Mobile Technologies Supporting Corporate Loyalty Schemes

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Declaration

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Signed:

Abstract

I'll put my abstract here someday...

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Acknowledgements

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Chapter 1

Introduction

1.1 Problem Statement and Motivation

Incentives are powerful tools long employed to encourage certain behaviours. In the context of a business, several implementation options are available, such as posters, emails, websites, employee workshops, and campaigns; but another commonly adopted method is that of a loyalty scheme. Loyalty applications available range from the basic stamp/sticker book, to the more modern smartcards (Fig. 1.1).

Commonly, simple paper-based systems are adopted by businesses due to low cost and implementation times; nonetheless systems like these have several issues

1. Some individuals may lose their stamp cards
2. There is an environmental impact associated with constantly printing stamp cards
3. Paper-based systems are not very secure and open to abuse

An opportunity exists for a general-purpose system to encompass loyalty programs via use of up-and-coming Near-Field Communication (NFC) technologies that are integrated inside modern smart phones. Moreover, elements of 'gamification' can be added as an extra dimension of loyalty to corporate persuasive technologies. (e.g. unlocking badges as they claim rewards, essentially playing versus themselves)

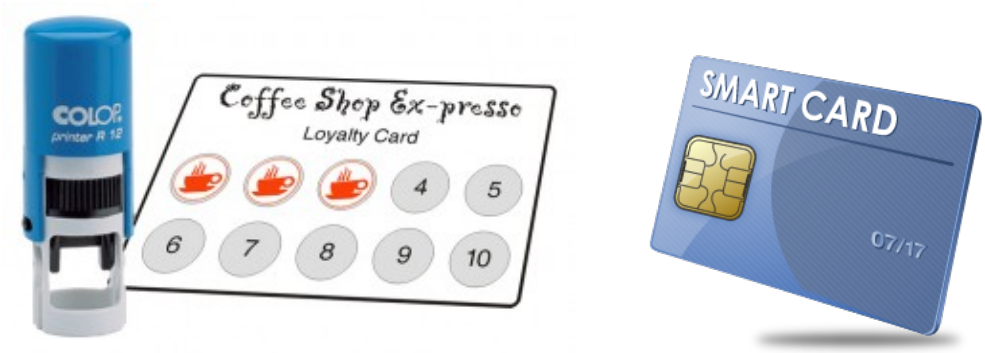

Figure 1.1: A paper stamp card & smart card

1.2 Rationale

The smartphone is now a staple item which many people cannot leave their home without. As of 2014, there is a worldwide user-base of approximately 1.75 billion smartphone devices [1]. Migration to phones allow the business to have a central hub of all of their loyalty schemes, eradicating the need for paper. This means that issues relating to paper-based systems, such as printing paper (environmental impact) and people losing their stampcards are no longer an issue. Moreover, businesses will now have the option to track use and monitor their schemes for further analysis. This grants them insight into how many users they have, allowing them to adjust loyalty schemes appropriately.

On the other hand the proposed solution is not without some problems of its own. For instance, not everybody owns a smartphone, so hybrid smartphone/paper solutions will need to be considered. Additionally, there exists specific disadvantages of smartphones, such as dependence on battery life and an internet connection.

1.3 Aim

The aim of this project is to develop a general purpose solution using a smartphone that supports businesses in creating, managing and deploying a simple loyalty scheme - using gamification elements to engage the users. The specific technology chosen is NFC in phones running the Android operating system.

1.4 Objectives

- Research the state-of-art surrounding NFC technology within loyalty and gamification systems
- Examine and analyse the current smartphone solutions available to manage loyalty systems
- Design and implement our solution
- Perform a field study with the system as an evaluation
- Look into the future possibilities of the system and the infrastructural requirements to support its use in a real-world environment

1.5 Deliverables

The primary deliverables we perceive for this project are two Android applications. A ‘Loyalty Stampbook’ application for consumers to collect, manage and use their loyalty

schemes – along with a 'Loyalty Manager' for businesses/employees to distribute 'stamps' to customers via NFC.

1.6 Significance & Contributions

NFC is a topic rising in popularity. Many new mobile smartphones now have a chip for NFC communication and many businesses are moving their 'card' based services onto smartphones. As such, it is beneficial to explore the possibilities of transferring traditional loyalty cards into the digital era.

Our solution provides a unique paper-less way for businesses to disseminate a loyalty scheme. We attempt to alleviate much of the hassle and cost to businesses with regards to implement

Moreover, we aimed to keep the solution very generic as to allow an element of branding and customisability, as well as using open protocols to extend the system to other mobile operating systems.

1.6.1 Similar Developments

There exist some similar mobile-based solutions to the one proposed, such as Apple's *PassBook*. Passbook is an iOS exclusive application that allows users to save their generic cards (i.e. boarding passes, event tickets, loyalty cards etc.) Though also a general purpose solution, there is a distinction on the technologies used (QR/Barcode Scanning) and the interactions presented to the users - For example, Passbook entails the one-way interaction of simply scanning barcodes. By adopting the two-way possibilities provided by NFC, richer interactions can be built and allow inter-communication between devices.

Other loyalty applications also exist, some using some combination of NFC or gamification elements; nonetheless they are specific to their associated brand. Starbucks' application on iOS is one such example (Fig. 1.2), offering users a digital QR version of their Starbucks card (Fig. 1.2c) and a medium to collect rewards in the form of stars. These stars, along with the account balance can be used to claim rewards and beverages. The opportunity of our proposed solution is to make an encompassing general-purpose solution that any business, big or small, can use to simply implement a loyalty program.

In the literature survey we shall cover primary technologies and research that enable these developments, along with confirming the need for a general-purpose solution.

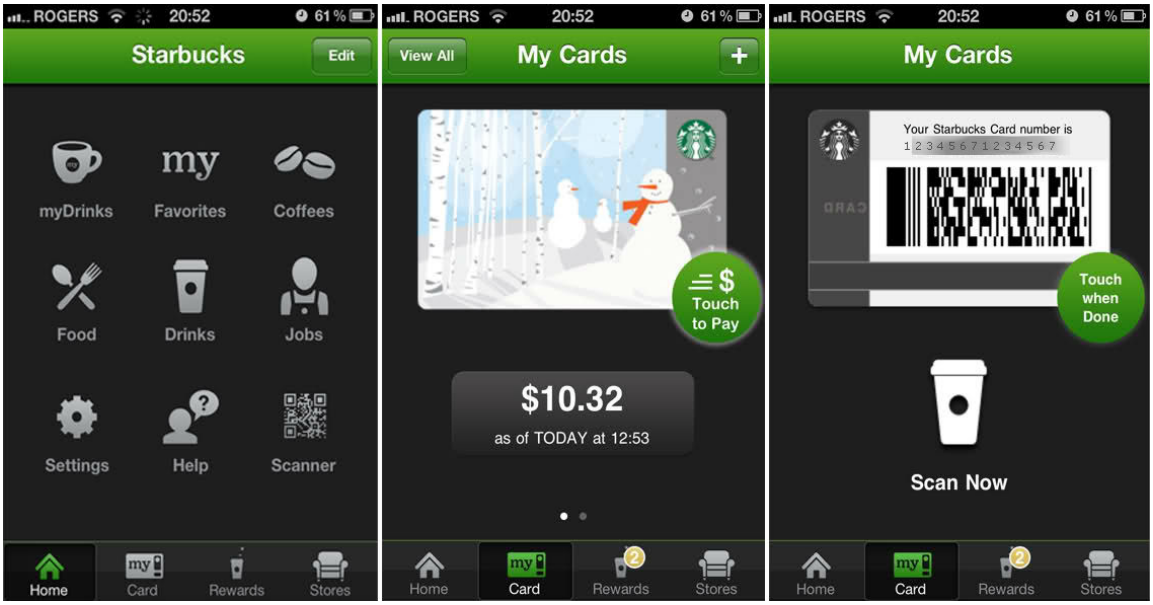

Figure 1.2: Starbucks application for iOS6 (a) The menu of the Starbucks app (b) The card and available balance (c) The bar-code presented to the baristas to scan

1.7 Resources Required

1.7.1 Technologies

Android Platform

Android is a smartphone operating system developed by Google. Along with Windows Mobile OS and Apple's iOS, these three operating systems are the biggest players in the global smartphone market. Android was selected for our system was most devices are equipped with an NFC chip and have well supported APIs regarding Host Card Emulation (See 1.7.1). With the introduction of iOS8, Apple now has support for NFC payments that work with the new iPhone 6; however APIs are unavailable to developers at this time and as a result, cannot be used. Windows Phone has similar NFC libraries to Android, but was not chosen due to it's low market share (2.5% as a pose to Android's 84.7%)[2].

Android SDK

The Android Software Development Kit (SDK) Will be required to develop, implement and test the Android applications. There are several methods that can be chosen regarding Android application development without having to use Google's JAVA SDK. Unfortunately, due to the specific dependencies on Google's NFC APIs, development will need to be done using the JAVA SDK.

Host Card Emulation (HCE)

NFC chips can be placed into Card Emulation mode in such a way (ISO 14443) that a reader classifies it in the same manner as a smartcard.[3]. Implementation of the system is dependent on use of this NFC facet. *Android 4.4 Kitkat* and above support this mode within the APIs.

1.7.2 Android Devices

For most cases of Android development, the bundled emulator with Google's Android SDK is sufficient; however due to the project's dependence on the NFC chip, at least two physical (preferably differently branded) devices need to be used. One will be running the Loyalty Manager, whilst others will be running our Loyalty Stampbook. Both devices must at least have the *Kitkat 4.4* iteration of Android in order to use Host Card Emulation.

1.8 Dissertation Overview

The rest of the dissertation is presented in the following chapters:

Chapter 2 *Literature & Technical Survey* – Here we will introduce the research topics of 'NFC', 'gamification' and 'persuasive technologies' and review their applications to the world of mobile applications.

Chapter 3 *Requirements & Design* – Divulges the process of outlining the design of the system.

Chapter 4 *Implementation* – A detail account of the system was built, along with the novel challenges presented.

Chapter 5 *Evaluation* – A field study with users in a natural environment. We attempt to gather quantitative and qualitative feedback, whilst trying to quantify the impact of gamification within the system.

Chapter 6 *Discussion*

Chapter 7 *Conclusions & Future Work* – A closing discussion for our system and the vision for the future.

Chapter 2

Literature & Technical Survey

2.1 Introduction

This chapter will explore the state-of-the-art surrounding near field communication, gamification and persuasive technologies, along with some current solutions implemented by the industry.

It is anticipated that the main deliverable for this dissertation would be two Android mobile applications to facilitate the creation, deployment and management of a Loyalty Scheme. As such, we will need to discuss the pressing research, benefits and issues that encompass creation of 'sticky' technologies on mobile platforms.

2.2 Near Field Communication (NFC)

Near Field Communication (NFC) is an up-and-coming wireless technology that is currently being adopted in many contexts. Using this proximity-based standard, Two individuals can share data by placing NFC-enabled devices within a few inches of eachother.(see example in Figure 1.1). The standard was first established by Nokia, Philips and Sony in 2004 to define next generation radio frequency communications [4].

Figure 2.1: Using the smartphones NFC chip with a VISA application on a wireless card reader as a form of contactless payment

2.2.1 Technical Fidelity of NFC

NFC is a close relative to Radio Frequency Identification (RFID), using the 13.56 MHz radio frequencies under 424Kbit/s bandwidth [5]; however it operates at a far shorter range (10cm versus 100m). As with RFID, there are two types of NFC devices - powered and unpowered. Powered devices surround themselves with an ultra-low power electrical field, inducing electric potential to other NFC devices within range; whereas unpowered devices (also known as "tags"), rely on this electric potential from powered devices as a power source during the interaction.

NFC devices can adopt several different modes for different interactions [6]

Tag Reading/Writing A powered NFC device in this mode can read and write information stored in tags. Websites, contacts and telephone numbers are commonly encoded in this manner. Upon reading the tag, it is the software's responsibility to act on the data in an appropriate manner [3]

Host Card Emulation NFC chips can be placed into Card Emulation mode in such a way (ISO 14443) [7] that a card reader classifies it in the same manner as a smartcard. NFC devices can keep different cards in storage and switch between emulating them as required. [3]

Peer-to-Peer Two powered NFC devices can bidirectionally share information between each other - for instance Bluetooth pairing information. [3]. In the case of a business environment, authentication can take place between two devices in the same bidirectional manner [8] as a form of 'secure log-in'.

2.2.2 NFC as an Interaction

lorem ipsum

2.2.3 Applications of NFC

Wireless communication technologies such as NFC have been around for some time. Many electrical devices with the capacity to communicate already use Wi-Fi, Infrared or Bluetooth; eventually these technologies make their way into modern smartphones and other domestic devices. Due to the openness of the NFC standard, there are a wide plethora of implementations facilitated by the technology:

• **Contactless Payment/Mobile Wallet** Starting from 2005, banks began integrating contactless chips inside debit/cards for payments under 20 USD/GBP (provided that the card reader supported contactless). From 2011, several large players such as Google, Apple and Paypal have developed mobile wallet applications, with Google and Apple primarily supporting NFC. Contactless cards too rely on the (ISO 14443) [7] smartcard standard, complementing the previously discussed host card emulation, allowing an NFC chip to emulate an identical smartcard. Whereas, contactless debit and credit cards are prevalent, Google Wallet and Apple Pay are not available outside of the US Market, reasonings being ill-documented.

• **Ticketing** Contactless ticketing has been available for a while, the Oyster card[9] being an iconic example; nonetheless it has the issue of being a proprietary, locked down technology. In 2014, contactless cards were enabled within the system. Some argue that the goal of removing cash-payments was a driving factor of the acceptance of contactless ticketing [9]. Moreover, Host Card Emulation infers that mobile wallet applications would also be able to take advantage of these readers.

• **Gaming** Game designers have always looked for ways to make video games more engaging. There are two methods in which they can implement NFC within their games, with the intent to make **Pervasive Games**. Such games expanding the play space into the player's ordinary social life [10]. Firstly, they may may use NFC to enrich collaboration and sociability. As an example, a study was done with two identical games, one with NFC and the other without[11]. Experiments were ran with two groups of individuals and findings showed a sharp increase in positive experience for NFC over touchscreen [11]

The second and more recent way NFC can be implemented in video games is through physical-digital mappings. The *Wii U* [12] video game console contains an NFC chip in the controller, allowing users to use NFC enabled figurines on the controller. The result of tapping these devices together makes figurines appear within the console as in-game characters.

• **Loyalty Schemes** Loyalty using NFC is a topic that is still being explored by industry. As such, there are some different and creative implementations available. The original NFC Loyalty solutions came in the form of staff/store cards; however with the advent of NFC in

mobile phones, pervasive solutions have been implemented such as *Orange EAT* [13]. In this scheme, consumers can tap specific NFC posters and tags in order to gain free rewards in the form of food and drink [14]. Unfortuantely this promotion was unsuccessful as at the time only 200,000 customers had an NFC enabled device on Orange (less than 1% of the total customer base) [14]. There are several other prototype solutions available; nonetheless they were not properly adopted as NFC was not available on enough phones.

2.2.4 NFC in Phones

NFC functionality in phones is actually not a new concept; phones with NFC chips have been around since 2006, but the adoption of NFC with manufacturers did not get popular until 2010 when a set of peer-peer standards were released to transfer useful information (contacts, URLs and bluetooth) [8]. Since then, popularity took off, with IHS[1] predicting that 939 million NFC enabled handsets would be shipped in 2018 (Fig. 2.2) [15].

World Shipments of NFC-enabled Cellular Handsets

	2013	2014	2015	2016	2017
Millions of Handsets Shipped	275	416	575	797	939

Source: IHS Inc., February 2014

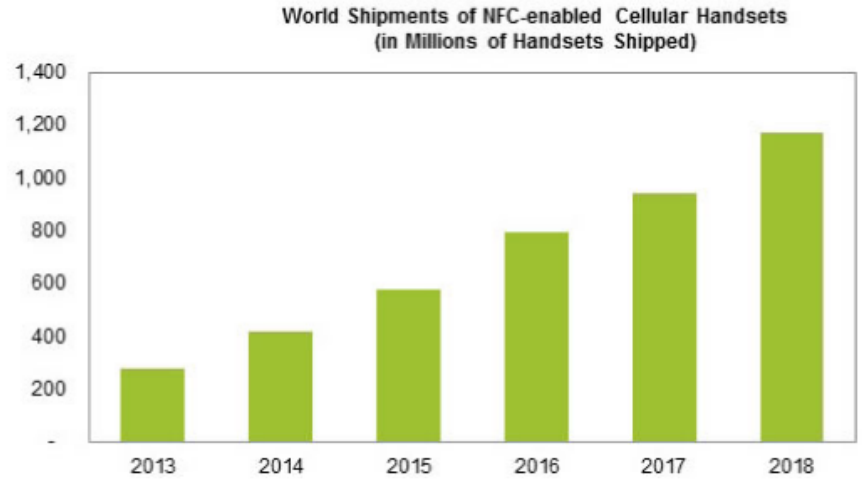

Figure 2.2: A chart depicting the predictions of mobile phones shipments that have NFC built-in

Interestingly, of all the applications mentioned in the above section, **all** of them have been implemented both with and without mobile phones. The advantage of using the mobile phone is that it has the capability to consolidate a potentially infinite amount of NFC cards, tags etc into just one chip.

Software support for NFC is something that must be accompanied with hardware. Android and Symbian implemented software support in 2011, Microsoft in 2012 and Apple in 2014. The fact that these implementations are very recent can be attributed to the rising popularity of NFC.

[1] IHS inc is a data and critical information provider for the technology industry

2.2.5 Areas of Research

In 2010 a survey was done of academic papers surrounding NFC [16]. The authors gathered a total of 74 research papers and used content-oriented classification [17] in order to split up NFC papers into four categories: NFC Theory, NFC Applications, NFC Infrastructure and NFC Ecosystem. The results of their findings are shown in table 2.1.

Classification	Description	Number of Papers	Percentage
NFC theory and development	The concepts and developments of NFC, along with future recommendations and ethics	15	**20.3%**
NFC Applications and Services Reader-Writer Mode Applications Host Card Emulation Applications Peer-to-Peer Applications	Discussing or developing different implementations of NFC applications and services based of NFC modes	30	**40.5%** 25.7% 13.5% 1.35%
NFC Infrastructure	Types of NFC technologies and their applications in the real world, also security and privacy	22	**29.7%**
NFC Ecosystem	frameworks for businesses that want to integrate NFC culture & models and strategies into their processes	7	**9.5%**

Table 2.1: Table showing the primary categories of NFC research

It can be observed that a huge proportion of NFC literature (40%) at the time was heavily focused on developing prototype applications and services. However, the specific types of applications were primarily 'Reader-Writer' mode as this was just before the introduction of NFC peer-to-peer standards.

The research identified that there was a gap in researching the development of NFC principles and theories or how to integrate such solutions into business models. As a result, we can argue that this business-orientated business gap was a factor for the slow adoption of NFC.

2.2.6 Limitations of NFC

The key limiting factor of NFC for the longest time was the slow adoption rate by businesses and manufacturers. Contactless payment, the predominate form of NFC interaction depended on specific NFC card readers to enable contactless functionality; furthermore we cannot underestimate the amount of effort it takes to introduce a new billing option to a country.

Analytics also show that NFC implementations are very fragmented with no apparent standard protocols [18]. This can be attributed to two reasons: the openness of the NFC platform encouraging different implementations and businesses wanting their own implementation for their own needs. For instance, in the example of loyalty schemes, each business might have a separate loyalty application which the customer needs to download and setup. These applications allow businesses to perform their own tracking and branding.

2.2.7 QR and NFC

2.3 Gamification

Over the years, a keen topic of research within Human Computer Interaction is that of user engagement. There are several different design models that afford this goal. One recent and popular example being gamification.

Gamification can be best described as

> "An informal umbrella term for the use of video game elements in non-gaming systems to improve user experience (UX) and user engagement." [19, p. 2425]

The need for gamification comes from the modern zeitgeist of the digital world, a world of engagement. Comparing the current opportunities for entertainment (i.e. video games, social media, the internet) to those from fifty years ago, provide users with much more choice. Furthermore, users are no longer registering traditional advertising in the same way they did fifty years ago. A study done with university students using eye-tracking technology with *Facebook* shows that students perceive less than a quarter of the site's adverts [20]. Experimenters concluded that this was due to users scrolling the timeline too quickly and learning where advertisements appear, therefore ignoring those areas.

By harnessing the power of play, designers can apply motivational affordances to improve user engagement. Gamification techniques are predicted as the future of marketing [6], with Gartner[2] stating that 50% of companies with innovation processes will incorporate gamification by 2015 [21].

2.3.1 History

The principles of "turning things into games" are actually not new. They have long been employed by parents and teachers to make activities seem more enticing to children; however applying game-like aspects to a business environment was only formally introduced in the 80's [22]. The word *Gamification* was coined in 2002 by Nick Pelling, an early computer games programmer that wanted to apply game-mechanics to different contexts [23]. Recently, gamification has become a buzzword amongst modern system designers. The rise in popularity can be shown in a Google Trends search (Fig. 2.3). This boom can be attributed to soaring video game popularity and cheap enabling technologies found in modern domestic appliances (i.e GPS, Internet Access, Bluetooth etc.) [24]

[2]Gartner is an IT research and advisory business

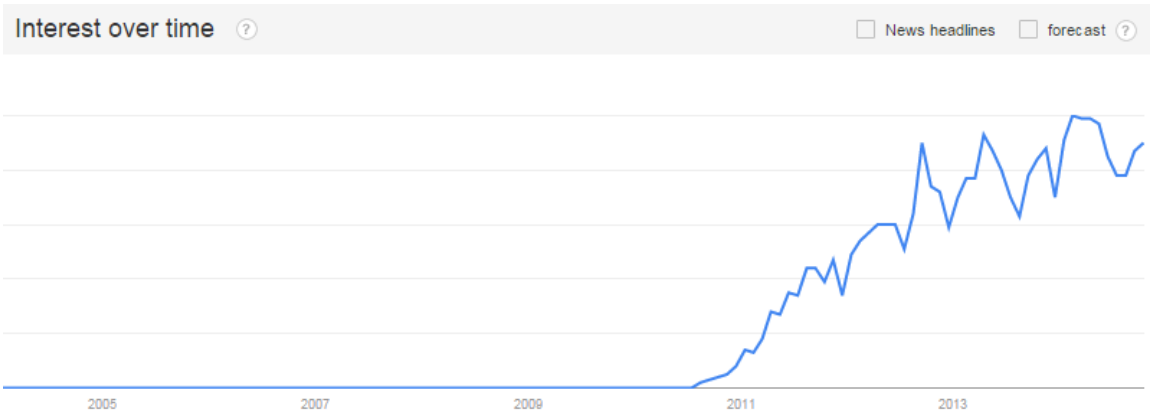

Figure 2.3: Google Trends graph depicting the search popularity of the term **Gamification** over the years

The use of gamification has also shifted over the years. Many reseachers [25][26] consider Charles Coonradt as pioneer in the field of gamification. In his acclaimed book *The Game Of Work* [22], Coonradt introduces "game-like concepts" inspired from sports as a means to increase employee productivity, satisfaction and motivation [22]. On the other hand, gamification in the digital age takes inspiration from video games to to improve user experience, engagement and loyalty. [6]

It can be argued that the two inspirations (sports vs. video games) present us with different flavours of gamification. Games of sport entail clear goals, instantaneous feedback, and the concept of striving to be better. Video games aim to keep players playing by providing psychological rewards such as achievements, unlocks and ability to compare their skill with their friends. Even though these two methods of gamification have some differences, their main shared trait lies in the way they play on our natural instinct of socialisation and competition. [27]

2.3.2 Gamification and Mobile Technologies

Although elements of gamification can be found in a variety of systems, mobile technologies have seen biggest boom in gamified systems. As mentioned earlier, a major contributer to this boom is the prevalence of cheap enabling technologies such as bluetooth, and GPS - all of which can be found on a modern smartphone. In 2009, Foursquare was one of the first successful gamified mobile applications; allowing users to "check-in", collect badges and receive recommendations on where to go next [28]. Five years later, Gartner predict that 70% of the top 2000 companies would have a gamified application by the end of 2014. [29]

2.3.3 Areas of Research

Areas of research of gamifcation using certain elements...

2.3.4 Critiques of Gamification

The application of gamification practises to digital applications is prevalent amongst business applications [29], nonetheless these practises have attracted criticisms. One view adopted by the video games industry is that gamification mistakenly portrays "game-like" properties, such as levels and scores as part of human behavioural complexity. [30]. Moreover, there are negative "exploitative" connotations (discussed later) to word gamification in the business world; therefore businesses generally prefer the term "motivational design" instead.

The concept of creating "sticky" systems via gamification techniques can also present us with systems that affect user behaviour negatively. The McDonalds Monopoly sweep-stake is a well known example of this phenomenon. The promotion involves the collection of monopoly stickers containing prizes from purchasing certain food and drink (more stickers with larger meals). Paxman et al [31] introduce examples where consumers change their purchasing habits in order to maximise the number of stickers they receive, linking these changes to childhood obesity [31]. Several theories of motivation exist explaining these behaviours; however Zichermann [28] considers motivational factors as unruly, yet admits "once you start giving someone a reward, you have to keep [them] in that reward loop forever" [28, p. 27].

2.4 Persuasive Technologies/Captology

Capturing the attention of an person for the purposes of persuading them is a problem that sympathises with many. Businessmen, politicians and teachers alike are examples of such professions - more specifically professions where persuasion is an integral factor of their success. There exist a plethora of methods to achieve this, for instance salesman study marketing, politicians study public speaking, whilst those in the realm of technology study captology (the art of persuasive technologies).

We can define 'persuasive technologies' as:

> Solutions which are designed with a purpose to change attitudes or behaviours via persuasion and social influence, but not through coercion [32][p.10]

Fogg, considered by many [33][34] as a pioneer in the research of captology, identifies the art as an intersection between technology and persuasion (Fig. 2.4).

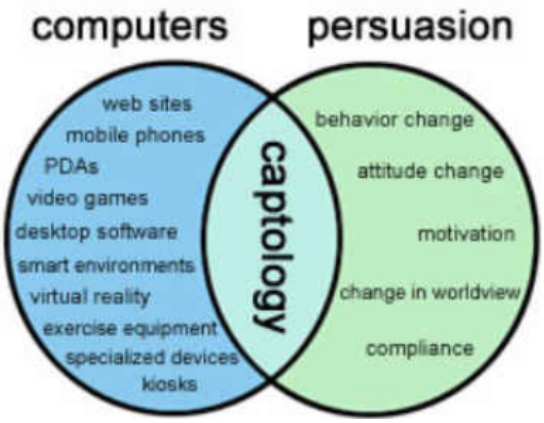

Figure 2.4: A Venn diagram showing the intersection of persuasion and technology - Captology

2.4.1 Types Of Motivation

It is also helpful to mention the types of motivations which affect people to do activities. Literature indicate that there are three main types of motivators that drive people to behave in a certain way, Deci and Ryan [35] define them as:

Extrinsic Motivation Incentives where motives to enact the task are not related necessarily to that specific behaviour - *i.e. Completionism*

Extrinsic motivation takes the form of leveraging the human Psyche. For instance, the example of a progress bar persuades the user to bring it up to 100%. The user may not be specifically motivated to perform the task, but they are motivated to complete the progress bar.

Intrinsic Motivation The act of making the intended behaviour so pleasurable that it becomes an end in itself - *i.e. Gamification*

The philosophy of this motivator is to persuade the user to engage with the activity in a way that they enjoy. Gamification exists within this realm of motivation, making activities more enticing to users.

Tangible Motivation External Incentives driving the motivations - *i.e.Rewards/Money*

These motivators usually offer some sort of reward such as money to entice the user to perform an action. Although only considered as short-term, it is useful at incentivising one-off activities that are difficult to make engaging, for example surveys.

Persuasive technologies afford the use of any combination of these to develop systems. We discuss an example in Sec. 2.4.3

2.4.2 Fogg's Taxonomy

Fogg characterises each persuasive technology by *functional roles*: tools, media or social actors. [36], of which technologies can identify as one or several of these categories. The proposed triad is designed to model the way in which users see and react to the following:

Tools These technologies are designed to make people's jobs easier[32]. For example a wizard or an Out of Box Experience (OOBE) can give users direction regarding the completion of a specific or complex user task.

Media Media-centric technologies are designed to provide users a platform to create experiences that develop, teach or enforce a behaviour. These can come in the form of games, interactive systems or stories; the best examples however are simulations. Simulations place the users in a specific environment where they must interact with rules of the system in order to hone a required set of behaviours; such behaviours can be for the purposes of testing or real-life skills.

Social Actors With the introduction of social actors, computer systems can now influence users using social cues. Actors can be persuasive by giving a human face to positive feedback, modeling an inded behavior or provide moral support to the user [32]. The *Microsoft Paperclip* is a famous example of a social actor to teach users how to use Microsoft Office. Research in this area is constantly developing as it's difficult to build 'human' characters without entering "uncanny valley".

2.4.3 Persuasive Technologies Through Gamification

Persuasive Technology is a broad term. As such, it can be argued that gamification exists within the realm of captlogy; nonetheless there exists the key differentiators of scope, more specifically - gamification is not necessarily linked to technology (although 'gamified' technologies are generally more common).

A well known case study of implementing persuasive technologies using gamification are The Piano Stairs (Fig. 2.5) [37]. In this example, tiles and speakers in the configuration of a piano were installed next to an escalator, each stair playing a specific note on the piano when stepped on. The purpose of this experiment was to get more commuters to take the 'healthier' stairs rather than the escalator. Results showed that people were taking the stairs frequently and in more 'musical ways', with some musicians attempting to play songs using them. There was however another factor that encouraged people to take the stairs: curiosity [37]. The staircase is so out of place that people are curious and thus want to explore and engage with the technology.

Figure 2.5: The piano tiles staircase

Applying the concept of Fogg's taxonomy and motivator types, this innovation is an example of a media-oriented technology, fueled by intrinsic motivation - making the act of going up the stairs more enjoyable. Although empirical evidence on users after taking the stairs was not tracked, it would be interesting to see whether these stairs impacted people's choice of taking other stairs in the long run.

2.5 Survey of Technologies

We now turn our focus to the developed solutions. These technologies were chosen as they use a combination of NFC, gamification or persuasive technologies. The first group will contain implementations dedicated to a certain business; whereas the second will look at more generic applications. The chosen solutions were only those where **Loyalty** was the core function of the technology, 'ecosystem-based' combined solutions were not considered.

In order to summarize these technologies later, each of the following should answer these questions:

- How does the user interact between the real world and the applications (what pervasive elements does the application possess)?
- What elements of gamification exist?
- In what ways are multiple loyalty schemes presented?
- Are there any subtle persuasion techniques employed?

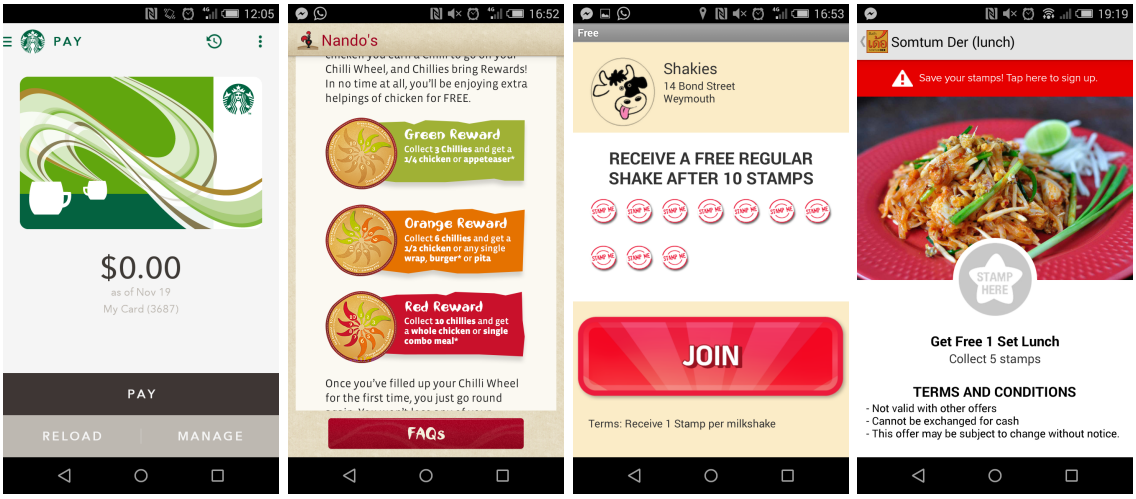

Figure 2.6: The technologies to be analysed: (a) Starbucks (b) Nandos (c) StampMe (d) Stamp

2.5.1 Starbucks Mobile Application

Overview The Starbucks mobile application is designed as a digital-companion to the standard plastic loyalty card they provide. The application allows user's to either have a digital-only card or transition their physical cards onto the app, allowing customers to view, top up and pay with their balance.

What are the pervasive elements? Aliased Card Using BQ barcode that is scanned by a barista.

What elements of Gamification exist? Collect Stars with each purchase, free drink on 15, upgrade to gold member upon collecting 50 stars.

In what ways are multiple loyalty schemes presented? The user can have up to 10 Starbucks cards but only claim free drinks with their stars.

Are there any subtle persuasion techniques employed? Extrinsic Motivation of filling a cup, personalise your card.

2.5.2 Nandos Mobile Application

Overview As with Starbucks, the Nandos' mobile application works in a very similar manner to the starbucks card. It allows users to register their current physical card; however this app is purely as a companion, informing users of the status of their loyalty points in the card.

What are the pervasive elements? There are no pervasive methods. The user must have and use a Nandos Card.

What elements of Gamification exist? No elements of gamification are used.

In what ways are multiple loyalty schemes presented? Loyalty schemes are presented as a progressive stampcard. Rewards of increasing value are granted upon reaching certain amounts of chillis

Are there any subtle persuasion techniques employed? When a users connects their card to the app, A wheel with different colored chillis are displayed. In order to get rewards, users must complete the wheel, displaying the example of extrinsic motivation via completionism - encouraging users to fill the wheel.

2.5.3 StampMe & Stamp

Overview StampMe & Stamp are both general purpose loyalty application for corporates to implement loyalty schemes. Businesses can only have one loyalty scheme that mainly adopts the "free x with y stamps" methodology. Users can browse for nearby shops that have available offers and collect numerous schemes.

What are the pervasive elements? In order to gather a stamp from these apps, the

business uses a proprietary digital stamping device to stamp the screen of the mobile phone, thus transferring a stamp. Although this is an interesting way to stamp the screen, information about the specific technology it uses proved impossible to find. It can however be inferred that this technology is not NFC as it works on both iOS (those with and without NFC chips) and Android.

What elements of Gamification exist? no offers or gamification elements are implemented within these applications.

In what ways are multiple loyalty schemes presented? Once a user 'joins' a business' loyalty scheme, it is added to a list of their current loyalty programs. The list is made out of simple text and does not display any information about the progress of the schemes - unless they explicitly click on the name of the business first.

Are there any subtle persuasion techniques employed? These applications attempt to clone a real Stampcard. This is considered a use of extrinsic motivation where users may not necessarily want to buy a coffee but want to complete their stamp card.

2.5.4 Summary of Solutions

We summarise the fidelity of the above systems into table 2.2.

	Pervasive Elements	Gamification Elements	Multiple Schemes	Persuasion Techniques
Starbucks	QR Code	Collecting Stars	None	Fill up cup with stars for a free drink
Nandos	None	None	Can claim different rewards depending on amount of built up chillis	Fill the wheel to increase chilli count
StampMe & Stamp	Proprietary System	None	Add multiple loyalty schemes from participating businesses	Affordance of real stampbook appearance

Table 2.2: A summary of the solutions discussed

2.6 Conclusions

Although there exists some general purpose loyalty solutions, they lack the polish and compared to the business-centric applications. On the other hand, those applications that are business-centric require users to install a mobile application for each loyalty card. Whereas large businesses have the resources to create such highly customised, high-fidelity systems, small businesses have little incentive to invest outside of paper-based solutions, mainly due to large development and implementation costs.

NFC with social elements is an area vastly untapped by businesses, mainly due to the slow uptake of NFC by the market; moreover it seems like those loyalty systems using the proprietary stamping technology seem to be re-inventing the wheel instead of using the open standard.

The opportunity of our proposed solution is to make an encompassing general-purpose solution that any business, big or small, can use to simply implement a loyalty program and push it out to any users of the application; collecting 'stamps' using NFC. All loyalty schemes will be automatically incorporated into a gamification framework provided by the application, providing businesses a gamified loyalty scheme with minimal effort.

Chapter 3

Requirements & Design

3.1 Introduction

This chapter describes and outlines the requirements for the proposed software solution. Requirements will set goals for the functionality of the software, whereas the design section allows us to translate these requirements onto paper. Both sections will become useful when testing whether the system is fit-for-purpose.

3.2 Requirement Methodology

In this section, system requirements will be presented. Two sources of requirements were used: firstly using information discovered from the literature survey; and secondly from an interview from a project manager at 'Company A'. These requirements are not to be used as an exhaustive list, but are to be used as a benchmark for ensuring the created product is fit-for-purpose.

3.2.1 The Interview

To gather business oriented requirements, an interview was conducted with a project manager, specialising in IT implementations for corporate facilities. several points discussed were integrated into the system as requirements. For instance:

6. What do you think of this solution? (The corporate loyalty app)

For this solution to be feasible and useful, it would need to be:

- Available for all of our permanent staff to use
- Easy integration for further sites and users globally
- Good usability aspects. GSK has 100,000 staff members with a variety of demographics, therefore all users should find it easy to use and better than the existing process
- The system would need to increment on a daily basis when the staff members enter site (once a day only)

Informed requirements M2, S2, S4, and C6.

The transcript of the interview can be found in the appendices.

3.2.2 Requirements

Our solution involves the creation of two Android applications, thus the requirements below will be marked whether they are for **Both** or exclusively for the **Loyalty Manager**, or **Loyalty Stampbook**. Effort will be made to maximise cross-system requirements. We found that there was an abundance of potential system requirements, however not all can be implemented in good time. As such, we present these requirements in MoSCoW Format [38] (Must Have, Should Have, Could Have, Won't Have) in order to categorise the importance of their delivery.

Must Have

M1 **Sign-In & Registration**
The user should be able to sign in with an existing account or register for a new one
[Both Systems] — Functional

M2 **Fast Stamping**
Access to the NFC stamping functionality should be available within a single tap from a home page
[Both Systems] — Functional

M3 **NFC Transmission**
The system must use NFC for data transmission and Host Card Emulation
[Both Systems] — Functional

M4 **Online Syncing**
The system must be able to sync a users 'stampbook' online
[Both Systems] — Functional

M5 **Sync on Interaction**
Syncing must take place as soon as there is an interaction that affects the stamp count of a scheme
[Both Systems] — Functional

M6 **Syncing Time**
The response time for syncing must be within 5 seconds
[Both Systems] — Non-functional

M7 **Feedback on Interaction**
The system must provide audio/visual feedback whenever a 'stamp' has taken place
[Both Systems] — Functional

'Must have' requirements are the minimum amount of features to be satisfied for the success of the system. As a result, these are of highest priority. Requirements defining gamification are not listed here as they are not 'key' to the system.

Should Have

S1 **Consistency**
The system should fit within the standards and design language of the Android operating system
[Both Systems] — Non-functional

S2 **Rewards Browsing**
The user should be able to easily browse their rewards available
[Loyalty Stampbook] — Functional

S3 **Badges**
Users should be able to collect badges upon completing certain goals
[Loyalty Stampbook] — Functional

S4 **Secure Communications**
NFC Communications between devices should be encrypted
[Both Systems] — Functional

S5 **Level-Restrictions**
Rewards should have a minimum-level required in order to claim
[Loyalty Stampbook] — Functional

S6 **Levelling System**
Users should be able to level up each of their loyalty schemes independently (20 - gold, 50, platinum)
[Loyalty Stampbook] — Functional

The 'should have's' represent features which should be included if the system if time permits. Generally these requirements add a layer of usability and engagement to the system; as such, most of the gamification implementation is defined here.

Could Have

C1 **Passive Card Emulation**
The system could allow passive host card emulation
[Loyalty Stampbook] — Functional

C2 **Branding**
The system could provide deep customisation options for each scheme
[Loyalty Manager] — Functional

C3 **Internet-Free Stamping**
Users could have the ability to gather stamps without being connected to the internet (facilitated by the Manager)
[Loyalty Manager] — Functional

C4 **Multiple Device Support**

Users could be able to login and use multiple devices seamlessly
[Loyalty Stampbook] — Functional

C5 **Personalisation**
The system could allow users to customise the appearance of their profile
[Loyalty Stampbook] — Functional

C6 **Restricted Schemes**
The system could allow for account-specific schemes (only authorised users have access to the scheme)
[Both Systems] — Functional

C7 **Transaction History**
The system could have a transaction history to allow users to see their recent activity
[Loyalty Stampbook] — Functional

These requirements represent bells-and-whistles requirements. Features in the 'could have' are desirable but not a necessity to the project's initial builds. Incorporations of these requirements into future builds of the system would greatly benefit user experience.

Won't Have

W1 **Payment Options**
The system will not facilitate any form of payment
[Both Systems] — Functional

W2 **Loyalty Sharing**
Users will not be able to transfer stamps between friends/accounts
[Loyalty Stampbook] — Functional

'Won't have' requirements are simply outside the scope of the project. Their functionality is either not the purpose of the system (W1), or facilitate unwanted features into the ecosystem (W2).

3.3 Design

3.3.1 Outline

Turning our attention to the design, here we present the system, matching the requirements, outlining how they meet the system requirements. Some interesting scenarios have been mentioned in the requirements that leave a wide scope of design challenges. A study is also undertaken that involves participatory design as an extension of the proposed design - in effect, asking potential users to tackle these challenges.

3.3.2 The Three Components of the System

As mentioned earlier, the proposed system involves two separate Android applications. However, in order to meet functional requirements M1, M4, C4 and C6 a database will need to be introduced in order to inter-connect user accounts, along with any relevant data (i.e. loyalty schemes, stamps and badges). Furthermore, a database is also useful from a security and continuity standpoint. For instance, backing-up stamps and schemes allows users to sync their accounts between phones, as well as preventing 'abusive' users from modifying the local variables for stamp count.

3.3.3 Modeling The Interaction

The key design challenge of the system is to ensure seamless and correct communications via NFC between each of the three system modules. As outlined in the literature survey, there are several modes that NFC can adopt [39], each changing the device's role as part of the interaction. In this case, Host Card Emulation (HCE) and NFC Readers can be setup in different configurations to facilitate these communications. Two such configurations were considered - Loyalty Manager using HCE and Loyalty Stampbook using HCE (Fig. 3.1). The difference between these configurations is small; however they each have distinct connotations. A discussion on their implications follows:

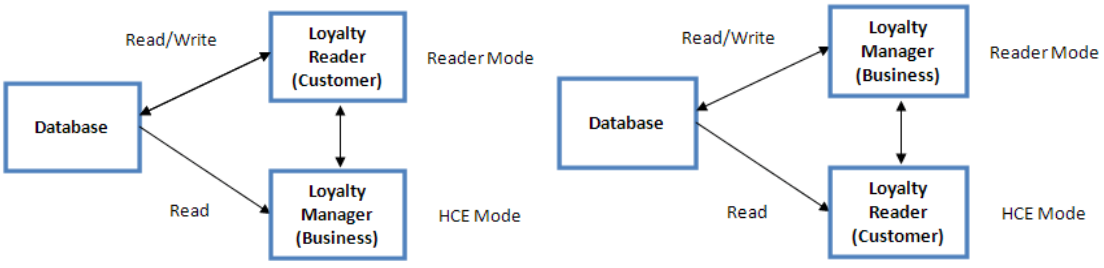

Figure 3.1: (i) Loyalty Manager using HCE. (ii) Loyalty Stampbook using HCE

Loyalty Manager using HCE

Loyalty Manager with HCE entails using the Manager application as a smartcard. In this case, the Loyalty Stampbook interfaces with the database to update the user's Stampbook.

The benefits and drawbacks of this configuration are:

+ Syncing is not necessary as the Manager will always have the updated Stampbook
+ Less logic required in the Applications to direct stamps
— Dependant on both applications having internet connection
— The user must have the Loyalty Stampbook open to collect stamps
— Data integrity issues if people maliciously modify code of the Loyalty Stampbook
— Differentiating between reward & stamp requests is difficult

Loyalty Stampbook using HCE

When the Loyalty Stampbook acts as the smartcard, several interactions differ. Primarily, the burden of dealing with the database is placed onto the Loyalty Manager.

The benefits and drawbacks of this configuration are:

+ The Loyalty Stampbook does not need to have the application open to collect a stamp, the phone functions as a passive smartcard.
+ Only the Loyalty Manager needs access to the internet. Customers will be able to collect and expend stamps whilst not connected
+ The Loyalty Manager can easily separate stamp requests from reward requests
+ Data is more secure as only the authorised Loyalty Manager has access to modify the database. Ultimately, this prevents user tampering and ensures data integrity within the system
— Complex logic required in both applications
— Providing specific feedback directly to the Loyalty Stampbook via the app is difficult

Chosen Model

Loyalty Stampbook using HCE was selected on the merit of its positives. Primarily, not requiring internet access from the customer, the ability to collect stamps without having the application open and its emphasis on security. On the other hand, it makes the implementation trickier, requiring more logic to support the two-way communications. None-the-less, we expect that this model will ultimately benefit the system by making it easier to use and understand for users.

User Feedback

Requirement M7 identifies the need for user feedback in both applications when stamping. Mobile operating systems provide several design patterns to accommodate interaction feedback, for instance: audio, notifications and haptic/vibration. For the Loyalty Stampbook, notifications were selected as the **primary** method as users may want to keep their phones on silent. Within the Loyalty Manager, responses can be presented as a 'toast'[40][1]. Moreover, we integrate an audible sound whenever two NFC devices make contact; however users will be able to mute this feature if the device is placed on silent.

3.3.4 Design Methodology

In order to develop the designs for the system components, a user-centered design[41] approach was taken for each iteration. The initial wireframe was mocked-up from Android design heuristics as a design language.

Design Language

One of Neilson's heuristics is 'Consistency and Standards' [42], in this case meaning that the solution should follow the platform conventions and design of the Android operating system. This satisfies the requirement S1. If this heuristic is met, users will feel more comfortable with the system as it will feel familiar to use. The latest standards outlined by Google describe *Material Design* [43], a visual design language to be used with the new *Android Lollipop* operating system with a goal to:

> *"Develop a single underlying system that allows for a unified [user] experience across platforms and device sizes"* [43, Introduction]

We present the designs to potential users within our target market (Age 16-40). Feedback was captured, analysed and incorporated into the next iteration. In the interest of time, only two iterations were incorporated for the Loyalty Stampbook and one for the Loyalty Manager.

[1] A small popup message in Android that provides simple feedback

3.3.5 Design Process - Loyalty Stampbook

Wire-Frame Mockups

The Wire-Frames were developed on paper using the Material Design guidelines discussed earlier (Fig. 3.2). An analysis of the design decisions follows:

Figure 3.2: The initial wireframe mockup for the Loyalty Stampbook using the Material Design guidelines

1. 'Pips' are a common design pattern on mobile devices. They serve as a page indicator and afford swiping on the screen. In this case, users can see all of their loyalty schemes in this page and can swipe between them.
2. The idea of having 'loyalty cards' was taken from the real world. Businesses may be able to customise the graphic on the card. Cards on mobile screens also afford flipping over for more information - within mobile applications this is done via a tap, meaning users can get details of a loyalty scheme by tapping the card.
3. Floating Action Buttons (FAB) are special buttons used to present users with the primary action of the application. In this case it is a stamp button that takes users to the stamp screen.
4. A list of available rewards for the users, notifying them which rewards are available.
5. A stamp screen to notify the users to tap their device onto the reader. Within this design, all NFC interactions are done with this screen open; however this screen may not be needed using the Loyalty Stampbook using HCE interaction model

Feedback For Next Iteration

- *"If it is so important, shouldn't the stamp button should be in all pages, not just the home page?"*

- *"How will gamification work in the design?"*

Feedback for this design was limited as paper-based mockups proved difficult to communicate links between the actions; Nonetheless, these points were considered for the next iteration.

Iteration 1 - Mockup

The first iteration was a near direct translation of the paper wire-frame into a navigable mockup (Fig. 3.3), with a few small changes following previous feedback. A dedicated loyalty scheme page was introduced to track potential gamification concepts, along with the addition of a stamp button on every page.

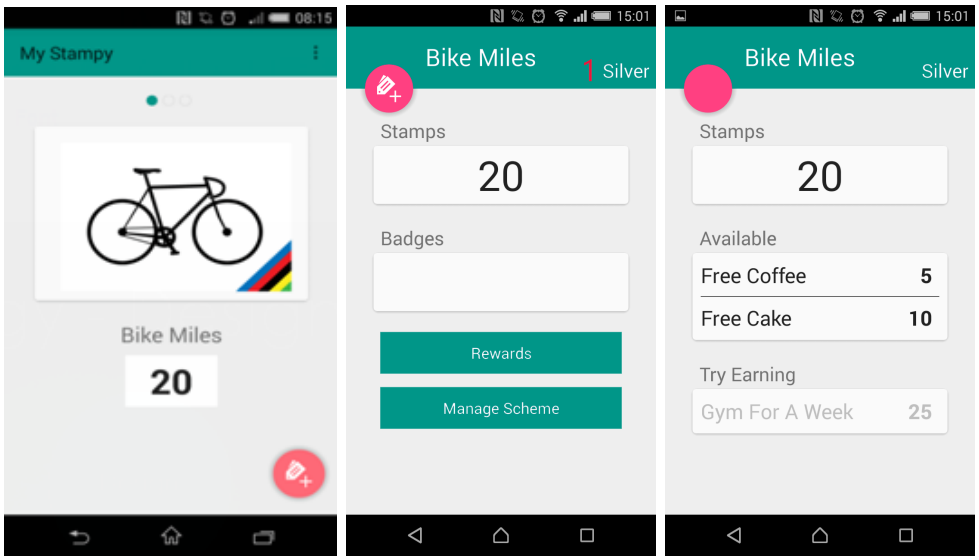

Figure 3.3: A mockup of the wireframe incorporating suggestions from last iteration

1. A dedicated loyalty scheme page for the user to explore the current loyalty scheme. These may be customisable for the business. Potential gamification methods, such as levels and badges would live here if implemented.

Feedback For Next Iteration

- *"If I have many loyalty schemes, It feel sluggish to scroll through all of them individually. Perhaps have them as a list"*
- *"If I have my own account, there should be a profile page"*
- *"It takes too many clicks to get to the rewards"* [2 clicks after finding scheme]
- *"The stamp button makes me thing I'm only stamping the visible scheme?"* [This was an unintentional consequence of the design]

- *"The app shoulds tell me when I have sufficient stamps to claim a reward"*

More issues were identified during this iteration as users were able to explore the design on an android device. Nevertheless, feedback clearly suggested that this design was slow, confusing and ultimately - not fit for purpose. Substantial changes had to be made.

Iteration 2 - Final Design

In order to remediate some of the design problems identified with the previous feedback, a very different approach had to be taken with the design - as presented in (Fig. 3.4). In order to present clarity, several UI aspects had to be removed; for instance the stamp button was removed and is to be replaced with instructions on how to stamp upon logging-in for the first time.

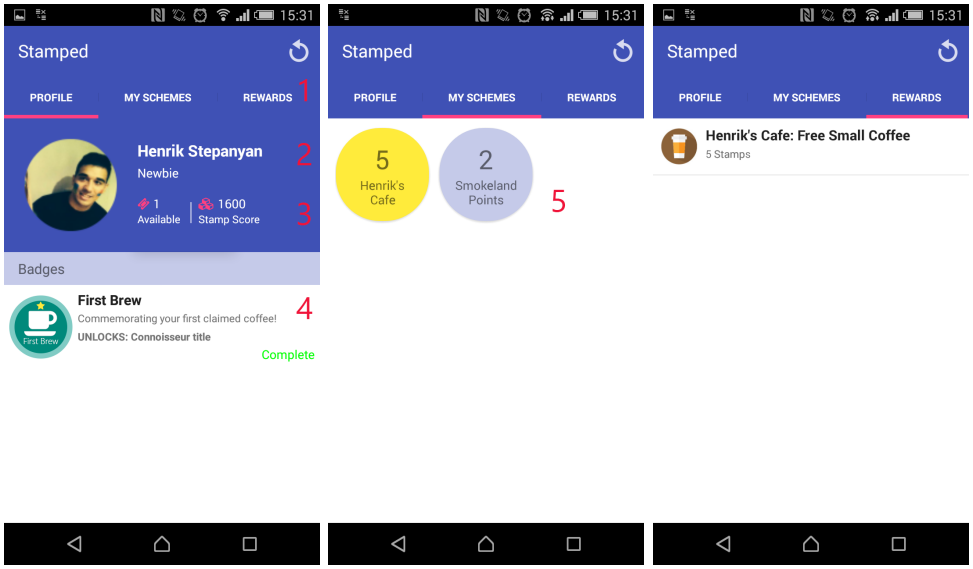

Figure 3.4: The final mockup of the Stampbook with a tabbed interface to be implemented

1. A tabbed interface allows switching between different functional areas of an app, therefore making them very useful if functionality can be categorised. Profile, My Schemes and Rewards were chosen as the functional categories. An action button exists visibly on the top right to sync a the users profile (loyalty schemes/rewards etc.) with the server.
2. The previous designs did not consider a having a user profile. The profile page aims to provide users a hub that presents them with their current account status. Customisability is also possible here, for instance the ability to add a profile picture, or to choose from a range of personal titles.
3. Indicators are a key aspect of Nielson's 'visibility of system state' heuristic [42]. A count of available rewards notifies how many claimable rewards the user has; whereas

stamp score is a gamification currency which could be used to claim exclusive rewards in the future.

4. A user profile is a prime location to display achieved user badges. For more detail, refer to *(3.3.8 Incorporating Gamification/Persuassion)*
5. Solutions we explored in the literature survey implemented loyalty schemes as lists. As a result, the 'loyalty card' design from the previous iterations were transformed into bubbles within a grid. Businesses may be able to customize the background of the bubble with their own brand image. By pressing on the bubble, users are able to see the status of the scheme (Fig. 3.9). Referencing previous feedback, a golden tint represents a loyalty scheme which has sufficient stamps to claim a reward.
6. Further facilitating reward discovery, the dedicated rewards tab presents users with **all** available rewards they can afford with their stamps. This centralisation enforces a single convenient location to claim a reward.

Feedback For Next Iteration

- *"There should be more room for businesses to customise their schemes according to their brand"*
- *"Single rewards per loyalty scheme is great, but the design doesn't accommodate multiple rewards very well"*

Eventhough feedback for this iteration will not be implemented in the respects of time, it is important for future work.

3.3.6 Design Process - Loyalty Manager

Wire-Frame Mockups

As with the Stampbook, wire-frames were developed on paper using the Material Design guidelines (Fig. 3.5). An analysis of the design decisions follows:

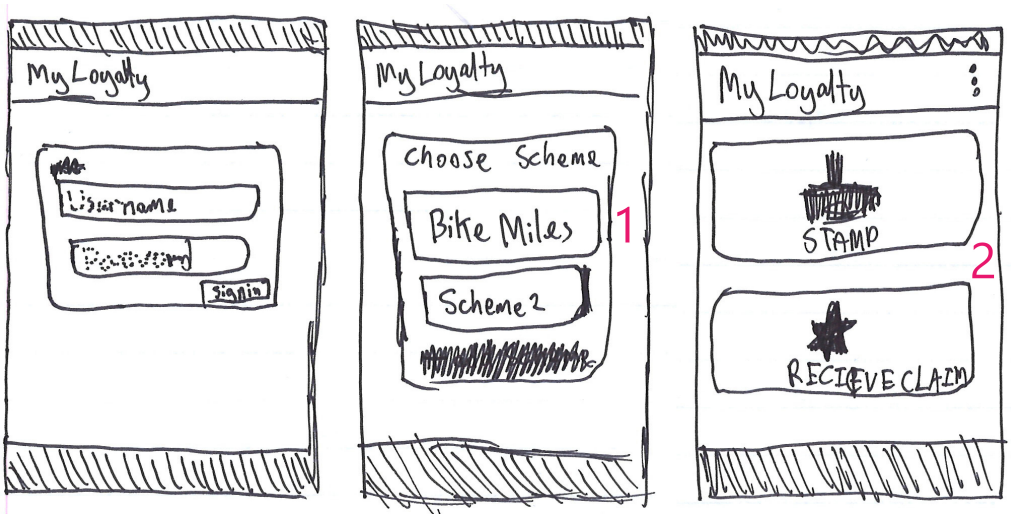

Figure 3.5: The initial wireframe mockup for the Manager using the Material Design guidelines

1. Users may manage more than loyalty scheme. As such, there exists a menu in order to select the appropriate scheme.
2. The stamp page is designed to be very simple with only two large accessible buttons. Pressing on either should enable the NFC chip in order to distribute a stamp or claim a user reward.

Feedback For Next Iteration

- *"There should be a way to distribute multiple stamps"*
- *"A log of recent transactions would be useful"*
- *"The interface does not notify what loyalty scheme being stamped"*

As the functionality of this application is simpler than the Stampbook, better feedback was collected from the wire-frames. Suggestions, along with design patterns from the Stampbook were incorporated into the next iteration.

Iteration 2 - Final Design

A final design was developed by combining the aesthetic of the final Loyalty Stampbook prototype, with the suggestions from the previous wireframe (Fig. 3.5).

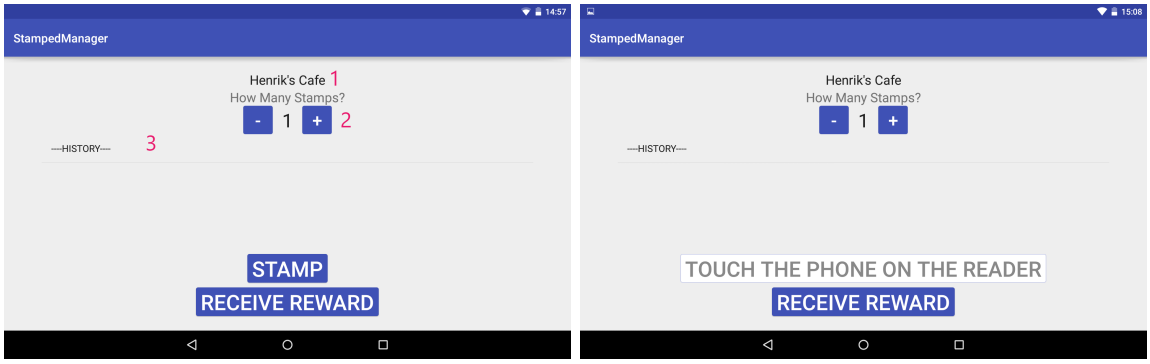

Figure 3.6: The final mockup of the Manager with the final aesthetic to be implemented

1. A notifier of the current loyalty scheme, as suggested from previous feedback.
2. A counter for the amount of stamps to distribute per tap. To facilitate ease of use, the number of stamps should reset back to one after every interaction. This will prevent any accidental 'overstamping' previous customers if the business employee forgets to reset the value.
3. The history provides a method of feedback to the employee. Upon all interactions, it should inform progress, successes and other key information regarding the loyalty schemes; however certain granularity had to be chosen. We would

Feedback For Next Iteration

- *"The buttons could be bigger like the original design"*
- *"There should exist an option to go back to the select a scheme page"*
- *"Transaction history need a way to be backed up"*

Due to limitations of time, this feedback will not be implemented into the system; however as with the Stampbook, they will be integral to future work.

3.3.7 Design Process - Database Design

Entity-Relationship Diagram

The design process for the database was somewhat different than the Android applications as there was no user interface aspect involved. Initially, entities were identified for the schema - they were then normalised and translated into an Entity-Relationship Diagram (ERD) (Fig. 3.7).

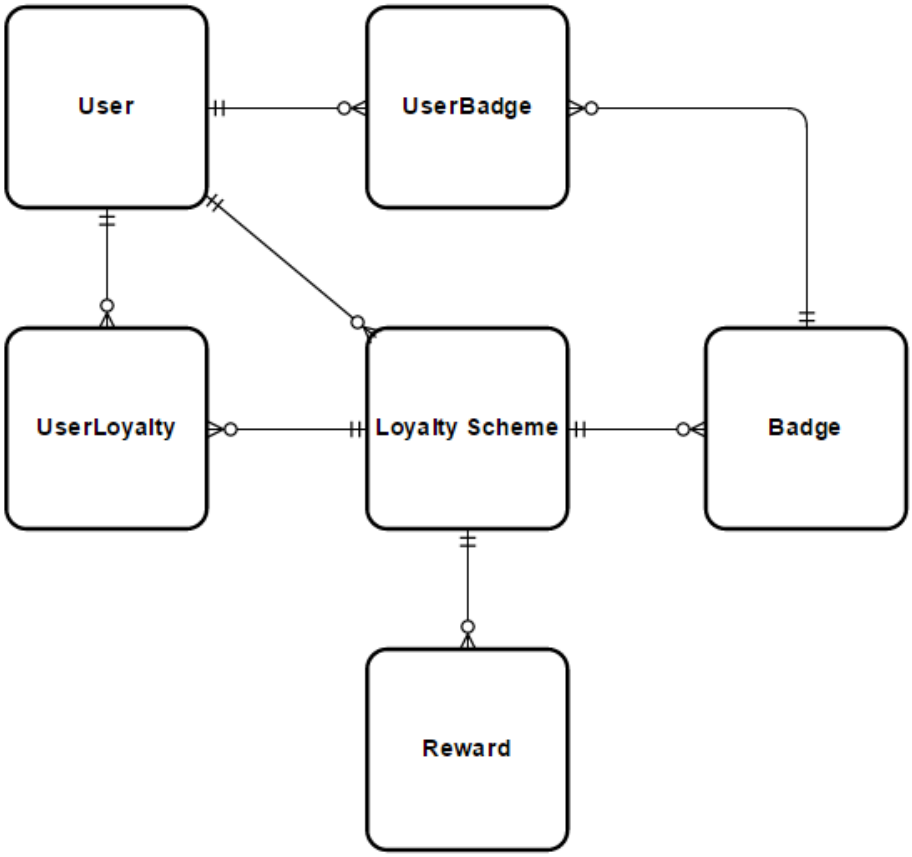

Figure 3.7: High-level Entity Relationship Diagram showing connections between different tables

Satisfied with the design, the following features were identified to be reflected as table attributes:

- *facilitation of the gamification platform*
- *facilitation of scheme tracking/business intelligence*

Final Database Schema

Building upon the initial ERD and incorporating the above features identified into the schema, a final database schema is proposed (Fig. 3.8).

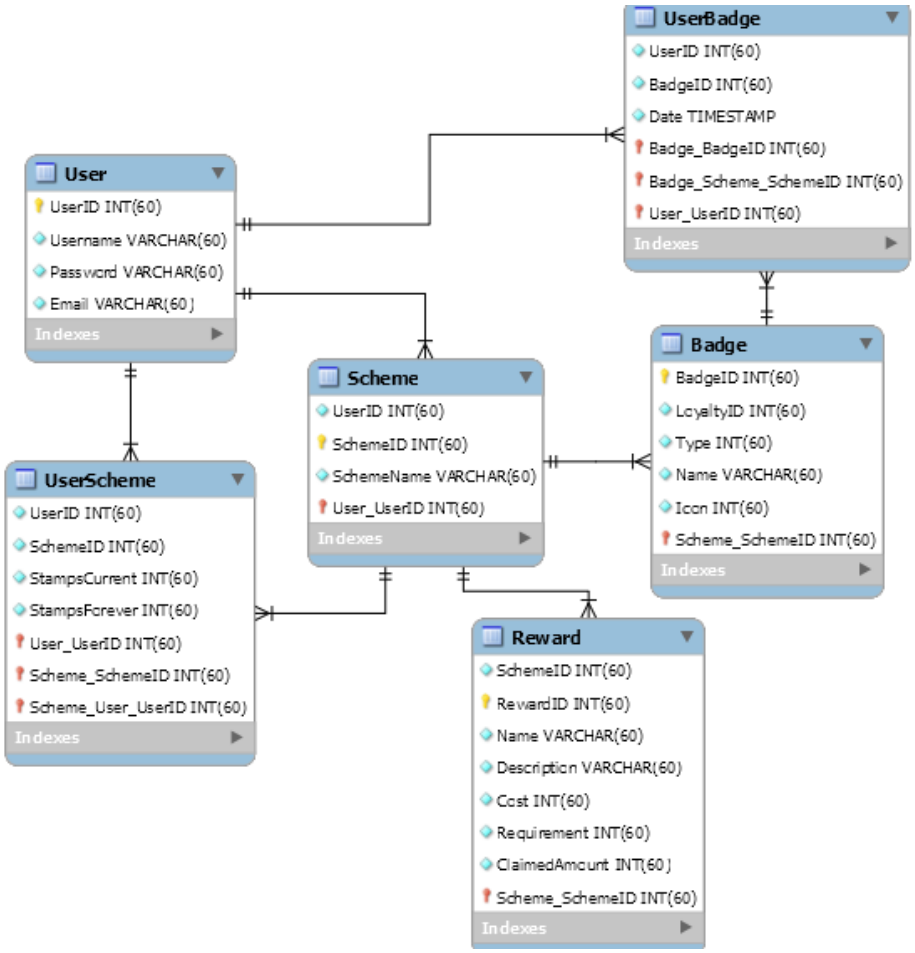

Figure 3.8: Final database model to be implemented

Analysis of Final Schema

In order to facilitate the gamification platform, we ensure that badges are indepedant from the loyalty schemes, affording the possible creation of unique badges by businesses. Moreover, the *stampsForever* attribute of UserScheme can be used to monitor how often a user visits a business. Leaderboards as gamification are also possible from this field.

ClaimedAmount from the Reward table, along with the aforementioned *stampsForever* attribute can be used by businesses to track the popularity of their schemes. This allows them to monitor changes and adapt their schemes accordingly.

3.3.8 Incorporating Gamification/Persuassion

Extrinsic Motivation

We previously defined the concept of 'extrinic motivation' as incentives where motives to enact the task are not related necessarily to that specific behaviour. These are commonly seen in loyalty cards - for instance users may not necessarily want to buy a coffee but want to complete their stamp card. One can argue that stampcards are not only extrinsic motivators, but also are an implementation of Nielson's 'match between system and the real world' heuristic. Several solutions we explored in the literature review implemented digital stampcard-like solutions.

Similar to the aforementioned systems we reviewed, a virtual stampcard appearance was integrated into our design (Fig. 3.9) as we felt it was an effective persuasive method.

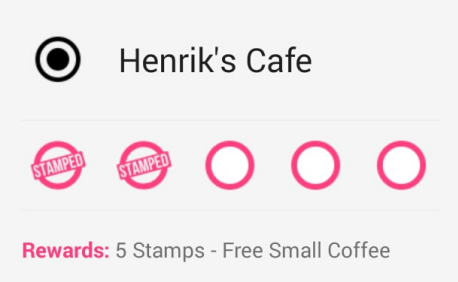

Figure 3.9: The loyalty scheme view displaying: reward, current stamps and the amount of stamps left in order to gather the reward

Badges

Badges were identified earlier as a type of gamification tool. They were not only one of the more popular tools, but also the simplest to implement. As with real-life, badges are awarded upon achieving certain goals. As such, we introduce simple achievements into our system. Moreover, we require an incentive to collect badges – therefore a title-system was added, allowing users to unlock certain and wear matching titles along with the achievement.

(Fig. 3.10) Shows how we integrated these principles into our design. The profile page makes an ideal home for collected badges.

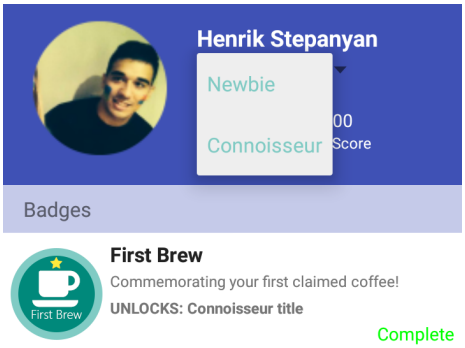

Figure 3.10: The badge view in the profile showing both the achievement and accompanied title earned by the user.

3.3.9 Naming The Systems

In order to give the system a brand identity, it was named 'Stamped' as it emphasises the software's focus on stamping. The 'Loyalty Stampbook' is to be called *Stamped*, whereas the 'Loyalty Manager' is to be referred to as the *Stamped Manager*. We hope that with a brand identity, users will be able to empathise and recognise the system better.

3.3.10 Conclusion

In this chapter we covered the requirements and design specification for our system 'Stamped'. Some of the design challenges were outlined, along with the different iterations that eventually lead to the final designs. The next chapter will cover the issue of implementation.

Chapter 4

Implementation

4.1 Introduction

In this chapter, we will present the different software components that were combined together to build our system. Problems with engineering and platform complexity will be highlighted, along with the process for solving them. The Android operating system brings many challenges with regards to development; however the goal is to explain those which are interesting when developing solutions relating to NFC. A basic knowledge of the Android platform will prove useful to fully understand this chapter.

4.2 Primary Technology

As explained earlier (blah blah reference), Stamped is to be developed on a popular mobile platform that supports the NFC standard, in this case Android. At this moment in time, developing a functional prototype for this system cannot be possible on another platform due to hardware and API limitations regarding NFC and Host Card Emulation. Expanding the solution to external platforms in the future will be difficult as it requires a rewrite with platform-specific code.

4.2.1 Software

Google provides a plethora of development tools in order to develop applications, one such tool is the development environment *Android Studio*. This kit provides an Integrated Development Environment (IDE) in order to design, configure and program the system. Android programs are coded using `JAVA` – therefore requiring an object oriented methodology.

Different Android devices run different versions of the operating system. Corresponding to each operating system version, there exists an accompanying Application Program Interface (API) that introduces new features to the ecosystem. We want our application to have the highest compatibility, but still contain the required features in order to satisfy the requirements. *Android 4.4 KitKat* is selected as this is when Host Card Emulation was initially introduced into the platform; however, this means that approximately 45% [44] of Android users have an appropriate version of operating system to run Stamped.

4.2.2 Hardware

Complementing the above choice of software, we require accommodating Android devices for development. Two devices were selected, a smartphone and a tablet. The tablet will be used to implement the Stamped Manager application as businesses will ideally mount Tablets onto a table next to employees to use. On the other hand, the phone will be used for the Stamped application as this is the common device customers will be using the system with. Both devices run the latest *Android 5.0 Lollipop* operating system - therefore supporting Host Card Emulation.

4.3 Other Notable Resources

4.3.1 Webserver with Database

To facilitate the backend of the system, we introduced a webserver/database backend in the design. A private webserver was purchased in order to facilitate the interactions with the database. The design database schema (Ref. SCHEMA) was imported into *PHPMyAdmin* and PHP files were developed to interface between the Applications and Webserver (The rationale for this can be found in (Sec. 4.4.3))

4.3.2 Android Debug Bridge (ADB)

Google provides a useful software for application testing called The Android Debug Bridge. This software interfaces with connected devices, providing the following features.

- The ability to see the console of the Android device in real-time whilst running the software
- The ability to control in-ward and out-bound network connections
- Error identification and debug output

ADB persists whenever there is a connection between Android Studio and a device, outputting feedback on its current state.

4.4 Implementation Complications

In this section a discussion follows the key implementation complexities whilst developing the system. Care was taken to abstract the problems of developing on the Android platform away from the issues.

4.4.1 Host Card Emulation

We earlier defined a need for an interaction architecture, identifying the Stamped application to interact using HCE as a smartcard. In order to do achieve this, a service will need to be created

Creating The Service

In order to provide functionality outside of an application, a 'service' must be implemented. A service is simply a component of an application which constantly runs in the background – Host Card Emulation is one such example of a component. In this case, the HCE service passively runs in the phone working memory, waiting to be triggered by an NFC Reader before sending a message. The purpose of having HCE in this form allows users to tap a reader to collect stamps **regardless of whether the application is open on the device or not**.

Android services must be carefully developed, as reckless design will lead to unwanted battery drain on the device. Fortunately Google provides a template class called *HostApduService* for HCE, ensuring that the service is optimised for power consumption.

Distinguishing Actions

A standard smartcard cannot tell what exactly is being read from it or when, a similar problem presents itself in the Host Card Service. The HCE service cannot atomically discriminate what message it needs to send, it can only react to an `onRead` event. To remediate this, we had to temporarily break the object oriented principle of encapsulation by introducing a shared global variable `NFCMessageType`. The message will allow the Manager application to discriminate what type of action we are broadcasting as a smartcard. Two such messages are adopted:

1. Stamp mode - Broadcasts the user account id
2. Reward mode - Broadcasts the user account id, the scheme id and the number of stamps to deduct in order to claim that reward

Passively the device is on 'Stamp' mode; however once a user selects a reward, they are presented with a popup (Fig. 3.9) to tap the reader in order to claim their reward. During this time, the HCE service will be in 'Reward' mode. As the popup is dismissed (from tapping the reader or having the user press cancel), we return back to Stamp mode. This technique underlies the systems ability to Understand Actions (Sec. 4.4.2).

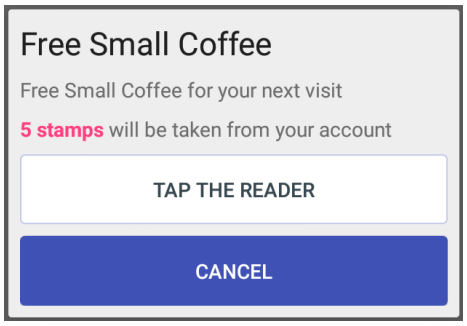

Figure 4.1: The popup presented to the user when they are about to claim a reward

Reacting to OnRead

The `onRead` function is usually strictly used to send a message to a reader. However, the event affords many opportunities for us to implement user feedback mentioned in the design chapter. For instance, we announce to the user whenever they have tapped their device using audio feedback and a notification (Fig. 4.2). This novel solution binds the interaction feedback to the service; therefore these functions can run in the background.

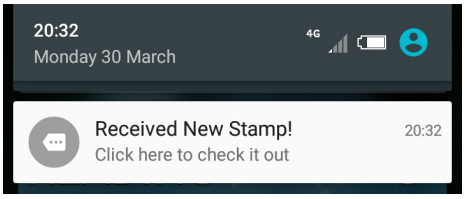

Figure 4.2: A Notification providing feedback to the user upon receiving a stamp

4.4.2 NFC Communications

Several presentation methods need to be put in place to facilitate NFC communication for our system. The messages being sent are simply hexadecimal plaintext; therefore there needs to be a way to send them in the correct format and carry some meaning to them. Here we demonstrate the principles to enable the Stamped Manager to understand messages.

Understanding Actions

The Stamped Manager must be able to distinguish the types of messages it receives. There are two kinds that it may encounter: A stamp request and a reward claim. We earlier explained two modes on the host card that send differing amounts of information. Likewise, the Manager was setup in order to analyse message content. If only the accountID was received, we know that Stamped Manager needs to provide a stamp, however when is presented with more information, the system recognises that a customer is claiming a reward and deducts the amount of stamps from their account.

Avoiding the 'Beam'

Android Beam is a feature of the Android platform to allow peer-peer data exchange over NFC [45]. Though it may have its uses (i.e Sending contacts, pictures), it can cause many problems for our system. Primarily, when two devices 'tap', the operating system may mistake it for a 'Beam' instead of a smartcard. This feature can be seen in (Fig. 4.3); however we draw attention to the message which says 'Touch to beam'. When this message appears, any input to the device other than that specific action is blocked. This will

naturally clash with the Stamped Manager, which is expecting a host card message instead of a 'Beam'

To solve this problem, we had to implement tight controls over how the Manager enables and disables its NFC chip, only enabling the chip whilst the reader is listening for a message from a host card.

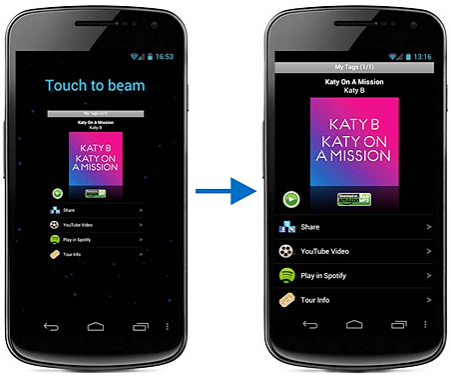

Figure 4.3: A demonstration of Android beam

ApplicationID Filtering

An Android device can emulate many smartcards simultaneously; however this is an issue for a NFC Reader as it will not be able to distinguish between the smartcards. We solve this issue through ApplicationID (AID) Filtering. Whenever a host card is setup, an ApplicationID must be assigned to it in the form of a hexadecimal string. An NFC Reader application can apply an AID filter with a matching hexadecimal string (Fig. 4.4) in order to identify and accept only the intended smartcard.

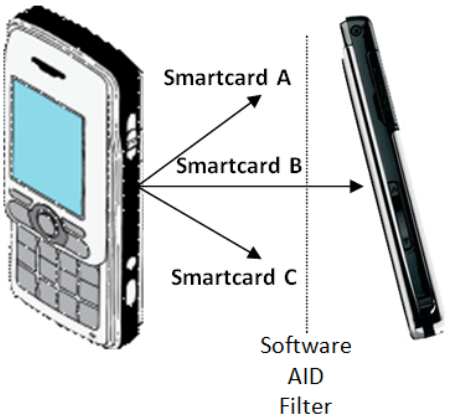

Figure 4.4: A schematic demonstrating software AID Filtering

4.4.3 Database Communication

A large part of the system interactions involve reporting back to the central database in order to sync 'stampbooks' along with user profiles. We deduced during the design stage that only the Stamped Manager will have access to modify entries in the database, whereas the user Stamped application will only be able to read from it – A discussion follows on the implementation of database communication for our system.

PHP Interface

Interfacing directly with SQL is highly difficult and insecure in the Android platform. To solve this a new interface had to be made using PHP. In this architecture, applications send `GET` and `PUT` requests to the server, identifying actions by using 'tags'. PHP in turn works as an intermediary, sending input to the database and providing output back to the Android application. Unfortunately this means that functions have to be written essentially twice, as they need to be written in JAVA to call a PHP, along with being written PHP to handle the input/output.

Database Requests

Requests to the database take time, and therefore must be threaded properly on mobile platforms. Android is very strict with regards requests what is allowed to run on the UI Thread. Requests that are recognised to be time consuming (i.e. Database requests) must be setup to run on a separate thread of execution. The adverse side effect of this requirement introduced the problem of race conditions in our UI.

Dealing With Race Conditions in the UI

Consider the following example – A user is syncing their 'stampbook' to see how many stamps they have for each of their loyalty schemes. The request runs in a background thread; however it does not update the new stamp values as they have already been drawn on screen. We fix this by constantly updating the views every few seconds. This solution was not ideal, nonetheless it did remediate our race conditions.

4.4.4 Internal Database Management

Storing information on Android can be non-intuitive. Basic credentials can be cached through plain text files; but in order to store the complex inter-relating data of our system. An internal database needs to be deployed to serve as local storage. Here we outline the novel challenges when working with both an internal and online database.

The Internal Database

Information gathered from querying the online database has to be stored somewhere, as a result, a `SQLite` database is setup with an identical schema. The idea is to have a clone of the parts relevant to the user (i.e. Account details, loyalty schemes, available rewards) of the online database stored locally. This vastly reduces the number of database calls that need to be made, as well as solving our information storage problem. On the other hand, it adds an extra layer of complexity as some SQL queries will still need to be run on the internal database **as well as** the online database.

4.5 Delivery of Requirements

Here we will compare how well the implemented system delivered on our earlier requirements.

4.5.1 Overview

Here we show a high-level overview of how many MoSoCoW requirements were completed.

- Must Have – 7/7
- Should Have – 3/6
- Could Have – 5/7
- Wont Have – 0/2

4.5.2 Requirement Fulfillment

M1 **Sign-In & Registration**
Users are able to sign-in to the system with their accounts

M2 **Fast Stamping**
Stamping in the adopted design is pervassive; therefore no buttons on the user interface is needed. Any tap on a listening reader will provide a stamp.

M3 **NFC Transmission**
Host Card Emulation is used to send messages over NFC.

M4 **Online Syncing**
The system actively syncs the status of user 'stampbooks' with the online database.

M5 **Sync on Interaction**
The `onRead` event triggers a sync with the database whenever an interaction between two devices take place

M6 **Syncing Time**
A fast backend and grouped data in the `JSON` format affords fast syncing.

M7 **Feedback on Interaction** *The system provides an audible sound and a notification whenever an interaction occurs.*

S1 **Consistency**
The system user interface was implemented using Google's Material Design.

S2 **Rewards Browsing**
There is a dedicated rewards tab to allow users to browse all available rewards for a loyalty scheme.

S3 **Badges**
Users are able to collect standard badges which earn a user 'title'.

C1 **Passive Card Emulation**
The system does use passive host card emulation.

C2 **Branding**
Some customisation options are available to schemes; however no frontend for them was implemented

C3 **Internet-Free Stamping**
Only Stamped Manager requires an internet connection in order to provide a stamp. Customers can sync their stampbook whenever they have an internet connection to update their local stampbook.

C4 **Multiple Device Support**
Having an online database affords the use of using your account on multiple devices - moreover they will be synced with eachother

C5 **User Personalisation**
Our system allows the personalisation of profile pictures and user-earned 'titles'.

4.6 Design Conformance

By following the criteria laid out in the design chapter, we managed to successfully produce two android applications which allow users to do the following:

1. Collect stamps for corporate loyalty schemes
2. Track progress of all loyalty schemes in real-time
3. Expend stamps in order to claim rewards
4. Collect badges to improve customer engagement

4.7 Conclusion

Throughout this chapter, we have concentrated on implementing a system in order to meet our requirements and design specifications. In the next chapter, we will introduce and perform a user field study to assess the system in a natural environment.

Chapter 5

Evaluation

5.1 Introduction

5.2 Field Study - Observation of The System In a Natural Environment

5.2.1 Pilot Study

5.3 Conclusion

Chapter 6

Discussion

6.1 Introduction

6.2 Conclusion

Chapter 7

Conclusions & Future Work

7.1 Conclusions

7.2 Future Work

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Appendix A

Interview Transcript

Tell me quickly about your role

I am a Business Analyst for the WREF (Worldwide Real Estate and Facilities) IT. My role within IT is facilitating any technological solutions required or requested by the WREF team; on or off-site.

What are Bike Miles within COMPANY A

Bike Miles within COMPANY A is a loyalty scheme for permanent COMPANY A staff members at 3 UK sites. Under the scheme, users who enter those sites are entitled to a sticker, which equates to £1 that can be spent in the bike shop (Evans Cycles). From the 3 sites that have the Bike Miles scheme, there are approximately 7000 staff members with 2100 users registered to the scheme of this, 800 active users (active users are those who have claimed more than £50 within the last year).This scheme is used to encourage our staff to get fit by riding to work, save the environment and help reduce the need for parking with the very limited spaces available at sites.

What's the current scenario now

The current scenario consists of the following:

1. Users come to the security barrier on site
2. They tear off a sticker
3. They then use their COMPANY A pass which opens the barrier, enabling them to enter the site
4. The sticker is put into a collecting paper card
5. The paper collection card is presented to the bike shop for money off

What problems are there to tackle?

With the existing there are a lot of problems to tackle as we believe people are abusing the system.

- Anyone can enter the scheme – Therefore we cannot track who is actually regularly riding their bikes onto sites. In regards to the 800 users listed above, they could potentially come into site in a car and still take a sticker.
- People are taking more than one sticker at a time, with no security preventing the problem
- Contractors are not entitled to the scheme, but could still take the stamps.
- We believe there is a 'black market' for the stamps whereby users are taking the stamps and passing/selling them on to other staff members.

What solutions have you guys thought about

We have looked at other ideas to try and overcome the problem, but under current COMPANY A policy no new applications can be submitted into the current pool of apps. With that in mind a solution was required whereby staff could use their existing COMPANY A

card to enter site and store Bike Money, or something similar with a smartphone:

- COMPANY As corporate device is the iPhone, an application with a QR code scanner which increments on a daily basis upon entering site
- NFC solution with sticker on the back of existing staff card – Or with the new iPhone 6 this is already incorporated.
- Fingerprint scanner (but no new applications)

What do you think of this solution? (The corporate loyalty app)

For this solution to be feasible and useful, it would need to be:

- Available for all of our permanent staff to use
- Easy integration for further sites and users globally
- Good usability aspects. COMPANY A has 100,000 staff members with a variety of demographics, therefore all users should find it easy to use and better than the existing process
- The system would need to increment on a daily basis when the staff members enter site (once a day only)

The corporate loyalty scheme is a great idea. Not only could it combat the issue of Bike Miles, as listed above, but it could also be used in conjunction with a lot of the other internal schemes that we have on site, such as Coffee loyalty scheme, gym membership, COMPANY A product store discounts (including online) etc.

Could it be considered by COMPANY A?

COMPANY A are always looking to improve, therefore if a product is received that significantly improves an existing process / technology it may be considered. Mobile phone applications have become more popular in general in recent years and this has rubbed off on COMPANY A staff members to change their perception (who previously were against mobile technologies). Also off the back of our recent success in winning an award for the Best Use of Mobile Technology Award (COMPANY A SiteMap App) we believe that mobile products can enhance our reputation internally and externally.

Appendix B

Initial Wireframes

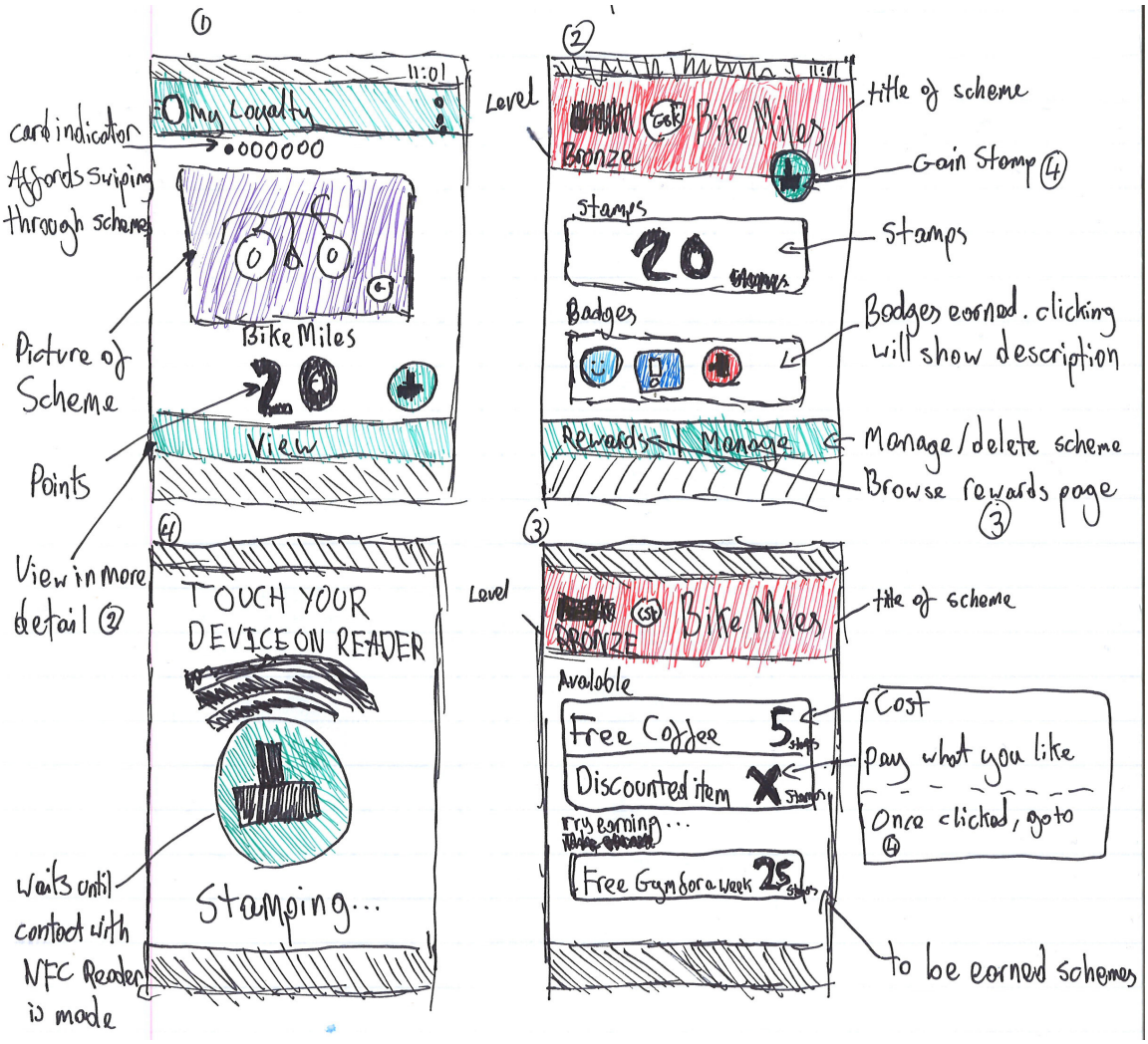

Figure B.1: The initial wireframes for the Stamped system