycle. The application is examined (by the design team or users) and good/bad points identified. These are rolled up into a new version of the application which is again examined. This is repeated until such time as the prototype is considered ‘as good as it gets’.

During user testing the backend of the application was not fully developed therefore a “Wizard of Oz” [141] testing scenario was adopted when prototyping the user facing components. This is beneficial as (1) user testing can proceed at the same pace, or even ahead of backend development and (2) early feedback on users’ expectations can be applied to the backend if a new feature is identified. The UI for the application is an Android app (here we use the term ‘app’ to refer to just the smartphone software and ‘application’ for the entire FeastMe system).

3.12 Paper prototype

Paper prototyping permits a fast way of investigating and improving an application with users. It can be applied to both the front and the backend of an application but is particularly useful when looking at the UX/UI [142]. It is especially helpful at the initial stages of development as it allows quick visualization and testing of different ideas.

3.12.1 Paper prototype v.1

After collecting all the functional requirements and data from the interviews, an initial paper prototype was designed and it was tested again to see the response of the user toward the application design and features. The user response at this stage is very important because it will feed into the development of the final application and early changes within the paper testing are quick and cheap.

3.12.2 Paper prototype v.2

After the feedback that was previously collected at the first stage a 2nd version of the paper prototype was built and the testing re-iterated. This led to a further paper prototype at the end of the study which could be later on be developed into a working application.
3. Methodology

3.13 Developed App Prototype

3.13.1 Developed App Prototype (v.1)

During the testing of the developed prototype of the application, an error was reported by participants when using the recipe feature. The reported error can be seen in Appendix D.

3.13.2 Developed App Prototype (Final Version)

A handout of the research project was handed to the participants in which they were presented with a user scenario so as they would be completely aware about the study being conducted. The project briefing handout can be found in the Appendix B section. The final version of the app was tested and evaluated with the participants. The feedback of the was collected from the participants which is analyzed and discussed in chapter 5. The final version of the developed prototype app can be seen in Chapter 4.

3.14 Scientific Approach vs Inductive Approach

The traditional scientific approach involves forming a hypothesis based on observation/previous study and then experimental investigation, usually providing quantitative data, to prove/disprove that hypothesis. In developing applications, however, a lot of qualitative data is generated and this is best characterised using the Inductive Approach [143]. This approach was used to evaluate the results of the user experience questionnaires. These included both open and closed questions for data collection and analysis.

3.15 Analytical Methods

In the present study questionnaires were analyzed and the aggregated data stored as Comma Separated Values (CSV) using a spreadsheet. Descriptive statistical analyses of this data was then carried out to identify trends, causations and possible correlations therein. The results and analysis of aggregate data from the questionnaire are detailed in chapter 5.
4. Development of the Prototype

Chapter 2 identified good and bad points in pre-existing applications targeted at reducing food waste. From there we identified that the addition of multi-user sync, targeted recipe suggestions and a valid help functionality would be beneficial. Chapter 3 then identified a number of FR from users of our proposed solution. This chapter explores the combining these previous results into developing a prototype of our ‘FeastMe’ application.

4.1 Paper Prototype

Within the user-centered design process a useful, early step is that of utilizing paper prototypes. In this approach, the designer draws hand-sketched designs, models and prototypes, which are intended to reflect the identified FR and user needs [142]. These ‘throwaway’ design concepts are then shown to users in a ‘Wizard of Oz’ scenario. In this way rapid feedback and redesign can be accomplished. Figure 4.1 shows an early design of FeastMe as shown to our user group.

![Image of FeastMe app paper prototype](image)

Fig. 4.1: Example of a FeastMe app paper prototype during the conceptual design stage.
4. Development of the Prototype

4.2 FeastMe Mobile App Prototype

Paper prototyping gained a number of suggestions from the users such as a form of individual user account, the ability to add a new family/group member to the system and a centralised system for managing products added via the “Your cart” option.

A Prototype mobile application was then developed in order to test the concept including these user suggested addons. This section describes the detailed technical process beginning from the authentication system up to the development of end prototype beta product. The developed version of the FeastMe app along with the interface images and brief working of each module are mentioned in the last section of this chapter.

4.3 Mobile Application Features

The Mobile Application was developed using the Ionic framework, it is cross platform mobile application development framework which enables the developer to write one single code using JavaScript and make mobile application for both Android and iOS.[131]. The application utilizes an authentication system for login and signup with a ‘family tree’ feature enabling the user to make use of multi account centralised system. After signup login, the user initially is presented with a ‘Your Cart’ feature allowing them to scan in a data matrix/barcode from an item they wish to add to the central (family) datastore. Once added other family members can view/update/delete these items. The datastore will issue reminders to users about items that items he/she had purchased which are near to their best before dates. Another feature that exists is the recipe search. This feature enables the user to search for Swedish recipes using our very own created Google custom search engine.

4.4 Implementation

Here we will briefly examine the technical details of the tools technologies which were utilized in development of this complete system architecture. This may be viewed as an n-tier architecture with three tiers: Presentation (UI), Business (API) and Data layers that sit between the user and the datastore.

As a datastore we opted for the scalable, NoSQL Firestore supplied by Google. Accessing this via their Firebase application provides the developer with a multi-client, realtime, syncing datastore with an offline capability that suits apps like multi-user FeastMe. With built in client authentication, widgets, plugins and integration with Android Studio it rapidly speeds up development of mobile apps.

4.4.1 The Presentation Layer – Ionic Framework

The Ionic 3 Framework is a cross platform Mobile Application development framework which enables the user to create both Android iOS mobile apps by just writing one single piece of code. Ionic then parcels these up in an OS specific wrapper than allows developers to use platform specific devices such as camera, accelerometer and
so on. Apps developed in this manner are known as hybrid applications. Ionic itself provides a powerful set of UI designs that are visible to the user in the Presentation Layer but, underneath, it harnesses two other frameworks – Angular JS and Apache Cordova.

4.4.2 The Presentation Layer - Angular JS

The Ionic Framework uses Angular JS as a basis for its scripting. Angular JS is, itself, a framework: a Javascript based, Model, View, Controller (MVC) one that is intended to permit developers to quickly construct client-side web applications based on HTML5. Such applications can run on all platforms that have an HTML5 compliant web browser. Ionic extends that functionality into mobile devices and provides an adaptive GUI for the application.

Extending a basic, static webpage that tends to use HTML/Javascript into a fully fledged web application with interactive, two way data flow tends to become overly complicated and burdensome to develop/update. A Javascript MVC framework wraps the underlying Javascript in an abstract layer that allows the application to be split into the three MVC components:

- Model – the data within the application.
- View - essentially the GUI of the application. It observes changes in the application data (whether user input or backend updates) and alters the display to keep the user informed.
- Controller – handles all input to the application and alters (controls) the model to reflect this.

4.4.3 The Presentation Layer - Apache Cordova

Early attempts to create a cross platform framework for mobile devices spawned a number of applications including Nitobi Phonegap. The ‘gap’ indicated the ability to bridge browser based applications with the built in, platform specific components of individual mobile devices. When Adobe bought out Nitobi they donated the framework to the Apache Foundation whereupon it became known as Apache Cordova.

while Cordova is a powerful tool featuring a multitude of plugins to allow developers to link their applications with the target mobile device it suffered from two major drawbacks –it was command line (CLI) driven and it did not offer any form of GUI for the applications being developed. Both these have been overcome by the inclusion in Ionic.

This does mean that Ionic tends to depend on the Cordova plugins and, where those have not been maintained or further developed lacks functionality in one or more platforms. An example relevant to this project is that of barcodes: the Cordova barcode plugin currently used by Ionic lacks support a number of barcodes – iOS (4) and Android (1) [132].
4.4.4 The Business Layer - Typescript (TS)

The business layer handles the data transfer to/from the users to the data layer. This communication is over HTTP/TSL from the mobile device to a REST API that fronts the Google Firestore. This API is the Google Firebase and the Ionic framework has a plugin that facilitates adding it to a project [144].

Ionic is built on the Typescript language and uses it to implement the plugin. Typescript is an extension of Javascript that adds extra functionality and, upon Ionic project completion, can be compiled down to cross platform compatible Javascript.

4.5 Major APIs

4.5.1 Firebase API

Firebase is an online Real-time database provided by Google with a built in API. The Firebase’s centralized database system is communicated with using JSON over secure HTTPS/TSL protocols. The mobile app FeastMe user authentication and sign up system for users was implemented. The user data is then posted to our Firebase Database using the Firebase API key authentication token in the form of API call. Whenever the user logsins the data of that specific user is then recalled from the Firebase online database in form of JSON and processed in the code.

4.5.2 QR Code API

The feature of scanning the QR Codes on the product was also embedded in the app. The type of QR Code used for this app is Data Matrix. Simple by just scanning the QR Code, the system adds that specific product in to Your Cart module. For utilizing this feature, a third-party Data Matrix Code scanning API or Plugin for Ionic framework was used, which enables to create an interface for user to scan and retrieve the QR Code pictorial data into the textual data for product/item.

4.5.3 Google Custom Search Engine

For recipe searching feature, Google Custom Search Engine API provided by Google was implemented. Whenever the user inputs any keyword, it is then sent to our already created online google custom search engine which holds some major website sources to derive the result sends it in JSON format to visualize it within the app. So, as a result the images, recipe quick overview along with its rating are shown. Whenever the user presses any recipe, the recipes will be shown within In-App browser of the FeastMe application, so user can easily get all the things in one single place.
4.6 Android Architecture

The architecture of Android is shown in figure 4.2. The application built on Ionic (including Cordova plugins) integrates with the Android framework that overlays the OS kernel. This includes the built in Android Webkit [145] an Open Source, cross platform, de facto standard content rendering engine for use in both web browsers and mobile applications.

![Diagram of Android Architecture]

**Fig. 4.2:** The multitier system architecture of an Android application.
4.7 App System Architecture

The above Figure 4.3 shows the architecture of the complete FeastMe mobile application. The first layer is the user interface layer, which is built on AngularJS using the GUI components provided by Ionic. It is responsible for interpreting user action events (e.g. click, tap, swipe) and data input and passing the results through to the business/backend layer.
4. Development of the Prototype

The Typescript backend has two main functions:

- to connect the user to the data storage
- divert data input for the recipe search to the Google CSE

The data layer is fronted by the Firebase API which has built in security/authorisation hooks allowing the mobile app to securely transfer data to/from the datastore without fear of compromise.

4.7.1 Use Case Diagram Description

<table>
<thead>
<tr>
<th>Symbol Name</th>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entity</td>
<td>![Entity Symbol]</td>
<td>Entity will the functions name can perform.</td>
</tr>
<tr>
<td>Line</td>
<td>![Line Symbol]</td>
<td>This Line use to connect the Actor with Entities.</td>
</tr>
<tr>
<td>Actor</td>
<td>![Actor Symbol]</td>
<td>This is the symbol of Actor means User.</td>
</tr>
<tr>
<td>Edge flow</td>
<td>![Edge flow Symbol]</td>
<td>This is showing the extended or include edge from Entity.</td>
</tr>
<tr>
<td>Options</td>
<td>&lt;&lt;extended&gt;&gt;</td>
<td>Extend means this option is not mandatory to add for working.</td>
</tr>
<tr>
<td>Options</td>
<td>&lt;&lt;include&gt;&gt;</td>
<td>include means this option is mandatory to add for working</td>
</tr>
</tbody>
</table>

Actor can do:

**Figure 4.4** below illustrates the actions an Actor can perform; Create account, Login, Logout etc. Upon the installation of App, the first screen will ask the user to Login or Sign up. Description of the use case is as below:

- User can access with is app as it is shown in first entity.
- **Your Cart:** User can go after click on Add cart option from side nav bar option user will see the list of options as it is showing in Image: Add new item, Select All, Delete, Custom
- **Custom:** there will separate screen showing edge entity like Reminder can set on specific product to show alert. And login include shows that user must register too see his cart products.
- **Trash:** From trash there is an extended edge shows you can recover your deleted products and can delete forever as well
- **Recipes:** extended edge shows user can search on based of keyword and will show list of data on specific keyword.
- **Family Tree:** From Family tree option in side nav bar you can refer your family or friend members for app or join from invitation to use/buy products.

- **Settings:** Popup on Screens can show that the status.

- **Help:** User can get help that how to use app.

- **Login:** It will ask from user Email and Password.

- **Create account:** User must enter these details to get register; Name, Email, Password, Gender and Address, where name, email & password are mandatory fields.

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**Fig. 4.4:** Use Case diagram of FeastMe app.
4.8 Family Tree & Your Cart Features

There are two major features in this app: Family Tree and Your Cart.

**Family Tree** - here the added items of the specific family member can be viewed and added. These two features rely on Firebase database querying architecture. The system is based on two Files (they are termed as Documents in Firebase); one is Items and the other is Users. For every user there exist his/her auto generated family number in the database which is always unique for every family. Families having same “Family number" are treated as one single family cart. Each member can be added in the same family tree, by scanning the unique QR code auto-generated in the app. For example, Family member "James" is Head of the family. In the Family tree module, a unique QR code which generated for "James", the other members would simply scan the QR code and would be added in James family tree (figure 4.14). Family members would go the option "Join Another Family" (Figure 4.13), which can be found in the Family tree module.

Any Items/products that are added by one person, will be added for whole family and same feature exists for item deletion. This feature enables a hassle-free family shopping experience, where the household members are aware about the products/items that are bought avoiding duplication.

**Your Cart** - this is interconnected and dependent on family feature, whenever an item is added its value is appended to the Item array of that specific family by using their specific assigned family number, so that it becomes visible to all family members and same exists for removing the item from the cart. The below Figure 4.5 describes the sequence of system.
4. Development of the Prototype

4.9 Recipe Search Results

Google Custom Search (formerly known as Google Co-op) is an online platform provided by Google that allows web developers to feature specialised information in web searches, refine and categorise queries and create customised search engines, based on Google web search [146]. The search results are retrieved through the Google Custom Search API by using a Custom Search Engine [147]. The CSE allows the developer to decide what websites are to be searched when terms are entered. The sites can be included and excluded in CSE according to the search scope that are pre-defined by the developer. The search scope can be further refined in terms of country. For the FeastMe mobile app, the recipe search would only produce Swedish recipes which are pre-defined in CSE for the app display. There can also be some sites retrieved that may still be written in English, so additional filtering and processing of the search results are needed to implement programmatically [148].

Fig. 4.5: Sequence Diagram of the Family tree and Your cart module.
4.10 Architecture of Recipe module

The System uses the Mobile Application interfaces and allows the user to signup login and retrieve its data from the Firebase Real-time database using the Firebase API which further processes and verifies the information provided the user able to proceed. Figure 4.6 diagram illustrates the working of recipe search module in the mobile application. The FeastMe mobile application client uses the RESTful API for pushing the data towards our online Google custom search engine. Once Google CSE receives the keyword search input from the user, it looks up for the results within the connected or already pre-defined Swedish recipes websites. The meta-data and the format of data to collect is already pre-defined for this project, which is then gathered and transformed into an array and sent through in JSON format. The gathered results are pre-processed and parse the JSON which is displayed at the client side front-end (smartphone display).
4. Development of the Prototype

4.11 Developed App Prototype (Final Version)

This section describes the features of the FeastMe app which were suggested by the participants during the initial stages of this study included with the additional features of Recipes, Family sync and help module that were a part of future works, are now included in the developed app. The FeastMe.apk link can be found in Appendix D of the thesis.

**Homepage:** Homepage as shown in figure 4.7 is the first user interface of FeastMe app. The first screen that appears once the app is installed in the smartphone. The user can select two options from the splash screen; signup as a new user or if he/she is already a user of this app can opt for the second option (I am a registered User).

Fig. 4.7: Homepage of FeastMe app
The Dashboard: The dashboard, the second point of interface of the app as shown in Figure 4.8, that display the menus features of the application. These are the set features a user can have the access to in order to perform a particular function.

Fig. 4.8: Dashboard menu of FeastMe app

---

Fig. 4.9: Your Cart menu of FeastMe app
Your Cart: In Figure 4.9 above, Here the users can add, delete and customize the items purchased/to be purchased. Two items are added as an example. As the term explains itself, the user can add, delete or customize multiple items at the same time. On selecting the custom option in shown in figure 4.10, the user can select date/time, type of notification; popup or popup with sound. User can also select the desired notification tone for the particular item. For Multiple selection of items to be reminded at the same time, the user is notified with a popup but in the form of a summary hence removing multiple notification that would annoy its users.

**Fig. 4.10:** Displays the customize menu
Recipes: In figure 4.11, the recipes module, the user can search Swedish recipes based on ingredient or recipe name from the search bar. The recipes are retrieved from 11 different websites embedded in the Google CSE. For example, a user types in an ingredient keyword of “Ginger”, the search results, displays the image of the recipe, the website from where the recipe is retrieved from and rating of the recipe (if any) as shown in figure 4.12. The ratings are provided by the website itself and not every result displays the rating of the recipe.

![Fig. 4.11: The recipe feature of the app](image)

![Fig. 4.12: Example search results of ginger ingredient keyword](image)
Family Tree: Here the user can add multiple members of his/her family to the family tree. The user is displayed with 2 options “Invite user” and “Join another Family” as shown in figure 4.13. Selecting the Invite user option, a unique barcode is generated by the primary user. To join the same family, the other family member needs to select the “Join another Family” option and then scan the unique barcode that was generated by the primary user. Figure 4.14 illustrate how a new member is added to the family. Adding of multiple members of the family in this menu who do shopping at the time same, would be able to see what items are bought by the household to avoid duplication.

Fig. 4.13: The family tree feature of the app

Fig. 4.14: A new member is added to the family
5. Results

In this section, the overall results of the app testing and evaluation are discussed. For the purpose of the development of this application, random participants were interviewed. Based their interview results, a paper prototype was iteratively designed/redesigned until the final prototype was produced based on their feedback. Analysis of the results obtained in chapter 5 are further discussed in chapter 6.

5.1 Types of Statistical Analysis Performed

The statistical analysis was performed on the responses of the participants that was collected from the questionnaire filled by them. The purpose of performing this statistical analysis it to analyze the data and the view of the users on the application are justified. The tests performed on the data are as follows:

- Cronbach’s Alpha
- Frequency Distribution
- Median
- Standard Deviation
- Average

5.2 Demographic Data

The study was conducted in Kalmar, Sweden and the participants played an important role in gathering the functional requirements of the application (discussed in section 3.9, User Group Selection). Focused group study, interviews and testing of the app were also conducted in the university library. The data was collected irrespective of the age group and gender. The participants were students at the university.

5.3 Cronbach’s Alpha Reliability Test Results

<table>
<thead>
<tr>
<th>Items</th>
<th>Cronbach Alpha</th>
<th>Std. Alpha</th>
<th>G6(smc)</th>
<th>Average K</th>
</tr>
</thead>
<tbody>
<tr>
<td>All items</td>
<td>0.7576</td>
<td>0.7484</td>
<td>0.9572</td>
<td>0.1986</td>
</tr>
<tr>
<td>Q1 excluded</td>
<td>0.7492</td>
<td>0.7337</td>
<td>0.9518</td>
<td>0.2003</td>
</tr>
<tr>
<td>Q2 excluded</td>
<td>0.7598</td>
<td>0.7515</td>
<td>0.9563</td>
<td>0.2156</td>
</tr>
<tr>
<td>Q3 excluded</td>
<td>0.7644</td>
<td>0.7583</td>
<td>0.9535</td>
<td>0.2219</td>
</tr>
<tr>
<td>Q4 excluded</td>
<td>0.7333</td>
<td>0.7219</td>
<td>0.9498</td>
<td>0.1909</td>
</tr>
<tr>
<td>Q5 excluded</td>
<td>0.7097</td>
<td>0.701</td>
<td>0.8952</td>
<td>0.1757</td>
</tr>
<tr>
<td>Q6 excluded</td>
<td>0.7733</td>
<td>0.7091</td>
<td>0.9544</td>
<td>0.2224</td>
</tr>
<tr>
<td>Q7 excluded</td>
<td>0.7136</td>
<td>0.7011</td>
<td>0.9447</td>
<td>0.1785</td>
</tr>
<tr>
<td>Q8 excluded</td>
<td>0.7252</td>
<td>0.7138</td>
<td>0.9508</td>
<td>0.1863</td>
</tr>
<tr>
<td>Q9 excluded</td>
<td>0.7260</td>
<td>0.7312</td>
<td>0.9512</td>
<td>0.1936</td>
</tr>
<tr>
<td>Q10 excluded</td>
<td>0.7101</td>
<td>0.8238</td>
<td>0.9381</td>
<td>0.1572</td>
</tr>
<tr>
<td>Q11 excluded</td>
<td>0.7867</td>
<td>0.7274</td>
<td>0.9313</td>
<td>0.1952</td>
</tr>
<tr>
<td>Q12 excluded</td>
<td>0.7579</td>
<td>0.7574</td>
<td>0.9285</td>
<td>0.2211</td>
</tr>
</tbody>
</table>

Fig. 5.1: Cronbach’s Alpha and Gutman’s Lamda Values
Cronbach’s Alpha [149] is an important reliability test for the evaluation questionnaire. Many times Alpha values have been criticized as a value of poor understanding and interpretation.[150,151].

In this case, the Cronbach’s Alpha reliability test was successfully passed with a good percentage, something that indicates strong, valid relationship between the questions. Some references mention that high values indicate redundancies in the questionnaire. This questionnaire was built with a reasonable number of questions aiming to provide the best possible outcome in the time given. Taking into account that the inter-relation values between items are over 0.7, and the majority of the items having inter-relation values over 0.720, it is a good indication of a good questionnaire building effort. Any additional modification seems not to provide significant changes to the reliability of the results.

Additionally, in the statistics table can identify high values over 0.920 in Gutman’s Lamda [152]. Guttman’s Lambda 6 (G6) considers the amount of variance in each item that can be accounted for the linear regression of all of the other items. This result is another indication that shortening the questionnaire will not lower the Alpha value significantly. The questionnaire design passed through many test and result rounds of editing and the focus was approach to the content discussed in order to conclude with the number and the content of the questions to the most relevant and on-point questions. The last and final version of the questionnaire was carefully inspected and accepted by the current supervisor.

In conclusion, the values of Alpha is a result of a robust relationship between the questions and eliminating the possibility of duplicate questions from the design phase to the actual interviews. The variety and the quality of the content shown in the questionnaire. Finally, we can conclude that Cronbach’s Alpha and Gutman’s Lamda are a good indicator of consistency within the questionnaire, something that can achieve reliable and worthy results.

5.4 Prototype Review Questionnaire

The questionnaire for the prototype review was divided into 3 sections. The first section presented questions related to Interface Design Characteristics of the prototype. The second section was the Short Answer Questions related to the app where the users can describe their views and opinions on the performance, content and information presented in the app. The last section presented questions related to the Prototype Tools i.e. the app labels, tools and understanding. The first and the last sections used linear Likert scale where, 1-Strongly agree; 2- Agree; 3-Neither Agree nor Disagree; 4- Disagree; 5-Strongly Disagree. The designed questionnaire can be found in Appendix A of the thesis.
5.4.1 Interface Design Characteristics

Questions 1: Control on the Interface Feedback from the questionnaire was monitored, about the user interface of the application. The results were compiled and tested.

a) Frequency distribution.

<table>
<thead>
<tr>
<th>1) User has good control of interface</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly Agree</td>
<td>5</td>
<td>33.3</td>
</tr>
<tr>
<td>Agree</td>
<td>10</td>
<td>66.7</td>
</tr>
<tr>
<td>Total</td>
<td>15</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Tab. 5.1: Frequency distribution results from question 1

Results: 33.3% participants strongly agree and 66.7% agree that user has good control of interface something that is shown in the pie chart below.

Fig. 5.1: Majority of users feel they have control of the interface
b) Descriptive Statistics

Descriptive statistics is the term given to the analysis of data that helps describe, show or summarize data in a meaningful way such that, for example, patterns might emerge from the data.

<table>
<thead>
<tr>
<th>User has good control of interface</th>
<th>Obs</th>
<th>Average</th>
<th>Stand. dev</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>15</td>
<td>1.66</td>
<td>0.48</td>
</tr>
</tbody>
</table>

**Tab. 5.2:** Represents the descriptive statistics of the variable

**Results:** The average value of good control of interface is 1.66 and its standard deviation is 0.48. As we can distinguish from the results of the descriptive statistics the majority of the people are answered positively. The average of 1.66 and standard deviation of 0.48 indicate a great design of the interface controls. As it seems nobody from the 15 people involved in this research found any difficulties navigating through the pages

**Questions 2: Understandable Common Words** For question 2, feedback was monitored about the common words used are use understandable. The results were compiled and tested and the frequency of strongly agreed and agreed was observed. **a) Frequency distribution.**

<table>
<thead>
<tr>
<th>2) Common words are used that are understandable</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly Agree</td>
<td>10</td>
<td>66.7</td>
</tr>
<tr>
<td>Agree</td>
<td>5</td>
<td>33.3</td>
</tr>
<tr>
<td>Total</td>
<td>15</td>
<td>100.0</td>
</tr>
</tbody>
</table>

**Tab. 5.3:** Frequency distribution results from question 2

**Results:** 66.7% participants strongly agree and 33.3% Figure 5.2 (below)
5. Results

Fig. 5.2: Majority of users found the language within the app understandable

b) Descriptive Statistics

<table>
<thead>
<tr>
<th>Common words are used that are understandable</th>
<th>Obs</th>
<th>Average</th>
<th>Stand. dev</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>15</td>
<td>1.33</td>
<td>0.48</td>
</tr>
</tbody>
</table>

Tab. 5.4: Represents the descriptive statistics of the variable

Results: The average value of common words is used that are understandable is 1.33 and its standard deviation is 0.48. The results of the second question which is asking the participants if common words used are understandable the majority of the participants are answered positively. These results indicate a good selection of words which are fully understandable from the people that used the application. The great average of 1.33 and the standard deviation of 0.48 are justifying these claims.
Questions 3: Navigation The feedback related to navigation in the app feature was collected and compiled from the user questionnaire. The frequency distribution of the feedback is as shown and the observations were made.

a) Frequency distribution.

<table>
<thead>
<tr>
<th>3)It is easy to navigate around</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly Agree</td>
<td>5</td>
<td>33.3</td>
</tr>
<tr>
<td>Agree</td>
<td>10</td>
<td>66.7</td>
</tr>
<tr>
<td>Total</td>
<td>15</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Tab. 5.5: Frequency distribution results from question 3

Results: 33.3% participants strongly agree and 66.7% agree – Figure 5.3 (below)

Fig. 5.3: Majority of users found the internal navigation simple to use.
b) Descriptive Statistics

<table>
<thead>
<tr>
<th>It is easy to navigate around</th>
<th>Obs</th>
<th>Average</th>
<th>Stand. Dev</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>15</td>
<td>1.66</td>
<td>0.48</td>
</tr>
</tbody>
</table>

**Tab. 5.6:** Represents the descriptive statistics of the variable

**Results:** The average value of it is easy to navigate around is 1.66 and its standard deviation is 0.48. As a matter of fact the author of this thesis is fully satisfied for the design efforts since the results shown that none of the users found any difficulties at navigating through the different screens of the application something that indicates a good designed user interface that brings a great user experience. The average of 1.66 and the standard deviation of 0.48 are great indicators of the claims.

**Questions 4: User Friendly Layout** The next feedback from the user interfaces was compiled and the user interaction with the application was observed. Results show the interface was marked in the favour of the user-friendly application. It is the interface which is easy to be used and the user experience on the interface is easily usable.

**a) Frequency distribution.**

<table>
<thead>
<tr>
<th>4) The layout is user friendly</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly Agree</td>
<td>6</td>
<td>40.0</td>
</tr>
<tr>
<td>Agree</td>
<td>9</td>
<td>60.0</td>
</tr>
<tr>
<td>Total</td>
<td>15</td>
<td>100.0</td>
</tr>
</tbody>
</table>

**Tab. 5.7:** Frequency distribution results from question 4

**Results:** 40% participants strongly agree and 60% agree – Figure 5.4 (below)
5. Results

Fig. 5.4: Majority of users found the UI layout easy to use.

b) Descriptive Statistics

<table>
<thead>
<tr>
<th>The layout is user friendly</th>
<th>Obs</th>
<th>Average</th>
<th>Stand. Dev</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>15</td>
<td>1.66</td>
<td>0.48</td>
</tr>
</tbody>
</table>

Tab. 5.8: Represents the descriptive statistics of the variable

Results: The average value of the layout is user friendly is 1.66 and its standard deviation is 0.48. As a fully dependent question with the previous one that related with the user interface and the user experience the results are similar. The participants found the layout friendly and the average of 1.66 and the standard deviation of 0.48 are justifying the good application design.
Questions 5: Presentation of Logical Order Information without Surprise
In this question the users were asked related to the surprises they can or have faced during the using of the application. It was asked to the users if the application information is presented in a logical order without any sudden surprises and the results were evaluated on it:

a) Frequency distribution.

<table>
<thead>
<tr>
<th>5) Information is presented in logical order without surprises</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly Agree</td>
<td>4</td>
<td>26.7</td>
</tr>
<tr>
<td>Agree</td>
<td>10</td>
<td>66.7</td>
</tr>
<tr>
<td>Neutral</td>
<td>1</td>
<td>6.7</td>
</tr>
<tr>
<td>Total</td>
<td>15</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Tab. 5.9: Frequency distribution results from question 5

Results: 26.7% participants strongly agree, 66% agree and 6% are neutral – Figure 5.5 (below)

Fig. 5.5: Majority of users found the order of data presented by the app to be logical.
b) Descriptive Statistics

<table>
<thead>
<tr>
<th>Information is presented in logical order without surprises</th>
<th>Obs</th>
<th>Average</th>
<th>Stand. Dev</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>15</td>
<td>1.80</td>
<td>0.56</td>
</tr>
</tbody>
</table>

**Tab. 5.10:** Represents the descriptive statistics of the variable

**Results:** The average value of information is presented in logical order without surprises is 1.80 and its standard deviation is 0.56. Another question that is related with the user experience is the presentation of the information provided inside the application. The majority of the people answered positively and a small percentage were neutral about the logical order. Author although is pretty optimistic about these results because the absence of negative feedback make her believe that with minor future modifications through an iteration of QA would make the application even better.

**Questions 6: Easy Navigation of App** The navigation on the application is how the application is directing the user to use and the way user is showing the response while using the application. Questions 6 is about the navigation on the application. The users were asked if it is easy for them to navigate on the application and answers were collected and the testing was performed:

a) **Frequency distribution.**

<table>
<thead>
<tr>
<th>6) Is the app easy to navigate?</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly Agree</td>
<td>10</td>
<td>66.7</td>
</tr>
<tr>
<td>Agree</td>
<td>5</td>
<td>33.3</td>
</tr>
<tr>
<td>Total</td>
<td>15</td>
<td>100.0</td>
</tr>
</tbody>
</table>

**Tab. 5.11:** Frequency distribution results from question 6

**Results:** 66.7% participants strongly agree and 33.3% agree – Figure 5.6 (below)
5. Results

Fig. 5.6: Majority of users found the app navigation easy to use. Focused group study, interviews and testing of the app were also conducted in the university library. The data was collected irrespective of the age group and gender. The participants were students at the university.

b) Descriptive Statistics

<table>
<thead>
<tr>
<th>Is the app easy to navigate?</th>
<th>Obs</th>
<th>Average</th>
<th>Stand. Dev</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>15</td>
<td>1.33</td>
<td>0.48</td>
</tr>
</tbody>
</table>

Tab. 5.12: Represents the descriptive statistics of the variable

Results: The average value of app navigation is 1.33 and its standard deviation is 0.48. Very positive results are presented in the question about the easiness of the navigation of the application. The majority of the participants found the navigation very easy and it is a result of a good design and smart choices inside the application like a clear menu and easy to read application modules. The average value of 1.33 and the standard deviation of 0.48 is a justification of the author’s claims and design efforts.
Questions 7: Speed of Response to Action  The feedback related to the speed efficiency of the application was mentioned to the users and the results shows that the speed of response in order to perform the action is done in an appropriate way and the users’ response was compiled and tested:

a) Frequency distribution.

<table>
<thead>
<tr>
<th>7) The speed of response to actions performed is appropriate</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly Agree</td>
<td>3</td>
<td>20.0</td>
</tr>
<tr>
<td>Agree</td>
<td>10</td>
<td>66.7</td>
</tr>
<tr>
<td>Neutral</td>
<td>2</td>
<td>13.3</td>
</tr>
<tr>
<td>Total</td>
<td>15</td>
<td>100.0</td>
</tr>
</tbody>
</table>

**Tab. 5.13:** Frequency distribution results from question 7

**Results:** 20% participants strongly agree, 66.7% agree, while 13.3% are neutral – Figure 5.7 (below)

**Fig. 5.7:** Majority of uses found no problem with the app response speed.
b) Descriptive Statistics

<table>
<thead>
<tr>
<th>The speed of response to actions performed is appropriate</th>
<th>Obs</th>
<th>Average</th>
<th>Stand. Dev</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>15</td>
<td>1.93</td>
<td>0.59</td>
</tr>
</tbody>
</table>

Tab. 5.14: Represents the descriptive statistics of the variable

Results: The average value of the speed of response to actions performed is appropriate is 1.93 and its standard deviation is 0.59. Regarding the responsiveness of the application most of the users found the application very responsive. There were serious efforts to make the application as fast as possible but some users were not sure if the responsiveness is up to their expectations. There are some reasons why these participants are neutral. One possible reason is the testing of the app of a power user of a smartphone which they have ultra-high expectations and another reason could be that they use a slow device. In general the results are pretty encouraging because the responsiveness could play major role in the future success of the application.
Questions 8: Troubles to Find the Specific Features In the next feedback, the users about the features of the application. The users were asked if they had any problem finding some specific features in the application. The results are as below.

a) Frequency distribution.

<table>
<thead>
<tr>
<th>Did you have trouble finding a specific feature?</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly Agree</td>
<td>1</td>
<td>6.7</td>
</tr>
<tr>
<td>Agree</td>
<td>4</td>
<td>26.7</td>
</tr>
<tr>
<td>Neutral</td>
<td>10</td>
<td>66.7</td>
</tr>
<tr>
<td>Total</td>
<td>15</td>
<td>100.0</td>
</tr>
</tbody>
</table>

**Tab. 5.15:** Frequency distribution results from question 8

**Results:** 6.7% participants strongly disagree, 26.7% disagree and 66.7% are neutral.

**Fig. 5.8:** No users specified a problem finding a particular feature in the app.
b) Descriptive Statistics

<table>
<thead>
<tr>
<th>Did you have trouble finding a specific feature?</th>
<th>Obs</th>
<th>Average</th>
<th>Stand. Dev</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>15</td>
<td>4.6</td>
<td>0.63</td>
</tr>
</tbody>
</table>

**Tab. 5.16:** Represents the descriptive statistics of the variable

**Results:** The average value of the trouble finding a specific feature is appropriate is 4.6 and its standard deviation is 0.63. These results are a first indication that the participants didn’t face trouble finding a specific feature. The neutrality presented in the results could probably cause some confusion because most of the users are using the application for the first time and some of the features are pretty innovative like the qr and barcode scan addition of a product along with their best before date and the participants probably would not fully aware of these kind of features from a previous application experience.
5.4.2 Short Answer Questions

Question 1: Overall Impression of Prototype

In this section of the questionnaire, the information related to the prototype design, content and performance of the application was to be analyzed based on open-ended questions. The overall responses on the application were received and the impression study was done on the responses of the users.

a) Answers presentation.

<table>
<thead>
<tr>
<th>1) What is your overall impression of the prototype design, information content, and performance?</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Responses</strong></td>
</tr>
<tr>
<td>It is user friendly.</td>
</tr>
<tr>
<td>Impressive</td>
</tr>
<tr>
<td>Impressive</td>
</tr>
<tr>
<td>Good</td>
</tr>
<tr>
<td>As a whole, it is a great initiative and application is well built</td>
</tr>
<tr>
<td>The concept of FeastMe is quite interesting and innovative easy to manage over grocery by simple scanning the barcode.</td>
</tr>
<tr>
<td>Great Concept</td>
</tr>
<tr>
<td>it was easy to use, great concept and very well executed.</td>
</tr>
<tr>
<td>user friendly app</td>
</tr>
<tr>
<td>Its pretty good in terms of design performance as a prototype</td>
</tr>
<tr>
<td>Good overall. Like the idea of the family sync.</td>
</tr>
<tr>
<td>Innovative</td>
</tr>
<tr>
<td>its great</td>
</tr>
<tr>
<td>Thumbs Up!</td>
</tr>
<tr>
<td>Good Work!!</td>
</tr>
</tbody>
</table>

Tab. 5.17: Answers presentation results from question 1

Results: The overall comments related to the prototype design, content and performance, the participants were seen positive. Words like impressive, innovative and great concept make the author feel very satisfied and happy for the overall effort. The summary of the first question answers could be the initiative for a further development and release.
Question 2: User Friendly Prototypes:

The users were asked about their views with regards to the prototype tools of the application, if the tools designed in the application easy to use or if there is any difficulty using these tools. The responses were collected and the tests were performed to check if the prototype tools are user friendly or not as per participant’s requirement.

a) Answers presentation.

<table>
<thead>
<tr>
<th>2) Are the prototype tools user-friendly?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Responses</td>
</tr>
<tr>
<td>Yes it is</td>
</tr>
<tr>
<td>Yes, very much</td>
</tr>
<tr>
<td>Absolutely</td>
</tr>
<tr>
<td>Yes</td>
</tr>
<tr>
<td>Yes, a lot</td>
</tr>
<tr>
<td>yeah I personally like the family tree, it’s probably that one tool we need it actually.</td>
</tr>
<tr>
<td>Yes</td>
</tr>
<tr>
<td>Yes</td>
</tr>
<tr>
<td>Yes, very understandable</td>
</tr>
<tr>
<td>Yes</td>
</tr>
<tr>
<td>Yes</td>
</tr>
<tr>
<td>Yes</td>
</tr>
<tr>
<td>Yes</td>
</tr>
<tr>
<td>Yes</td>
</tr>
</tbody>
</table>

Tab. 5.19: Answers presentation results from question 2

Results: The overall comments of the participants were very positive. The prototypes are the first touch of the participant and the app and it is the first crash test of the application and you as a developer could earn a lot of feedback and find bugs and problems from the early stages which is very valuable. A user friendly prototype could make a difference between success and failure.
Question 3: Additional Comments

The analysis of this section is very important as it was based on the comments or reviews of the users. This was done to check the comments of the users on the application as the overall impression of the users on the app can help in the future studies to evaluate the application and it will also help to see if there are some negative comments about the application and if so, they can be resolved in time. The user responses were collected and the testing was performed.

a) Answers presentation.

Results: The overall comments of the participants were positive something that

| 3) Please provide any additional comments. Was there anything on your mind while working with the prototype or through this questionnaire that you have not communicated? |
|-----------------|-----------------|
| Responses       |                 |
| Buying items through RFID | none, everything is clear |
| No              | It was clear |
| None, Everything was clearly explained in the written handout provided. | Everything seemed Professional. |
| No, it is a Good Concept | Purpose, procedure etc were clearly mentioned at the start of the questionnaire which is good. Also, what the prototype is about was also stated in the handout. |
| No              | None as such.. |
| Good initiative | No |

Tab. 5.21: Answers presentation results from question 3

reveals good design and adequate amount of functionalities. As a matter of fact the participants didn’t comment something that could change radical the development of the app.
Question 4: Missing Features

In this part of the questionnaire, the user comments are analyzed for any missing features or lack any sub-features in the application. It is done to validate the functionality of the application as at the time of development there is a possibility that if some feature might have got ignored. The user response on this question is analyzed by doing the testing on it.

a) Answers presentation.

<table>
<thead>
<tr>
<th>4)Was anything obvious lacking or missing?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Responses</td>
</tr>
<tr>
<td>Everything is okay but in the next phase</td>
</tr>
<tr>
<td>RFID tags can enhance this buying process.</td>
</tr>
<tr>
<td>None</td>
</tr>
<tr>
<td>No</td>
</tr>
<tr>
<td>No. Looking forward the version to</td>
</tr>
<tr>
<td>be launched on Appstore</td>
</tr>
<tr>
<td>No</td>
</tr>
<tr>
<td>No, nothing obvious is lacking</td>
</tr>
<tr>
<td>The recipe section is helpful</td>
</tr>
<tr>
<td>No</td>
</tr>
<tr>
<td>No</td>
</tr>
<tr>
<td>Probably more login options.</td>
</tr>
<tr>
<td>Nothing as such</td>
</tr>
<tr>
<td>No</td>
</tr>
<tr>
<td>No</td>
</tr>
<tr>
<td>No</td>
</tr>
<tr>
<td>Nothing</td>
</tr>
<tr>
<td>No</td>
</tr>
<tr>
<td>No</td>
</tr>
</tbody>
</table>

**Tab. 5.23:** Frequency distribution results from question 4

Results: The participants commented as no obvious lacking were found in the application. Suggestion for future work were also given. The comments were positive for the app prototype since the majority didn’t find any obvious missing features. Some additional features proposed and discussed and they will be taken into serious consideration for future developments.
5.4.3 Prototype Tools

Question 1: Easy Understanding of Actions of Tools
This section of the questionnaire was to monitor the types of the actions a tool can perform. The users were questioned, if it is easy for them to understand the functionality a tool can perform. The purpose of this question was observe the user understanding towards the application.

a) Frequency distribution.

<table>
<thead>
<tr>
<th>1) It is easy to understand what action each tool will perform</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly Agree</td>
<td>8</td>
<td>53.3</td>
</tr>
<tr>
<td>Agree</td>
<td>7</td>
<td>46.7</td>
</tr>
<tr>
<td>Total</td>
<td>15</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Tab. 5.25: Frequency distribution results from question 1

Results: 53.3% strongly agree and 46.7% agreed – Figure 5.9 (below)

Fig. 5.9: All users reported that they understood the action of each tool within the app
b) Descriptive Statistics

<table>
<thead>
<tr>
<th>It is easy to understand what action each tool will perform</th>
<th>Obs</th>
<th>Average</th>
<th>Stand. Dev</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>15</td>
<td>1.46</td>
<td>0.51</td>
</tr>
</tbody>
</table>

**Tab. 5.26**: Represents the descriptive statistics of the variable

**Results**: The average value of tool performance is 1.46 and its standard deviation is 0.51. The answers given indicate very good understanding among the features and the purpose of each one. This is very important due to the fact that the features are clearly state their status and the user have a clear picture of the functionalities and the actions. The average of 1.46 and the standard deviation of 0.51 could support these claims.

**Question 2: Text Labels on Each Tool Button**

It is important to mention the labels on the buttons of the application as it will help the users to use the application with more understanding. Responses were gathered and tested:

a) Frequency distribution.

<table>
<thead>
<tr>
<th>2) The text labels on each tool button are appropriate:</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly Agree</td>
<td>6</td>
<td>40.0</td>
</tr>
<tr>
<td>Agree</td>
<td>9</td>
<td>60.0</td>
</tr>
<tr>
<td>Total</td>
<td>15</td>
<td>100.0</td>
</tr>
</tbody>
</table>

**Tab. 5.27**: Frequency distribution results from question 2

**Results**: 40% participants strongly agree and 60% - Figure 5.10 (below)
5. Results

Fig. 5.10: All participants felt that the tool button labels were applicable

b) Descriptive Statistics

<table>
<thead>
<tr>
<th>The text labels on each tool button are appropriate</th>
<th>Obs</th>
<th>Average</th>
<th>Stand. Dev</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>15</td>
<td>1.66</td>
<td>0.48</td>
</tr>
</tbody>
</table>

Tab. 5.28: Represents the descriptive statistics of the variable

Results: The average value of text labels on each tool button are appropriate is 1.66 and its standard deviation is 0.48. The results of this questions is another clue that validate the careful design effort since all text labels in the buttons are appropriate and indicate the purpose of each one. The average of 1.66 and the standard deviation of 0.48 are a clear indicator of the good work done in the development of the prototype.
Question 3: How easy was it to use a Tool
In question 3, the users were asked if it was easy to use the tool/feature they were using and how easy was it to find a particular tool/feature they were looking for to use. The feedback to this question was further tested and the analysis was performed.

a) Frequency distribution.

<table>
<thead>
<tr>
<th></th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly Agree</td>
<td>10</td>
<td>66.7</td>
</tr>
<tr>
<td>Agree</td>
<td>4</td>
<td>26.7</td>
</tr>
<tr>
<td>Neutral</td>
<td>1</td>
<td>6.7</td>
</tr>
<tr>
<td>Total</td>
<td>15</td>
<td>100.0</td>
</tr>
</tbody>
</table>

**Tab. 5.29:** Frequency distribution results from question 3

**Results:** 66.7% participants strongly agreed, 26.7% agreed and 6.7% are neutral – Figure 5.11 (below)

**Fig. 5.11:** Majority of users felt that the purpose of each tool could be easily discerned if not obvious.
b) Descriptive Statistics

<table>
<thead>
<tr>
<th>If I don’t know what a particular tool will do, I can easily find out</th>
<th>Obs</th>
<th>Average</th>
<th>Stand. Dev</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>15</td>
<td>1.40</td>
<td>0.63</td>
</tr>
</tbody>
</table>

**Tab. 5.30:** Represents the descriptive statistics of the variable

**Results:** The average value of particular tool is 1.4 and its standard deviation is 0.63. Similar results regarding the design of the application take place here as well. The participants could understand the functionalities of the prototype application even in the first touch with the application. Some of the participants may need some extra time to get familiar with the buttons but the majority is using the features without any problem. The average of 1.4 and standard deviation of 0.63 are very convincing about a good design effort.

**Question 4: Selection of a Tool**
The feedback related to the selected tool was collected. The purpose of this questions was to observe if the user was aware of the tool and its functionality.

a) Frequency distribution.

<table>
<thead>
<tr>
<th>4) I can always tell what tool is selected at any given time</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly Agree</td>
<td>6</td>
<td>40.0</td>
</tr>
<tr>
<td>Agree</td>
<td>9</td>
<td>60.0</td>
</tr>
<tr>
<td>Total</td>
<td>15</td>
<td>100.0</td>
</tr>
</tbody>
</table>

**Tab. 5.31:** Frequency distribution results from question 4

**Results:** 40% participants strongly agreed and 60% people agree – Figure 5.12 (below)
Fig. 5.12: All users were aware of what tool they were using at any point

b) Descriptive Statistics

<table>
<thead>
<tr>
<th>I can always tell what tool is selected at any given time</th>
<th>Obs</th>
<th>Average</th>
<th>Stand. Dev</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>15</td>
<td>1.60</td>
<td>0.50</td>
</tr>
</tbody>
</table>

Tab. 5.32: Represents the descriptive statistics of the variable

Results: The average value of particular tool selection is 1.60 and its standard deviation is 0.50. One very important aspect of a prototype application design is to inform the user about the current status of the application so they can easily find the right buttons to navigate through the application. These design techniques could differentiate a good application from a bad application and not frustrate the participants trying to find their position inside the application. The average of 1.60 and the standard deviation of 0.50 are great numbers for this questions. As a matter of fact the developer could be proud of a good design effort.
5. Results

5.5 Application Module Views from Interviews

The number of participants in the study were 15. A number of suggestions were suggested by the participants during the interview. The data was collected from the participants and the recommendations were analyzed. Overall response collected and analyzed from the participants was positive. The recipe and best before date reminder features of the app were rated as the best module combination by the users. Also, the family sync and help module were appreciated by the participants. The bar chart indicates that 11 out of 15 participants (73% participants) liked your cart/expiry reminder, 12 out of 15 (80% participants) liked recipes, 10 out of 15 (66.66% participants) for the family tree and only 3 participants (20% participants) liked the help module. The participants were much interested in the combination of your cart/expiry reminder and recipe module. This does not fully satisfy RQ2 as we did not physically measure food waste within sample households. It does indicate though that the app should go some way in helping to reduce waste. Overall, the app was understandable, rated good in terms of performance and usability. The help module was not used by many participants. Based on the feedback, we may conclude that the app was easy, user-friendly and understandable by the participants that the help module was not much used.

![Fig. 5.13: Overall rating of the app module/features](image)

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2 Would an integrated recipe search engine inside the application help?
6. Discussion

6.1 Introduction

Previous works have shown that food waste can be reduced by highlighting issues to consumers. This increases both their awareness of the problem and their food literacy but it is difficult to maintain their daily enthusiasm/interest in the problem.

The FeastMe application has four main modules which we will briefly discuss in turn:

- Your Cart/Expiry reminder
- Recipe
- Family sync
- Help

6.1.1 Your Cart Module

This module was intended to be lightweight and simple for two reasons:

1. Intended primary use is in a supermarket while shopping. It therefore needs to be simple to use, potentially single handed in many case scenarios.

2. As the main data input to the application is should avoid the problems of data input fatigue [28] in order that consistently accurate data is recorded and users do not lose interest in using the application.

6.1.1.1 Module UI & UX

The module presents a simple interface with four buttons below the initially empty list of food items. Once an item is scanned it is appended to the list. Users thought it a useful improvement that the scanned in data could then be manually customized. There were no negative comments made regarding the UI or UX of this module users finding it simple and uncomplicated in use.

6.1.1.2 Future work

Despite the lack of negative comments, it was felt that the UI of this module could be improved by:

- Giving the ‘add item’ button more prominence over the others.

- Leaving the buttons in view rather than allowing the list of items to push them down off the screen necessitating a scroll/swipe to relocate them.

Regarding the UX/functionality it was felt that a quantity field for identical items with the same expiry date would be better than two duplicate listings.
6.1.2 Recipes Module

This module provides recipes tailored to the Swedish locale by way of a Google CSE. Keyword driven searches return recipes based on ingredients and/or title. Again, there were no negative comments from users.

6.1.2.1 Future work

As a proof of concept this module sufficed but for the future would be much more useful by providing results targeted at items in the household collective pantry that are nearing expiry/end of life. Thus, a user could simply select an item from the app inventory and ask for a recipe using that item. The ability to combine multiple items from the list and/or staple dry goods in the larder would also be useful. In this way the ‘Your Cart’ and Recipe modules could be closer integrated and reduce the number of user interactions needed to connect an expiring item with a suitable recipe. The Google CSE uses a custom list of websites to search, that list could be editable by users or a superuser and a possibility of exporting favourite recipes to the app Firestore (see below).

6.1.3 Family Sync Module

Previous studies have indicated that multiple occupancy households tend to waste more food that singles/couples. Accordingly, FeastMe was targeted at larger households and therefore required a means of including all household members in the app. The Family Sync Module is intended to fulfill that requirement. User feedback was that a Family Tree option should be included that would allow users to add multiple members. This was incorporated by way of a user invitation function: a QR Code would be generated and by scanning it into their own device other family members could join the group. Once joined they could view the combined family food stocks (synchronized in real time by way of the Firestore system) and thus avoid duplicate/unnecessary purchases. Members could be deleted from within the app.

6.1.3.1 Future work

See the users/superuser below.
6.1.4 Help Module

The Help Module was constructed around a list of FAQs that covered anticipated problems that users may encounter e.g. adding a new user. The FAQs are editable by the app developer only.

Once again, the test users had no negative comments to make regarding this module.

6.1.4.1 Future work

This module would benefit from further work by way of user scenarios/user testing to determine just how useful a static list of FAQs are when compared to an interactive help button within the UI screens that would supply targeted help rather than generic FAQ.

6.2 The Application Modules as a Whole

At times it was felt that the integration between the four modules could have been better – as exampled above by the recipe search and help functionality. Rather than have to traverse through the dashboard to access one module from another a ‘cross module’ linking where appropriate would hope to improve the UX.

While the user feedback (see Chapter 5) was almost entirely neutral or positive it was provided only as part of an initial investigation into the UI/UX and usability of the application with regard to food waste. The questionnaire used [1] was designed to examine the UI of the app and, in particular, the affordances [1,2] offered. It can be concluded from the positive responses that these affordances were correctly provided and that the UI was thus intuitive and simple to use. Much of the success here can be laid at the door of the Ionic framework. By providing a de facto standard set of UI components it enables the developer to quickly assemble an interface that an average smartphone user can navigate/utilise.

However the usability of the application as a whole needs to be the subject of further design iterations – it is still at a prototype stage. As such it would benefit from user scenarios, case studies and so on especially with regard to users who may not be as au fait with smartphone use as the test subjects.

Currently there is no admin/superuser built into the system. All users have the same rights and privileges and can access all areas of the application. In a production scenario this could permit misuse/abuse of the system and it would be best if a superuser group was created to handle critical operations thus protecting them from abuse.
6.3 Cross platform extensibility

As FeastMe was built using Ionic/Cordova then it can be compiled to run on any OS enabled by Cordova – chiefly Android and iOS. We have shown that the Android variation operates as designed however we were not able to repeat this for iOS. Apple have devoted much time and energy into creating a Business Ecosystem [153] for their iOS product family. Effectively this is a style of vendor lock in. They tightly control third party access to this in several ways including developer’s access to their smartphone applications. There is no ‘freemium’ or student access – all users have to pay a standard fee which, for this project, was felt to be too expensive. Thus while we cannot say with 100% certainty that the app will run on iOS we feel that this aspect of the RQ has been satisfied.

6.3.1 Data storage

Modern Cloud data storage system feature scalability and extensibility. The Google Firebase/Firestore system with NoSQL queries, JSON data transfer and Javascript based programming is a typical example. It provides a highly attractive, Freemium solution for mobile application developer. For developers without hard core coding skills Firebase/Firestore provides turnkey authorization, real time data sync and other options ‘out of the box’.

This is a major advantage for small, prototyping projects such as this one, there is a trade off in that the project data is being entrusted/shared with a third party (Google) and that may not be appropriate for larger/commercial applications if that data is personal or sensitive in nature i.e. subject to GDPR.

6.4 Recipes

It was felt that using the Google Custom Search Engine to submit a keyword search to a preset list of recipe websites worked as a proof of concept. The results were displayed to the user in an unsorted order within the application. This would reduce waste by providing recipe suggestions including the items most likely to perish.

As it stands this functionality is a bit of a blunt instrument requiring a lot of user interaction to obtain results of varying relevancy. A smoother UX could be obtained by using a premium recipe API such as Spoonacular [154] that is accessed directly from the Your Cart listing by highlighting one, or more, ingredients.
6.5 Overall project management

As it stands this project was a solo effort. This meant that there was insufficient time to progress the front end app design beyond an Alpha prototype if the earlier paper prototype/UI/UX development were not to be skipped and the backend code developed to a workable state. This also meant keeping the number of participants in the user studies down to a maximum of fifteen. We were also aware that by recruiting the users from within the peer group an Lineaus University we were possibly biasing the group towards a more technologically able demographic than general society (i.e. a preponderance of Rogers’ ‘Early Adopters’ [155] and Parasuraman’s ‘Explorers and Pioneers’.) This was exempled by the double mention in the questionnaire responses of utilizing RFID tags as part of the project. To a member of the technocrati these would appear eminently suitable for inclusion – however RFID use was already previously identified as a de-motivator within the ZmartFRI study [25]. A non-technical user would be unlikely to be aware of RFID and its uses so would not suggest it.

6.6 Answering the Research Questions

This section will examine the three RQs presented in Chapter 1.5 and discuss how well they were answered drawing on the subsequent Chapters.

6.6.1 RQ1: Could a smart(er) best before managing and notification system help to reduce food waste?

Food waste is a truly international problem and, in wealthy area like Western Europe over a third of the total comes from the end consumer. Previous works in this field have already shown that this consumer food waste can be reduced by way of targeted food management and education initiatives (see Chapter 2). These studies often found that well-meaning and carefully thought out ideas failed to deliver the expected results after use by the intended user groups. This was often due to users becoming fatigued/bored of inputting and/or recording data. Reducing this data fatigue would, therefore, help reduce food waste. ‘Smartening up’ data handling by combining the nowadays ubiquitous smartphone with the also ubiquitous product barcoding would serve that purpose. Shoppers who already scan in their grocery shopping could now, simultaneously, update their household inventory with zero extra effort.

This study did not progress to real time/field trials of the original prototype therefore we cannot define an answer to RQ1 in terms of the physical amounts of food waste saved. However, we can examine the responses from the users to using the prototypes (Chapter 5). Responses varied from neutral to highly positive with no negatives – users found the app simple and easy to use. From this we can infer a positive answer to RQ1: the easy app reduces data input fatigue which keeps users motivated to utilize a household food management system of the type which has been previously proven to cut domestic food waste.
6.6.2 RQ2: Would an integrated recipe search engine inside the application help?

A recipe suggestion engine based on products included in the household inventory was built into the app. This would provide recipe suggestions based on the ingredients known to be in the house. By targeting those perishable foodstuffs nearest their ‘best before’ dates this would reduce their wastage. A by-product of this would be to improve the food literacy of household members by providing dietary information for both their favorite and newly suggested dishes.

Again, as there was no field study of the full application, we have to infer the answer to RQ2 from our user’s comments and answers. These were in the positive so we would suggest that yes, the recipe module would help reduce household food waste but a truly positive answer to RQ2 would be dependent on further studies.

6.6.3 RQ3: The purchase of duplicate and/or excessive foodstuffs lead to waste. Most families already have a shopping strategy with shared shopping list. Could this be enhanced and extended into a multiple occupancy household by way of a sharing and synchronizing application?

RQ3 is the extension of RQ1 from a nuclear or extended (multi-generational) family household into a less formal, multi-occupancy one as may be found in the typical shared student house. Such mixed households have a higher proportion of food waste than the norm [84]. Previous studies had also shown that people are reluctant to consume food provided by an unfamiliar third party and that this reluctance extended into student households [24]. By using our app to produce the Lim’s Social Recipes [77] as well as synchronize food purchasing/consumption it was hoped to break down this reluctance/save food.

Again whether we have satisfied this RQ has to be defined in terms of the user responses rather than based on any physical, measurable, real-time studies. If, as with RQ1, we accept the favorable responses to the questionnaires (Chapter 5) as giving a positive answer then we are not taking into account the physical reality of sharing foodstuffs across a relatively unfamiliar household. The uncomfortable feelings that this can evoke are only uncovered by questioning users during, and after actual sharing. Farr-Wharton found that even in an enlightened, post graduate student household/work environment such feelings still arose [84].

We can only suggest then that RQ3 cannot fully be answered without a proper field trial. Yes, our synchronized, central inventory can be used by any household but, in the case of multi-occupancy ones we cannot reliably predict if it will reduce food waste without further study.
7. Summary

7.1 Conclusion

Food waste has become one of the most talked and researched topics in the world. The environmental and economic results are many on top of the stark fact that while we waste food in Europe, people in other countries go hungry. In general the wealthier the greater the GDP of a country, the higher the consumer food waste rates are – and consumers account for around a third of all food loss from field to plate.

The common causes of food waste at consumer levels are:

- Lack of appropriate food planning.
- Purchase and preparation of too much food.
- Over preparation of food in a restaurant.
- Consumer behaviours.
- Not being aware of the best before the date of the products present in the fridge/ stored area.
- Not aware of the usage of the product purchased on how to use it.

During the course of this research in this thesis, an application was designed to challenge the problem at the consumer level. The central goal of this project was to create a solution that minimizes food waste within multiple occupancy households by applying digital technology at the foodstuffs POS to create a common household food listing and then to remind/notify and suggest recipes for the products.

A number of supermarkets now offer a BYOD/self scanning mobile app that allow shoppers to barcode scan their groceries into their baskets and then check out at the POS with no staff input. Previous scientific studies into applying IT to consumer food waste have identified user data input fatigue as a major demotivator for users.

A novel aspect of this study is to duplicate the existing POS data in the users’ app into the household central foodstuffs datastore thus avoiding the data input bottleneck of previous works.

7.1.1 The FeastMe Application Approach

FeastMe presents as a typical Cloud/web based mobile application. There is an ‘app’ for the user that fronts a data transfer/distribution system for a scalable Cloud datastore. For the development of this user app, our initial ideas were discussed with potential users. Functional and non-functional requirements were then drawn up. A simple interaction design cycle was then followed. An iterative prototyping of the app and its UI was undertaken.
A paper prototype was designed and presented to the user. The users evaluated the prototype and suggested further changes to the application. An improved version of the paper prototype with new requirements from users was re-designed at this stage. A questionnaire was designed, and the application-related questions were asked. Survey participants suggested requirements such as not too many notifications, pop-ups, reminders, the right to select items to notify users, and date and time reminders.

Most importantly, the application UI needed to be user-friendly, and the application needs to protect the user’s personal information and make its security reliable. The requirements gathered during the interview were tested many times with the participants.

Based on the paper prototype, the app conceptual design was accomplished and the application was developed on the Ionic framework. AngularJS is used for application front-end development platforms. The backend was developed using Typescript and the application database was Firebase.

The app features include: users can scan products, add them to the cart, set reminders for purchased items, search for recipes (Swedish only), and add families members in the FeastMe app. When a product is scanned, the user can set an alarm and notification pop-up on the screen at a specific date/time. The survey asked users for their opinions on application usability, performance, and functionality. According to user reviews, this application is very easy to use and user-friendly. In particular, the recipe module is a unique feature and has been favoured by users (recipe search by ingredient and recipe name). Family sync was also popular among many users. Users also shared their views on the notification feature (the best before date reminder), combined with the app’s recipe feature can be very helpful in reducing food waste at the home level. Also, looking at the statistics of food wasted every year around the world, which is increasing over time, users rated the app as a good initiative to reduce food waste and improve health.

7.2 Limitations

There are certain limitations in this study. Primarily the inability to link the ICA BYOD shopping app data into the project. Subject to the appropriate data security checks this would not be a major problem for a commercial version of this project.

Due to the legal limitations of GS1, GS1 Databar could not be used for this application. Also - due to Ionic framework limitations, scanning of GS1 are not supported. If this application is developed at a professional level, then a native application i.e. compatible with the GS1 Databar is required if Ionic is to be the framework. Therefore the data matrix code, which does not require legal permissions was used for prototype demo purposes only. Within the project it was felt that there has to be more testing and more validation of the app itself. For this purpose, there is a need of the more participants to involve in the interviews and give their generalized feedbacks. In particular whether the app overcomes the data input fatigue problems found in earlier studies. The survey was more focused on the usability aspects of the best before date reminder and recipe search and there is a need to attain more qualitative information for evaluating cognitive aspects.
7.3 Future Work

Much of the detailed future work required in respect of the mobile app has been mentioned in Chapter 6. The daily advances in consumer technology need to be taken into account for updated versions of the application – for example during the writing up of the thesis the Spoonacular Recipe API has become available with a ‘Nordic’ recipe feed – that could replace the Google CSE part of the study with an easier to integrate, multi-ethnic REST API. The data security within the application needs to be addressed – currently there is no admin/superuser group which allows all users to access all aspects of the application. Personal data held needs to be inline with the GDPR and any full integration with the supermarkets’ POS systems would likewise need scrutiny. while the project has identified the ICA supermarket chain as an individual candidate for the prototype, integration with other retailers would be a useful addition. This could then permit a price comparison feature by interrogating multiple retailer’s APIs in real time. The recipe module itself could be the major ‘hook’ to keep users interested in the application. Abdiu [107] found that users were interested in seeing the financial implications of their food wastage. Adding this plus other ethnic recipe types, dietary preferences/allergies, calorie counting, portion costing and favorite meals could make FeastMe more enticing and increase/maintain user interaction. However these should not be added at the expense of keeping the app lightweight and easy to use in order that users do not lose their motivation through over complication of the app/interface.
References


[63] FAO. Food wastage footprint: Impacts on natural resources. FAO; 2013


[96] Pujol N. Freemium: attributes of an emerging business model. Available at SSRN 1718663 2010


Appendix A

a) Prototype Review Questionnaire

Page 1 Ethical Statement

Ethical statement

PURPOSE
The purpose of this research is to obtain user feedback on the prototype mobile application.

PROCEDURES
If you decide to be in this study, your part will involve answering one set of questions about your experience with the prototype mobile application.

RISKS / DISCOMFORTS
There are no foreseeable risks or discomforts associated with your participation in this study.

CONFIDENTIALITY
All the information we get from you will be not be linked to you at all. We do not ask for any personal information.

COSTS TO YOU
There are no foreseeable costs for you to participate in this study.

ALTERNATIVES
Your alternative if being in this study is to simply not participate.

YOUR RIGHTS AS A RESEARCH SUBJECT
Your participation in this study is voluntary. You do not have to be in this study if you don't want to be. You have the right to change your mind and leave the study at any time without giving any reason, and without penalty.

QUESTIONS ABOUT THE STUDY OR YOUR RIGHTS AS A RESEARCH SUBJECT
If you have any questions, concerns, or complaints about the study, you may contact:
Benish Fatima – ntf222cy@student.imu.se

If you agree to these terms please continue with the study. This means that you have read the information given in this consent form, and you would like to be a volunteer in this study. If you do not agree with the terms then please close the browser window.
### Section 1: Interface Design Characteristics

Please rate the characteristics of the prototype interface on the left with the appropriate scale to the right. Where:

1=Strongly agree, 2=Agree, 3=Neither Agree Nor Disagree, 4=Disagree, 5=Strongly Disagree

<table>
<thead>
<tr>
<th>Question</th>
<th>Scale</th>
<th>Strongly Agree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. User has good control of interface</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Common words are used that are understandable</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. It is easy to navigate around</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. The layout is user friendly</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Information is presented in logical order without surprises</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Is the app easy to navigate?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. The speed of response to actions performed is appropriate</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Did you have trouble finding a specific feature?</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Section #2  Short Answer Questions

1) What is your overall impression of the prototype design, information content, and performance? *

Short answer: text

2) Are the prototype tools user-friendly? *

Short answer: text

3) Please provide any additional comments. Was there anything on your mind while working with the prototype or through this questionnaire that you have not communicated? *

Short answer: text

4) Was anything obvious lacking or missing? *

Short answer: text
Section #3 Prototype Tools

Please rate the characteristics of the prototype interface on the left with the appropriate scale to the right. Where:
1-Strongly agree;  2- Agree;  3-Neither Agree Nor Disagree;  4- Disagree;  5-Strongly Disagree

1) It is easy to understand what action each tool will perform: *

   1 2 3 4 5

   Strongly Agree  |  |  |  |  |  | Strongly Disagree

2) The text labels on each tool button are appropriate: *

   1 2 3 4 5

   Strongly Agree  |  |  |  |  |  | Strongly Disagree

3) If I don’t know what a particular tool will do, I can easily find out: *

   1 2 3 4 5

   Strongly Agree  |  |  |  |  |  | Strongly Disagree

4) I can always tell what tool is selected at any given time: *

   1 2 3 4 5

   Strongly Agree  |  |  |  |  |  | Strongly Disagree
Thank You

Thank you for taking part in the study. This research is part of Master’s Thesis, Social Media and Web Technologies, Master Program at Linnaeus University, Sweden.

The purpose of this research is to analyse to what extend would this mobile application (prototype) be helpful in reducing food wastage at home.
Appendix B

b) Project Briefing

Research briefing

Introduction

The aim of this research is to provide a solution that would be helpful to reduce food wastage at user-end (household level) with the use of digital technologies (smartphones).

Scenario

A customer uses a self-service app to ease his/her shopping experience. Once the shopping is completed and the user checkout, the shopping cart in the app usually become empty with no data. Assuming, that the purchased items are still in the app cart even after checkout and the app has the best before date of all the food items that are purchased.

Your Task

You and your household members are responsible for the monthly grocery shopping. Assuming you are already users of a hassle free self-scanning shopping application. We now ask to use a new Feastme mobile application (which is android based). The purpose of this app is to analyze to what extend would this mobile application be helpful in reducing food wastage at home. Barcodes of certain items are provided for testing purposes. First step would be to sign up and then scan the barcodes assuming that these are actually placed on the items you are about to purchase. The rest is for you to test and explore. Please provide your feedback for the application by filling questionnaire in the link provided.

https://docs.google.com/forms/d/1xnPAfB6mUjCDRNVrRb2PkJMUzeACOUFY_hxcn7V1ogak/edit
Appendix C

c) Open Ended Interview Questions

Feastme app—Interview Session

Open-Ended Task: Please spend 5 minutes exploring the app like you normally would.

1. What would you expect to be able to do with this app?
2. What do you think of this app?
3. List out 3 things you dislike and like about the app
4. What feature in the app might keep people from using this app?
5. How would you describe the product in your own words?
6. Can you see yourself ever using this product?
7. Can you think of any other product that resembles this one?
Appendix D

d) FeastMe.apk File and Demo Barcode Links

- FeastMe.apk File link:
  https://drive.google.com/file/d/1hAaHP6FjPVxYu_gYEt_
  uLFCSEEIT_BJe/view?usp=drivesdk

- Demo Barcode link:
  https://drive.google.com/file/d/1vMOiQBr7Wv54beKvF7Jt7EMPf4HMAbFM
  /view?usp=drivesdk
e) XSS Error