Designing a Software System to Improve Employee Motivation Through Behavior Change

HAMPUS HAMMARLUND
Designing a Software System to Improve Employee Motivation Through Behavior Change

HAMPUS HAMMARLUND
phham@kth.se

Master's in Computer Science
Date: December 15, 2019
Supervisor: Mathias Ekstedt
Examiner: Robert Lagerström
School of Electrical Engineering and Computer Science
Host company: KDDI Research Inc.
Host supervisor: Jaakko Hyry
Swedish title: Utformande av ett mjukvarusystem för att förbättra anställdas motivation med hjälp av beteendeförändring
Abstract

Due to unique circumstances, Japan is facing world leading rates of employee dissatisfaction. This trend in turn has had a ripple effect causing many other aspects of employee’s lives to be effected. One such area is work motivation, and in turn overall performance has also suffered. With the large impact this problem is having companies now have a financial incentive to help employees, beyond the social wellbeing argument that could be made before.

A solution to this problem that the current project explored is a software system to increase employee motivation through behavior change. Using a software system to collect voluntary data on employees, the individual needs of users can be determined. These individual needs can then be addressed through tailored behavior change intervention.

Through the course of the current paper the system’s architecture and evaluation will be covered. The current paper will also include the design of the behavior change intervention used during the experiments. Then from the results of these experiments it will be argued why the system designed and developed was a good solution to the problem of low employee motivation.
Sammanfattning


En lösning till det här problemet som den här projektet utforskade är ett mjukvarusystem för att förbättra anställdas motivation genom beteendeförändring. Genom att använda ett mjukvarusystem för att samla in frivilligt given information om anställda så kan deras behov bestämmas. De anställdas individuella behov kan sedan tillfredsställas med skräddarsydda lösningar.

Den här rapporten kommer att beskriva mjukvarusystemets arkitektur och utvärdering. Rapporten kommer också att beskriva konstruktionen av systemet för beteendeförändring genom påverkan som användes i projektet. Baserat på undersökningarnas resultat så läggs slutsatsen fram att mjukvarusystemet som utvecklats och realiserats är en bra lösning för att förbättra problemet med låg nivå av motivering bland anställda.
Acknowledgement

The first group of people I would like to give special recognition to are four researchers at KDDI Research Inc. that provided incredibly helpful guidance throughout the current project. Dr. Jaakko Hyry, Dr. Akio Yoneyama, Dr. Panikos Heracleous, and Dr. Masura Honjo. Additionally, I would like to thank the whole research group at the host company for their help and participation in the experiment of the system.

The final person I would like to thank is Dr. Akira Onozawa. It was with his help that I was able to conduct my master’s thesis in Japan.
# Contents

1 Introduction 1  
1.1 Research Question ................................. 2  
1.2 Scope ........................................... 2  
1.3 Outline ........................................ 3  

2 Background 4  
2.1 Motivation ....................................... 4  
2.2 Japanese Work Culture .............................. 5  
   2.2.1 Historical Context ............................. 6  
   2.2.2 Employee Motivation ......................... 8  
2.3 Behavior Change .................................. 10  
   2.3.1 Overview ................................... 10  
   2.3.2 Behavior Change Support Systems .......... 12  
   2.3.3 Persuasive Systems Design .................. 13  
2.4 Software Architecture ............................. 14  
   2.4.1 An Overview ................................ 14  
   2.4.2 Requirements Engineering ................. 14  
   2.4.3 Methods of Software Architecture Evaluation .... 15  
2.5 Existing Motivation Systems ...................... 16  
   2.5.1 General Form of Systems ................... 16  
   2.5.2 Patents ................................... 17  

3 Methods 18  
3.1 Project Timeline ................................. 18  
   3.1.1 Pilot Study ................................ 18  
   3.1.2 Full System ................................. 19  
3.2 Software Architecture Method ..................... 19  
   3.2.1 Story Boarding .............................. 20  
   3.2.2 System Requirements ....................... 20
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.2.3 System Design and Evaluation</td>
<td>21</td>
</tr>
<tr>
<td>3.2.4 Practical Evaluation</td>
<td>22</td>
</tr>
<tr>
<td>3.3 Behavior Change</td>
<td>23</td>
</tr>
<tr>
<td>3.3.1 Intervention Design</td>
<td>23</td>
</tr>
<tr>
<td>3.3.2 Behavior Change Evaluation</td>
<td>23</td>
</tr>
<tr>
<td>4 System Design</td>
<td>25</td>
</tr>
<tr>
<td>4.1 System Requirements</td>
<td>25</td>
</tr>
<tr>
<td>4.2 Behavior Change Design</td>
<td>28</td>
</tr>
<tr>
<td>4.2.1 Overview</td>
<td>29</td>
</tr>
<tr>
<td>4.2.2 Surveys</td>
<td>30</td>
</tr>
<tr>
<td>4.2.3 Activities</td>
<td>31</td>
</tr>
<tr>
<td>4.2.4 Priming</td>
<td>32</td>
</tr>
<tr>
<td>4.3 Final System Architecture</td>
<td>33</td>
</tr>
<tr>
<td>4.3.1 Overview</td>
<td>33</td>
</tr>
<tr>
<td>4.3.2 Central Repository</td>
<td>34</td>
</tr>
<tr>
<td>4.3.3 Smartphone App</td>
<td>36</td>
</tr>
<tr>
<td>4.3.4 Public Information Display</td>
<td>40</td>
</tr>
<tr>
<td>4.4 Implementation and System Flow</td>
<td>42</td>
</tr>
<tr>
<td>4.4.1 User Experience</td>
<td>42</td>
</tr>
<tr>
<td>4.4.2 User Grouping</td>
<td>45</td>
</tr>
<tr>
<td>4.4.3 System Diagram and Data Flow</td>
<td>46</td>
</tr>
<tr>
<td>5 Results</td>
<td>50</td>
</tr>
<tr>
<td>5.1 System Evaluation</td>
<td>50</td>
</tr>
<tr>
<td>5.1.1 Fulfillment of System Requirements</td>
<td>50</td>
</tr>
<tr>
<td>5.1.2 Practical Evaluation</td>
<td>50</td>
</tr>
<tr>
<td>5.1.3 User Grouping</td>
<td>53</td>
</tr>
<tr>
<td>5.2 Behavior Change Evaluation</td>
<td>54</td>
</tr>
<tr>
<td>5.2.1 Overall Results</td>
<td>54</td>
</tr>
<tr>
<td>5.2.2 Analysis</td>
<td>56</td>
</tr>
<tr>
<td>6 Discussion</td>
<td>57</td>
</tr>
<tr>
<td>6.1 System Architecture</td>
<td>57</td>
</tr>
<tr>
<td>6.2 Behavior Change Design</td>
<td>58</td>
</tr>
<tr>
<td>6.3 Ethical and Social Impact</td>
<td>59</td>
</tr>
<tr>
<td>6.4 Implementation</td>
<td>60</td>
</tr>
<tr>
<td>6.5 Future Work</td>
<td>60</td>
</tr>
<tr>
<td>7 Conclusions</td>
<td>62</td>
</tr>
<tr>
<td>Section</td>
<td>Page</td>
</tr>
<tr>
<td>-----------------------</td>
<td>------</td>
</tr>
<tr>
<td>Bibliography</td>
<td>64</td>
</tr>
<tr>
<td>Appendix A Surveys</td>
<td>69</td>
</tr>
<tr>
<td>Appendix B Factor Analysis</td>
<td>74</td>
</tr>
</tbody>
</table>
Chapter 1

Introduction

Rates of depression and general dissatisfaction are on the rise all around the developed world [1], with Japan specifically being heavily affected by this trend. For Japan one of the main contributions to this trend is a low level of work satisfaction. Since the 1960s Japan has scored the lowest on cross-national surveys examining satisfaction of workers [2]. This condition has been partially attributed to a phenomenon known as karoshi, death by overwork. The worker burnout in turn has also caused general decreases in motivation and employee efficiency.

Solving these problems has become a great concern for employers. Not just from a social responsibility sense of caring for others, rather there is a business argument for solving the systemic issues of Japanese work culture. The traditional solution to such problems would be to create a human resources policy to improve conditions. While this approach is a good start, they have intrinsic problems in that they are generally applied equally to everyone. The issue with blanket application is that not everyone has the same needs and those that need help the most may not engage with the solution.

This situation is where software systems can greatly benefit those in need, by increasing wellbeing and motivation. The needs of individuals can be measured, and solutions can be tailored to those that would benefit from it the most. With the increasing prevalence of technology in people’s everyday life, there is an equal increase in the possibility to use that access for the benefit of the user.

While improving the delivery of intervention to people is a crucial step in improving working conditions, the method by which intervention happens is equally important. The method for the current project is behavior change and persuasive system design. These frameworks for intervention design describe
a way to get people to change a targeted behavior, and ideally make a lasting change in the individual. The way these frameworks will be used for the current project is to develop intervention to encourage certain behavior that will lead to increased motivation and wellbeing.

Although the primary focus of the current project is to use software architecture to create a software system, the path for achieving that is complicated. Through the course of the current project and this paper many different fields will need to be understood and utilized. The background of motivation and Japanese work culture must be understood. How people are affected by behavior change must be put in context with the problem of motivation. Finally, using this knowledge, a method of system architecture can be developed and employed to create a powerful software system.

1.1 Research Question

The overall goal of the current project is to create a novel system to enable behavior change. In the pursuit of achieving this goal the following research question must be answered.

*What is the design of a software system that can improve employee motivation through behavior change?*

1.2 Scope

Aspects of the current project extend into areas not normally associated with computer science or software system design. Due to this breadth, it is important to clearly establish the limits and what the current project will actually focus on. To make things clear, the primary focus of the current project will be the design of a software system to achieve the goal of behavior change.

With the catalyst of the current project being behavior change and employee motivation through wellbeing, this subject will also be covered in the current paper. Due to the current paper not being in the field of psychology, all responsibility will not be on the author. The approach for the behavior change aspect will be to collaborate with researchers at the host company.

Now we will shift to set limits on what parts of system design that will not be extensively covered. One of the larger areas is security and privacy of user data, while these will be brought up, it will not be thoroughly discussed. Additionally, in depth explanations about the implementation of the system
will not be brought up. Some aspects of implementation will be presented, for example frameworks used, but specific architecture within those frameworks will not be covered.

1.3 Outline

The current paper will be broken down into the following chapters.

**Background**

This chapter will be split into two main topics. The first area will cover the reason the current project exists. Which includes an overview of motivation, Japanese work culture, and behavior change. The second topic will bring the focus onto software architecture and existing systems that attempt to improve employee motivation and wellbeing.

**Method**

This chapter will focus on the approach taken during the course of the current project. Which includes both the software architecture method and the approach to achieving behavior change.

**System Design**

The system design chapter will first cover the system requirements for the current project. Following the requirements the design for both the behavior change and the system architecture will be given.

**Results**

Two different areas will be covered in the results chapter. The first is an evaluation of the system in both the practical performance and the satisfaction of the system requirements. Additionally, an overview of the behavior change results will be given.

**Discussion and Conclusion**

The primary focus of the final two chapters will be to interpret the results presented and cover the implications of the system and its design. Included will be an analysis and possible future work for both the system itself and the behavior change design used.
Chapter 2

Background

With the current project containing many aspects not traditionally associated with computer science or software engineering, this chapter will primarily establish necessary background knowledge for those non-traditional areas. The first thing this section will cover is a short overview of what the literature says about motivation. With this groundwork established, the most important part to cover will be the Japanese context in which the current project takes place. To cover this context, the second section will cover two things. The first is the historical context that led to the current work culture in Japan. Second, a section on Japan-specific employee motivation will be presented. Following that section, we will transition to bringing up the main two components which inform the design of the software system: behavior change and persuasive system design. Each of these are frameworks for how to set up and cause a change in a behavior. The next major section of background that will be given is an introduction to how a system architecture can be created and evaluated. Finally, a review of existing systems will be presented.

2.1 Motivation

Before diving into Japan-specific background information, it is important to go over a couple general aspects of motivation. First, why motivation is important. To get organizations interested in changing, there has to be a material gain from implementing a new policy or system. When it comes to motivation it is not just about trying to have happy employees, there is a direct business benefit from investing in it. Several papers point to motivation and job satisfaction being closely associated with one another. This association leads to their increase or decrease causing work performance to also improve or suffer
Previous research has also strived to quantify the impact of depression and low motivation. For Japan, the total economic burden of depression in 2008 was $11 billion. With $6 billion of the total being direct workplace costs [1].

In order to understand motivation, you need to have a framework for what kind of factors actually impact motivation. One important framework for motivation is Herzberg’s Two Factor Theory [5]. This framework sets up two types of factors that play into motivation, hygiene factors and motivating factors. Hygiene factors are baseline needs that must be fulfilled in order for an employee to be in a state in which they can be motivated. These factors do not directly motivate, but without them a person cannot be effectively motivated, if at all. Examples of hygiene factors can be working conditions, salary, or job security. The other half of the framework is the motivating factors. These are the elements of the job that can actually increase motivation, and therefore job satisfaction and performance. Their absence won’t necessarily demotivate a person, but if they are applied correctly they can increase motivation. A few examples of motivating factors are achievement recognition, work responsibility, or advancement opportunities. Many different factors can seem like true motivating factors but are actually hygiene factors. What Herzberg’s theory indicates is that employees, like all people, desire a sense of fulfillment and sense of satisfaction with their lives. To motivate an employee they must have their base needs taken care of, additionally they must also be presented with an opportunity to achieve higher-order satisfaction. Understanding this framework is important for identifying actual motivating factors and ensuring the different factors are utilized correctly. See figure 2.1 for an overview of hygiene and motivating factors.

2.2 Japanese Work Culture

From a western perspective the work culture of Japan can seem drastically different. With stories of long working hours and immense pressure, or concepts like lifetime employment. In order to clarify common misconceptions, this section will discuss Japanese Work Culture. First, some historical context is required to understand how the modern Japanese work culture developed. From there, we will cover current employee motivation in Japan along with how it compares to western nations.
2.2.1 Historical Context

In the wake of World War 2, Japan went through major economic growth known as the Japanese economic miracle. This growth and restructuring led Japan to develop a unique economic style referred to as *communitarian capitalism* [7]. Over time this system developed into a working culture valuing communal agreement and success over the individual [8]. This social pressure of not wanting to disappoint others is also a contributing reason to the famously long working hours.

With all of this success and group agreement, what went wrong? The relationship between employers and the workers really started to unravel in the 1990s when the economic miracle came to an abrupt end. The Japanese economic bubble bursting represented an end to the massive economic development and growth of the national GDP. This recession moved Japan into the economic condition they are still in to this day, one of stagnation with ever increasing costs. In other more traditional forms of capitalism an economic downturn leads to a decrease in spending in an effort for firms to stay afloat. Under communitarian capitalism this cutting of spending was not possible. The social pressure of keeping existing deals and lifetime employment meant costs could not be significantly reduced. Without this release firms looked for other approaches. As a response to the economic crisis employers pushed for longer hours and extra days of work for no extra pay [2]. Many employees

![Herzberg's Two Factor Theory](image-url)
Table 2.1: Job embeddedness [9]. Examples of the three dimensions that keeps an employee at a job. Viewed as either on-the-job or off-the-job.

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>On-the-job</th>
<th>Off-the-job</th>
</tr>
</thead>
<tbody>
<tr>
<td>Links</td>
<td>Work friends and group members</td>
<td>Non-work friends and family</td>
</tr>
<tr>
<td>Fit</td>
<td>Personal values, career goals, and job knowledge</td>
<td>Local culture, weather, and activities</td>
</tr>
<tr>
<td>Sacrifice</td>
<td>Giving up great colleagues or supervisors</td>
<td>Giving up a local community</td>
</tr>
</tbody>
</table>

cracked under the pressure and most firms in Japan failed to recover from the recession. This condition created the phenomenon known as karoshi, death by overwork.

Into the mid- and late-90s the recession was still in full effect, causing a further worsening of conditions for many employees. A practice known as ijime began, a form of bullying of subordinates by supervisors and coworkers. This harassment was done as a way for people to vent their frustration with the condition of the company and the country as a whole. Many victims were driven into further isolation or in some cases even suicide. While these practices are looked down upon by the media and the country as a whole their effects have left a lasting impact on the workforce with many accepting it as the norm.

When comparing the work culture of different countries, one area that sets Japan apart from other western nations is the general reason employees feel attached to their work. One way this difference can be viewed is with the job embeddedness theory [9]. It breaks down what keeps people at a job into several categories which are split based on if it is on-the-job or off-the-job. These categories are links, fit, and sacrifice. See table 2.1 for a breakdown of these categories. Generally speaking, in western countries employees feel tied to the job by both on-the-job and off-the-job factors at about equal levels. Job embeddedness is very different in Japan where an employee’s attachment to a job is almost entirely based on-the-job related factors. This imbalance puts a lot of power in the hands of employers in their ability to keep people at a company.
2.2.2 Employee Motivation

In order to build a system to increase employee motivation, understanding what the employees value is required. It would just be a waste of resources to try and motivate employees based on a factor that does not affect any outcomes. This section first covers a comparison of worker motivation in Japan and other countries, followed by a thorough explanation of motivation specific to Japan.

When comparing Japan, the United States, and Germany there are unique aspects of motivation for each country [10]. These differences could be because the society of each country is based on different views of the individual. The United States is very individualistic with fairly low levels of power distance and uncertainty avoidance. With power distance being the gap of power between different ranks within a social hierarchy and uncertainty avoidance being the level to which an individual or group accepts the risk associated with an action. Germany is similar with its individualistic attitude, but has very low levels of power distance, masculinity, and uncertainty avoidance. While Japan’s culture can be characterized as masculine, with high uncertainty avoidance and low power distance.

What [10] also showed is that young and older employees in Japan value different things. Young employees being defined as under 35 and older employees being above 55 years old. For both age groups, having a good relationship with management and having an important job was seen as valuable. Although having an interesting job was more important for young employees as compared to older employees. Young employees had a couple more unique motivating factors, job security and independent work. These factors also line up with [11] that states that countries like Japan and the United States have seen rising levels of individualism, especially among young people.

With the previous paper establishing a difference of what motivates people in different countries it is crucial to identify specific motivating factors for Japanese workers. In [12] the researchers constructed a list of 15 motivating factors. These items were then used in a survey, where Japanese workers were asked to rate each item on a Likert Scale. The Likert Scale can be thought of as a rating scale, where a response is on a spectrum. The scale from the survey is 1 to 7, where 1 means the item does not have an impact on motivation and 7 means it has a high impact on motivation. The results of the survey, with the average rating and overall rank, are shown in table 2.2. The current paper used these results as a foundation for determining employee motivation and ways to improve it. The researchers also stated some conclusions that were very
Table 2.2: Employee motivational factor ranking [12]. Ranking of motivational factors by Japanese workers on a scale of 1 to 7. Higher rating meaning it contributes more to motivation.

<table>
<thead>
<tr>
<th>Motivating Factor</th>
<th>Mean Rating</th>
<th>Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sense of achievement</td>
<td>5.97</td>
<td>1</td>
</tr>
<tr>
<td>Salary</td>
<td>5.91</td>
<td>2</td>
</tr>
<tr>
<td>Work/job recognition</td>
<td>5.84</td>
<td>3</td>
</tr>
<tr>
<td>Fair evaluation</td>
<td>5.82</td>
<td>4</td>
</tr>
<tr>
<td>Self-growth</td>
<td>5.63</td>
<td>5</td>
</tr>
<tr>
<td>Quality of supervision and leadership</td>
<td>5.42</td>
<td>6</td>
</tr>
<tr>
<td>Company’s growth prospects</td>
<td>5.37</td>
<td>7</td>
</tr>
<tr>
<td>Job advancement</td>
<td>5.36</td>
<td>8</td>
</tr>
<tr>
<td>Amount of responsibility</td>
<td>5.30</td>
<td>9</td>
</tr>
<tr>
<td>Challenging work</td>
<td>5.29</td>
<td>10</td>
</tr>
<tr>
<td>Interpersonal relationship</td>
<td>5.24</td>
<td>11</td>
</tr>
<tr>
<td>Employee empowerment</td>
<td>5.18</td>
<td>12</td>
</tr>
<tr>
<td>Company policy and administration</td>
<td>4.99</td>
<td>13</td>
</tr>
<tr>
<td>Working conditions</td>
<td>4.96</td>
<td>14</td>
</tr>
<tr>
<td>Job security</td>
<td>4.80</td>
<td>15</td>
</tr>
</tbody>
</table>

important for the current paper. The overall trend of Japanese human resource (HR) style and employee motivation is a shift from the traditional community orientation to a more individual focus. These general trends can be seen in table 2.3.

With the workplace trend toward individual orientation, it is very important to understand the impact of merit-based rewards. Do they have a positive impact and if so, what types are the best? In [6] the researchers investigated the impact of merit-based rewards on job satisfaction, which can be correlated with motivation level. What they found is that merit-based rewards have a positive impact on highly educated Japanese workers. This trend was also seen in both men and women, although men saw a greater benefit from merit-based rewards as compared to women.

When looking at merit-based rewards, there are two main types that an employer can use: wage- and promotion-based rewards. In [13] the researchers examined the impact of both types of merit-based incentives. What they found is that both have a positive impact on employee job satisfaction. When comparing the two, having a fair promotion system was the more important factor
Table 2.3: Japanese HR style trends [12]. The younger generation has made a push toward a more individualistic view of work and their role in society.

for job satisfaction and motivation. From this result the researchers suggest enriching jobs in terms of responsibilities and development with wage increases following that track.

Understanding what motivates different types of employees is a vital component in tailoring an intervention strategy to that group of people. Using this context was an important part of constructing the system for the current project.

2.3 Behavior Change

The end goal of the system for the current project was to increase employee motivation. To actually achieve this increase in motivation a concept known as behavior change was utilized. To give an understanding of behavior change this section will first give an overview of the field, and then cover two leading frameworks, behavior change support systems (BCSS) and persuasive systems design (PSD).

2.3.1 Overview

Behavior change as a field is very broad and can contain many different areas of research. In its simplest form, behavior change as a concept describes the attempt to get an individual to change a targeted behavior through changes in attitude [14]. To get more fundamental, it may be good to understand behavior itself. One good way of understanding behavior is the Fogg Behavior Model [15]. There are three elements to the model: motivation, ability, and a prompt. As can be seen in figure 2.2, sufficient motivation and ability is required for a prompt to cause a behavior to occur. Conversely, lacking motivation or ability will cause a prompt to have no effect. Viewing any given behavior through this lens can give valuable insight into how people act.
Figure 2.2: Fogg Behavior Model [15]. The graph represents the dimensions that determine if a prompt will successfully cause a behavior to happen. Original image created by Goodmanguy is licensed under CC BY-SA 4.0. License is available at https://creativecommons.org/licenses/by-sa/4.0/

There are many topics and theories related to behavior change. All of them seek to explain how and why people perform certain actions. Two of the best regarded papers include the Theory of Reasoned Action [16] and the Theory of Planned Behavior [17]. Each of these theories explain behavior as being based on the individual’s attitude toward the behavior. Whether that is the subjective norms about the behavior or the level of difficulty in performing the behavior. With the rise of technology, a new avenue to influence behavior has become available to researchers. From this expansion papers like the Technology Acceptance Model [18] have been written to explain an individual’s intentions. What this paper outlines is that a system’s perceived usefulness and ease of use will determine an individual’s intention to use the system. To create a good system perception is key, but backing it up with a solid core product is vital.
Table 2.4: BCSS outcome and change design matrix [14]. Used to determine what kind of change the system is trying to accomplish.

### 2.3.2 Behavior Change Support Systems

Taken from the prominent theory crafting paper on the subject, "A behavior change support system (BCSS) is a sociotechnical information system with psychological and behavioral outcomes designed to form, alter or reinforce attitudes, behaviors or an act of complying without using coercion or deception." [14]

The paper proposes a framework for designing a BCSS known as the outcome/change (O/C) matrix. The matrix describes three successful changes: complying, change in behavior, or change of attitudes. This list represents an ascending order of difficulty. Where complying is simply getting the user to perform an action without any underlying changes. An example of this change could be a system reminding the user to take their medication. While a change in attitude represents a shift in the user’s thought process. Each of these changes intersects with different types of outcomes: forming, altering, and reinforcing. Forming outcome means the formulation of a behavior that did not exist. Altering outcome means changes in a person’s existing response. Finally, reinforcing outcome represents reinforcement of a currently held behavior. The interaction between these outcomes and changes can be seen in table 2.4.

When designing a BCSS much thought must be put into what the goal is and where on the O/C matrix the system falls. With this framework in mind you must remember that unlike general information systems, the role of a BCSS is to modify the user’s behavior. Because of this direct goal, much more care must be taken in the design process. Along with other considerations like ethical issues around influencing people.
1. Information technology is never neutral.
2. People like their views about the world to be organized and consistent.
3. Direct and indirect routes are key persuasion strategies.
4. Persuasion is often incremental.
5. Persuasion through persuasive systems should always be open.
6. Persuasive systems should aim at unobtrusiveness.
7. Persuasive systems should aim at being both useful and easy to use.

Table 2.5: Postulates behind persuasive system design [19]. These postulates must be considered when creating a system with the purpose of influencing a user.

### 2.3.3 Persuasive Systems Design

To get people to actually change their behavior can be a very challenging task. It is not as simple as telling people to do something or coercing a behavior. To create effective behavior change methods we can use a framework known as persuasive systems design [19]. The authors present seven postulates that must be considered when designing or evaluating a persuasive system. These items cover a wide range of factors for a persuasive system. From how we view users to how system features should work. See table 2.5 for a full list.

When designing an intervention method, it is crucial to understand the persuasion context. This context can be broken down into three elements: the intent, the event, and the strategy.

The intent can be thought of as who the persuader is. When the system is electronic the system obviously cannot have intention of its own, so for example the entity that put it in place could be the persuader. From [20] there can be three different sources of intent. Those who create the system, those who distribute the system, and the person adopting the system. It is important to note that for a system to be ethical the intent and bias behind the system must be disclosed to the user.

For the persuasion event the primary thing to consider is the use context. Depending on the problem being looked at, different approaches should be considered. In general, persuasive systems should aim at reinforcing good attitudes and make them easy to do, even in challenging situations. Along with use context there is the user context, which refers to the differences in individual ability and needs. The final aspect of the persuasion event is the technology context. When designing a persuasive system, the strengths and weaknesses of the specific technology must be considered. Put simply, just
because one technology worked in one situation, doesn’t mean it will work in another context.

The final element of the persuasion context is the strategy. This element is fairly straightforward, it simply describes the way behavior change would be implemented. One of the central questions when considering the persuasive strategy is the route by which to reach the user, be it direct or indirect. The strategy must be tailored not only to the problem that is trying to be solved but also the type of people being targeted.

### 2.4 Software Architecture

Software architecture is often thought of as a list of technologies to be used, or diagrams of different parts of the software stack [21]. When in reality, software architecture is much simpler and more elegant. In its most basic form, software architecture represents "the set of principal design decisions about the system" [22]. In this section an overview of software architecture will be given along with prominent methods.

#### 2.4.1 An Overview

The use of software architecture has become one of the primary ways to evaluate a software system’s overall quality [23]. Although, the concept of predicting a software’s quality based on the high-level design is not a new one. Several decades ago, in [24] the authors describe the use of modularization as a way of improving flexibility and comprehensibility. Additionally, in [25] they introduce the idea of module coupling and cohesion in order to evaluate alternatives for program decomposition.

Creating a software architecture for a system is, however, not a guarantee of success. But what it does do, is set boundaries for the quality of the system being created [26]. A terrible design puts a ceiling on how good the system can be. While a great design allows for a well-built system, with a floor on the quality. Having defined paths and procedures in design and evaluation is how a great design can be created and then realized [27].

#### 2.4.2 Requirements Engineering

Creating an architectural design can be a daunting task, with it being challenging to identify where to even start. For any software architecture approach the starting point is to define what a system needs. One method for defining these
needs is known as requirements engineering [28]. Put simply by [29], "Requirements engineering is the branch of software engineering concerned with the real-world goals for, functions of, and constraints on software systems. It is also concerned with the relationship of these factors to precise specifications of software behavior."

The crucial aspect of this definition is the connection to real-world goals. Requirements engineering must act as the bridge between what is desired and what is to be made. They also represent the what and the why of the system [30]. What this approach provides is that during the development of a system you should be able to continually refer back to the requirements to evaluate the process of design and development.

A requirements document can also provide security for all parties involved with the development of a system [31]. For example, with a group of investors, managers, and developers each of these groups can have a different way of looking at and approaching problems. Leaving a goal vague can cause miscommunication that could result in large disagreements further down the project timeline. Instead, if an explicit requirements document has been produced and agreed to then there can exist an objective point of reference for any discussions during and at the end of the project life cycle.

2.4.3 Methods of Software Architecture Evaluation

When building a software system’s architecture there needs to be a continuous process of evaluation. This process is to determine if the design is on the right course and whether it is fulfilling the requirements set out for the project. From [28], there are many varying approaches to evaluating the strength of an architecture, this section will go over a few main methods.

One method of evaluation which is very useful is scenario-based evaluation. This method can be a powerful way to assess the quality attributes of a system by running the proposed system through a series of hypotheticals. An example the author brings up is testing the maintainability of the system. If a given change would be required to be made to the completed system, how difficult would such a change be to implement. This kind of evaluation is powerful for the reason that it can be used to test the system with realistic situations and link them to specific attributes of the architecture.

A second method is simulation-based evaluation, which can be used to test quality and functional attributes of the system architecture. The difference between this method and the scenario-based method just brought up is that simulation analysis addresses specific execution sequences rather than more
broad scenarios. An example of how this method can be used is to test the operational capacity of the system. If given a chain of inputs, what does the system do and where does any data flow.

To shift into a more objective measure, mathematical models can be a powerful tool for system evaluation. Different from the other two approaches, this method allows for a static evaluation of the architecture. How this method takes shape can vary greatly depending on the type of system being built. One example the author brought up is performance measurement. Based on the expected input what are the performance requirements of the system.

There are many other methods for architecture analysis which vary in importance depending on the project at hand [32]. The three presented here are a general overview of some of the basic approaches that can be taken.

### 2.5 Existing Motivation Systems

With the increased focus on general employee wellbeing there have been many efforts to identify and try to solve problems in the workplace. These have come in the form of general human resource initiatives and information technology systems. This section will cover some of the different types of systems that exist as well as a couple patents related to the current project.

#### 2.5.1 General Form of Systems

Generally speaking, previous systems fall into one of two categories. The first type are systems that just collect data related to employee motivation and wellbeing. These can take the form of either physical or digital surveys. Many of these systems do not seek to directly solve the problem, but instead find trends and explore the perceived problems. Examples of this kind of system are the previously cited studies on employee motivation.

On the other end of the spectrum are the systems aiming to solve a problem directly. The second type of system is a blanket application of an intervention method on employees without any tailoring to individual needs being considered. These kinds of initiatives can be effective, as found by [33] over a series of companies. Targeting prevalent problems and applying it to everyone can increase overall motivation and wellbeing. One specific example of this type of system is Unipos¹, a platform for showing appreciation through a

point-based system. The goal is to get people to give positive feedback and encourage coworkers to help each other.

Another example of a similar system is Happydonia\(^2\), developed by a company in Spain. On the surface this service is trying to provide a very similar result as what we are trying to achieve in the current project. Their goal is to use a platform to increase internal communication and improve the overall quality of employee communication. Achieving this goal is done by providing multiple features to make it easier to communicate with coworkers. The approach for this system is similar to that of Unipos, everyone has access to the system.

### 2.5.2 Patents

Fortunately, when looking into patents related to motivation systems, nothing was found that exactly matched the proposed system. There are however, two patents that are related and somewhat similar that can be helpful to consider.

The first patent\(^3\) proposes a system that automatically matches changes in behavior to defined states and motivational profiles. The use of behavior and motivation in this patent are much broader than their use in the current paper. Additionally, the patent describes its use for general improvements in a user’s lifestyle, including physical and mental health. As of the writing of the current paper the status of the patent is abandoned.

Another patent\(^4\) focuses on matching collected data to behavior change. Specifically collecting data through wearable or mobile devices. Part of the patent also includes using the data to identify a habit which then has behavior change applied to it, if it is deemed to be negative. Based off of the diagrams given, this patent’s main focus seems to be fitness and physical wellbeing. Like the previous patent, this patent is also abandoned.

---


Chapter 3

Methods

This chapter will cover the methodology of the current paper. The first section will go over the timeline the current project took. With the current project being primarily about software architecture outlining the design process is very important. Because of this focus the following section this chapter will cover is the software architecture method. The final section that will be covered is how behavior change will be handled.

3.1 Project Timeline

A fundamental aspect of the current project is designing around the needs of people. With this human element the development needed to be split into two main parts. These parts were setup to inform the design of the following components. This section will cover the purpose of each of these steps and why they were deemed necessary. See figure 3.1 for a rough timeline.

3.1.1 Pilot Study

Much of the research conducted for the literature study of the current project was done on employee motivation, specifically on the Japanese workforce. In an attempt to validate our review and initial assumptions, the first step in development was to create and distribute a survey on various motivational factors.
This survey was done for two main reasons. The first reason was to see if we could reproduce similar results as found in the literature and to understand the general trends in the host company. The second reason was to inform what motivational factors development would focus on. Due to the limited time of the current project, selecting the motivational factors with the greatest impact was vital. If the most important factors could be selected, they would then be the focus in the proceeding steps.

3.1.2 Full System

Once the motivational factors to focus on were selected, work on the full system could begin. With data collection and measuring the human experience of using the system being a vital component, the release schedule of the system was split into two phases. This phasing was done to get an initial version in the hand’s of the users while the bulk of development was completed.

For the first phase of development the main focus was on creating a system that could collect survey information about the users. This phase would include a smartphone application as the user’s main point of access, and a server to hold all of the collected data. Having this initial version distributed to users would allow for quick data collection and to observe any possible changes after behavior change intervention was administered. More details about this decision will be given in the design chapter.

The second phase of the system would include the primary purpose of the current project, the behavior change intervention. This update was distributed about one month after the start of the first phase. For the remaining time left of the current project, approximately two months, the experiment of trying to increase employee motivation would be carried out. With a flexible design of the different components of the system, changes and iteration on the design would continue during the experiment.

3.2 Software Architecture Method

The primary aspect of the current project is the design of a software system. In order to ensure that any architecture produced can be effective and efficient, a formal design process must be established. This section will cover the steps used to create the software system described in the current paper.
3.2.1 Story Boarding

Unlike a software system that only serves a technical or backend purpose, a system that primarily interacts with regular people brings with it unique challenges. Working through technical use cases is an important part of this process as well but formulating how a user would or should interact with the system is crucial for the current project.

This aspect is why the first step of the design process was to consider how the user was to access the system. Creating simple user stories was the chosen way to fulfill this step of the process. Storyboards can be as simple as illustrating a notification system, like the example in figure 3.2. They allow a simple overview of what kind of interaction the user could expect but also the kind of information that they would want to see in a given context [34]. Moving a project from the abstract into a more real context allows the designer to consider problems and solutions they might otherwise not have. These simple storyboards can then be used as an important resource in constructing the system requirements during the next step of the design process.

3.2.2 System Requirements

As discussed in the background chapter, requirements engineering can be an effective way of assembling all of the necessary pieces the system requires. This step not only focuses on the functional requirements of the system but the qualitative aspects as well. For the functional requirements these can link directly to components of the final design and implementation. The quality requirements can be broken down into development quality requirements and operational quality requirements [28].

The development quality requirements are those relating directly to the software engineering. How maintainable, reusable, or flexible is the system
are some of the important factors. On the other end of the spectrum are the operational quality requirements. These requirements relate to how the software system behaves in action, for example performance and reliability. Like previously stated, these requirements are not easy to link to direct components of the system. Rather they are an emergent property of the system as a whole.

Going through the requirements engineering is not only important from a design perspective but it can help in other areas as well. As the current project, and many others in the industry and academy, is conducted at a host company where there are expectations from external sources. Compiling a complete document of all the aspects of the system before the primary design or implementation work is done can help to ensure all parties are satisfied with the final product. For projects spanning several months, or even years, this process can be even more important. It can keep a project centered on the original goal and not let development stray unnecessarily.

### 3.2.3 System Design and Evaluation

With the system requirements in place the core of the architecture design work can take place. This process can be split into two main components, the functionality-based design and the evaluation of that design and the quality-based aspects. An overview of this process can be seen in figure 3.3.

Using the system requirements as input, the top-level design of the soft-
ware system is first created. It is important that this design begins with the
greatest level of abstraction possible. Once these entities have been identified
then work on their interaction can begin. This process describes a top down
approach, working from most abstract to a concrete design. While in this stage
of the process, the only concern should be with the functional requirements of
the system. Completely detaching the design from the quality aspects is not
possible but keeping the focus on the functionality allows for a general and
repeatable process.

Once a design that satisfies the functional requirements has been created
it is time to evaluate and assess the quality of the design. Performing a true
evaluation of the final system at this stage is not possible, so the aim of this
step is to look at the potential of the design from multiple perspectives. To put
the design through multiple trials the current project will use three approaches.
The first is scenario-based evaluation. This approach will primarily be used to
assess the maintainability and flexibility of the system and to ensure develop-
ment quality [28, 35]. A set of scenarios will be created to test the challenge of
updating the system to conform to a change in the overall system requirements.
The second approach is simulation of the architecture. Using this approach,
the design of the system can be tested to see if given a set of inputs will the
system return the correct output. This task can test both the quality require-
ments and the functional requirements of the system. The final approach is a
subjective analysis of the system as a whole. Given the previous experience
of those involved in the current project, does the design and purpose of the
current project fit together or does the hypothetical implementation feel right.

With the architecture now being put through the various evaluation strate-
gies it will be known what works and what must be redesigned. This step is
where the process of architecture transformation comes in. Given the identi-
fied areas of improvement it will be up to the designer to trace the problem to
its source and change the architecture to conform to the system requirements.
This task can take the form of changing the design or even the context of the
system itself. Once all of the changes have been made the evaluation of the
system architecture is repeated. This loop of evaluation and transformation
continues ad nauseam until all functional and quality requirements are satis-
fied.

3.2.4 Practical Evaluation

The scope of the current project is not limited to only creating a system design
but also to implement and test it. Implementation of the architecture followed
standard practices in the respective environments along with code quality and
testing. For the current project, testing the system practically required distribu-
tion of the system in the research group of the host company. This testing
allowed for validation of the architecture from a design and technical perspec-
tive, but also gave initial results for the behavior change aspects of the current
project.

3.3 Behavior Change

3.3.1 Intervention Design

With behavior change being a field that falls outside of traditional computer
science this aspect is an element of the current project that was done in col-
laboration with a behavior change researcher at the host company.

The behavior change methods were designed to increase employee motiva-
tion. To accomplish this goal the frameworks set out in BCSS and PSD were
used. Utilizing these frameworks allows for the creation of valid and effective
behavior change methods. As mentioned in the project timeline section, the
intervention used was selected partially based on the data that was collected
during the course of the current project. This work was done not only to val-
idae the findings from the literature, but to also narrow down a promising
factor that could be effective at the host company.

3.3.2 Behavior Change Evaluation

The core purpose of the current project is to design and develop a software
system, specifically from a architectural and technical perspective. While not
crucial to the success of the current project, the performance of the behavior
change methods are an important aspect to analyze. The effects of the behavior
change methods are measured in several different ways.

- Change in wellbeing over time
- Participant observation
- Subjective analysis

One aspect of the system is to conduct regular surveys designed to measure
the overall wellbeing of the participants. The same set of surveys were dis-
tributed before and after the behavior change methods were introduced. This
follow-up was done in hopes that an overall change in wellbeing could be observed in the users.

The last two types of analysis that was done was to see if there was an observable change in the behavior of the users. Both participant observation and subjective analysis can be used to see if there is a noticeable change in the user’s behavior or the overall mood of the group. This approach is an important method because it can be used to assess the potential of a system that the data might not show.

It is important to note that these analysis methods were designed with some input from experts in the field. But any results or conclusions about the behavior change method’s effectiveness should be viewed skeptically and be seen as early findings that, at best, can motivate further research.
Chapter 4

System Design

This chapter will cover the design of all aspects of the system. The first section will go over the overall purpose of the system, which will include different use cases, the system requirements, and the design of the behavior change that will be used within the scope of the current project. After the higher order purpose of the current project is detailed, the next section will cover the design of the software system itself. The final section will then cover the implementation and the flow of the system.

4.1 System Requirements

At the core of any good system design there must be a clear overarching purpose. The aim of the following section will be to focus on some example storyboards and the system requirements. As discussed in the method chapter, creating storyboards representing basic usage of the system can be a powerful way to draw out the system requirements. To demonstrate this flow, this section will first present a few examples of storyboards, with explanations, followed by the requirements for the full system.

In its most basic form, the purpose of the system is to improve employee motivation and overall wellbeing. These kind of basic concepts can be expressed in a simple storyboard, as seen in figure 4.1. Creating storyboards like this example are a good way to start thinking about the form of a system. In this example storyboard, the use of the system should give the user some kind of tangible benefit.

Moving to more concrete example storyboards, figure 4.2 and 4.3 each represent specific aspects of the system. In figure 4.2, the storyboard shows the idea that the system should allow for active engagement and some way to...
reengage the users to perform some task. From this storyboard we can draw many functional requirements, for example a reminder system or dynamically generated content. Shifting to the storyboard in figure 4.3, it represents another component of the system: presenting content to the user to prepare them to actively engage with the system later. An example of a system requirement that can be taken from this storyboard is that different components in the system should be consistent in the result they are trying to achieve or the information to show to the user, allowing the user to associate and remember.

The design process being used for the current project splits the overall system requirements into two categories, functional- and quality-based. The list of functional- and quality-based requirements are presented in table 4.1 and 4.2, respectively. Each requirement is given a title and further explanation. Both sets of requirements will later be referenced in Section 4.3 demonstrating and justifying how they are fulfilled. For a full list of explicit justifications for each, see Section 5.1.1. These requirements represent the overall system,
requirements for specific components are given in their respective sections.

The set of functional requirements comes directly from what the system is required to achieve. While the quality requirements are a more mixed case. Some quality requirement items can come specifically from the type of system being designed, but most of the quality requirements are based off of general attributes of a software architecture [36]. With the quality-based requirements not necessarily coming directly from features of the system it is important to elaborate on each one. As was brought up in [28], quality attributes can be split into two categories: development and operational quality requirements. The remainder of this section will elaborate on the quality requirements based on this breakdown.

For the current project, the two development-based quality requirements are maintainability and flexibility. First up, maintainability refers to the ease to which a design and system can be kept running and updated over time. This attribute has a direct material cost during the lifetime of the system. A system with a low level of maintainability will require engineers to spend more time and effort performing maintenance tasks. The way maintainability can be evaluated is with defined scenarios for common tasks associated with keeping the system running [35]. Next, the requirement of flexibility can also be a way of viewing future costs of a system design. As a simple definition, flexibility is the ease to which a system can adapt to change. One way to view this requirement is the level of dependency different parts of a system have on each other. A system with a high level of flexibility would allow for easy swapping of components. Like maintainability, flexibility can also be evaluated through defined scenarios [37]. An example scenario could be switching platforms. Playing out this scenario will show how many different components
would need to change because of that switch in platforms. When it comes to determining if the requirements have passed the evaluation, both of these requirements can be considered fulfilled when predicted work and costs reach an acceptable level.

Moving over to the operational-based quality requirements, the remaining quality requirements fall into this category. First we can cover the two more concrete requirements, performance and security. What makes them more concrete is the relatively simple goals that can be created for each one and their evaluation strategy. For performance, we can set a specific target and use simulation-based evaluation to determine if the designed system could achieve its performance goals given a realistic set of inputs [28]. Similarly for security we can create an abstract set of rules and then create a set of simulations to see if any of these rules can be violated. As this is the design portion of development, practical evaluation of security comes later in the process, but the real world security is based off of the rules created during design. Shifting over to the remaining two requirements, ease of access and usability, they are more subjective by their nature. One of the primary ways to evaluate them comes down to a subjective analysis to see if what has been designed is reasonable and fits within generally accepted standards and practices. These standards will vary depending on what component is being designed, but for example good usability would be a UI design that conforms to what a user would expect on a given platform. For both of these requirements the use of scenario-based evaluation can also be utilized to test the system [38]. For example, ease of access can be evaluated to test if a user could access the system in a way they would expect or want to. A similar process can be taken for usability with scenarios based around concepts such as learnability or efficiency. Each of these requirements are crucial to the correct and smooth operation of the system, whether it is from a technical perspective, with performance and security, or from an experience perspective, with ease of use and usability.

4.2 Behavior Change Design

The core goal that the system in the current project is trying to accomplish is to increase employee motivation through behavior change. Specifically, trying to encourage behavior that increases overall wellbeing. Due to the time limits placed on the current project, the specific behavior change that can be implemented is restricted. In this section the type of behavior change that will be used is covered along with the components that go along with that method.
<table>
<thead>
<tr>
<th>Requirement</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>User profile</td>
<td>A user should be able to maintain a consistent user profile to allow tracking of data over time.</td>
</tr>
<tr>
<td>User anonymity</td>
<td>Data collected by the system should maintain user anonymity.</td>
</tr>
<tr>
<td>Dynamic content</td>
<td>Content in the system should be able to be updated and added over time.</td>
</tr>
<tr>
<td>User engagement</td>
<td>The system should be able to prompt users to engage with content when relevant.</td>
</tr>
<tr>
<td>System consistency</td>
<td>Different components and users in the system should have access to the same data to maintain consistency.</td>
</tr>
<tr>
<td>Data collection</td>
<td>The system should be able to survey users on various subjects and retrieve responses.</td>
</tr>
<tr>
<td>Content targeting</td>
<td>The system should be able to provide different content to different users based on a set of rules.</td>
</tr>
</tbody>
</table>

Table 4.1: Functional requirements of the overall system.

### 4.2.1 Overview

Following the literature study conducted for the current project, validating what was found became important. We wanted to confirm if the broad trends of employee motivation in Japan were consistent in the host company. To do this validation a survey of motivational factors was constructed and sent to various groups at the host company, see table A.3 for a full list of questions. From this survey it was determined that the overall trends in Japan generally lined up with the environment at the host company. For example, the highly ranked factors included items like self-growth and social relationships. A more in depth explanation of the results is presented in the results chapter, Section 5.2.

From these findings it was decided that social relationships would be the best motivational factor to focus on for the current project. This decision was made for a few reasons. The main reason was that the various motivational factors related to social relationships covered the whole range of employee categories, specifically age and job position. Secondly, according to the literature concerning social relationships in the workplace, increasing it can bring many different improvements, such as team cohesion [39, 40], making it a powerful factor to target for behavior change. The third reason it was chosen was its relative simplicity to implement in the time frame of the current...
<table>
<thead>
<tr>
<th>Requirement</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ease of access</td>
<td>Users should be able to easily access the system on a convenient platform.</td>
</tr>
<tr>
<td>Performance</td>
<td>The experience of using the system should be smooth and without significant load times for the user.</td>
</tr>
<tr>
<td>Flexibility</td>
<td>Given changes in requirements the architecture should be able to be changed with minimal effort.</td>
</tr>
<tr>
<td>Maintainability</td>
<td>The system should be able to be updated and maintained by any development team without significant challenges.</td>
</tr>
<tr>
<td>Usability</td>
<td>Interaction with the system should be straightforward and adhere to accepted design principles.</td>
</tr>
<tr>
<td>Security</td>
<td>The data in the system should be protected from both other users of the system and unauthorized access.</td>
</tr>
</tbody>
</table>

Table 4.2: Quality requirements of the overall system.

project. Other factors such as sense of achievement or self-growth are much more abstract and harder to target. While social relationship factors are more straightforward and easier to plan around.

With the factors that we want to target selected, the components of the behavior change method needs to be constructed. For our system this design consists of three main parts, surveys, activities, and priming. These components will be explained in the remaining parts of this section.

### 4.2.2 Surveys

Collecting data is an integral part of a behavior change system. Not only in determining if intervention was successful, but also to decide who is targeted by what approach. These two goals of data collection are what will be used in the system.

For determining how the behavior change intervention will be used, some information about the users is necessary. The primary way this data collection was done was to have users complete a motivational factor survey, similar to the one distributed in the pilot study. The goal of this survey is to categorize the users based on the kind of factors that motivate them. Collecting this information will allow for tailored intervention based on their needs. These decisions about targeting will further be informed by some demographic data about the users. Questions like age or job title can influence how someone should re-
In most ways my life is close to my ideal.
The conditions of my life are excellent.
I am satisfied with my life.
So far I have gotten the important things I want in life.
If I could live my life over, I would change almost nothing.

Table 4.3: Wellbeing survey example. Each question is answered on a scale of 1 to 7, where 1 is strongly disagree and 7 is strongly agree.

The second type of survey is used to determine if the behavior change is effective. This task took the form of surveys with questions about the general wellbeing of the user. The questions in the surveys were taken from well regarded surveys in the field of psychology. A total of 5 surveys consisting of 5 to 7 questions each were used. See table 4.3 for an example survey, the full list of surveys are available in Appendix A, tables A.4-A.8. Users received one new survey a week, finishing all 5 surveys before any behavior change intervention was implemented. Then after the whole set was finished the intervention was added and the same set of surveys was done again. The goal was to get a before and after view of the participant’s wellbeing, with respect to the behavior change methods. Taking the surveys over a longer period of time was done in order to get a larger time frame of data and to decrease the effect of outliers, such as very good or bad days.

4.2.3 Activities

With the interpersonal relationships being the chosen target, an intervention method for how to encourage it needed to be developed. In order to cast as wide a net as possible the main focus we decided to encourage was informal interaction. The reason for this decision was that if informal communication at work increases it would in turn increase team cohesion and improve many different aspects of interpersonal relationships.

To facilitate informal communication, people need to be put in situations where they would be more comfortable speaking casually. The setting with the lowest barrier to entry for socializing to take place is activities happening...
during or directly after working hours. Examples of these situations include eating lunch together, talking during breaks, or meeting for dinner and drinks after work (a very common event in Japan). The structure we created is an activity system where any person can create an event and other people can reply with whether they are interested or not.

The proposed method of intervention also solves for those that do not feel included or are too shy to make a move to join social events. An argument could also be made that this goal could be accomplished with some human resources initiative, rather than creating a software system. The value we see in the system is the ability to target the people who actually need the help and give them personalized feedback. Additionally, more features can be added to the system in the future, targeting different factors.

### 4.2.4 Priming

Two of the major aspects of behavior change is to get the subject to view the change favorably and to have them feel like they brought it upon themselves. One of the ways this feeling can be accomplished is through a concept known as priming. This concept represents "a nonconscious influence of past experience on current performance or behavior" [42]. Or put more simply, by presenting a subject with a stimulus you can affect a decision they will make in the future. An example of stimuli effecting basic behavior was done in [43]. The walking speed of two groups was observed, one group was primed with stereotypes about elderly people being slow while the other group was presented with neutral descriptions. The group that was primed was then observed to walk slower than the group that was not primed.

In the current project, our goal is to take this priming concept and use it as a way to enhance our behavior change method. The basic approach was to attempt to influence people to react more positively to the idea of doing informal activities with coworkers. This approach can be done by priming people with positive messages about the activities or create social pressure by bringing up that people have enjoyed previous events. With this positive association in their minds we hoped this would increase the chances of people engaging with activities. Performing this kind of subconscious influence has ethical implications, which is brought up in the discussion chapter.
4.3 Final System Architecture

This section will cover the architecture design of the system for the current project. The first area that will be covered is an overview of the major components of the system. Each of these components will then be broken down further in more detail for the remainder of this section. This breakdown will include higher order explanations in the abstract but also go into some basic implementation design.

4.3.1 Overview

Before breaking down the system into components, it is important to understand the general flow of information and the process for decision making. An overview of this process can be seen in figure 4.4. Before the system can perform its main function, it must collect information from the users. This data collection comes in the form of surveys, and as brought up in the previous section, these surveys are primarily the motivating factors and wellbeing survey. From this data users are automatically sorted into different groups based on their individual need. With the different groups formed, targeted intervention can be performed. For the current project intervention takes the form of activities for those that need an increase in social relationships. This point is the start of the main loop of the system. Over the course of the intervention user feedback is collected to measure the impact of the intervention. With this new data the grouping of users is reevaluated and any necessary changes are made. From these new groups, a new set of targeted intervention can happen. This loop continues to run over the course of the experiment and life of the system.

Distilling the purpose from the behavior change design, any system architecture must accomplish three things: distribute surveys, manage activities, and facilitate priming. A system that can perform these features could take many different forms, with varying number of component and degree of complexity. In its most abstract form, the simplest configuration that accomplishes this need is one component that acts as a terminal for user access, a central repository for all information, and a final medium that can display informa-
To bring these components into the real world, user access was decided for the current project to be a smartphone application. The central repository is a server with an universally accessible database. Finally, the method of priming is done by public displays setup in the workplace. The relationship between these components is shown in figure 4.5. Essentially, communication for all components in the system is done through the server to have some guarantee of consistency between individual instances of each component.

In order to provide surveys and activity management, the application component needs the ability to both read and write from the server. For the public display it only needs to be able to read from the server because it will not be used to generate new data itself. Constructing the system in this manner would allow for the fulfillment of all applicable functional requirements. Although, that does assume that the design of the individual components is done correctly, which will be justified later in this chapter. This configuration is the basic setup of the whole system from a component view. In the following sections each component will be explained in more detail.

### 4.3.2 Central Repository

In order to maintain consistency across the entire system there needs to be a way to share information between users. The simplest way to achieve this functionality is through a server that holds and manages data. There are many
different ways this component could be setup, all the way from building your own and managing it, to using providers that offer backend as a service [44, 45]. With the current project requiring the design and development of several different components it was determined that using a provider closer to the backend as a service end of the spectrum was the ideal choice. After comparing the many providers in the industry, it was decided to go with Firebase by Google. The reasons for this decision was the wide range of features that would allow for quick development, along with a pricing structure that made it possible to conduct the current project’s experiments with little to no cost. For the remainder of this section the individual components of the server and their design will be discussed.

Authentication

Looking at the primary motivation of the current project, in order to provide a tailored experience based on the needs of individual users, maintaining a user profile is required. The server must be able to distribute unique profiles to individual users that can also be used to authenticate them later on. To also maintain the requirement of anonymity and security, the profile cannot be used to identify the user behind the profile and the profile must be usable only by the user it was issued to. This design can be fulfilled by Firebase authentication, which includes anonymous authentication as an option.

Database and Storage

There are many requirements for the system that leads to the inclusion of a central database. Capabilities like collecting survey responses, distributing dynamic content, and system consistency all lead to this feature. In order to maintain a level of security in the system and protect user data it must also be able to restrict access to different data. This approach includes only allowing the user who created the data to read and write to that data. Basically, allowing a new account to create a private directory that only they and the admin can view.

All of these needs can be accomplished by the Firestore feature in Firebase. It provides a noSQL database [46] that can be secured based on authentication state. This functionality will allow for the current project’s functional and quality requirements to be satisfied and implemented smoothly.

---

There are also design elements that need to draw from the data stored in the central repository. This need comes from the requirement of user engagement; users should be made aware of relevant content. One aspect of this requirement is reacting to new data being added to the database. For example, drawing from the behavior change design, if a new activity is posted then those who have been identified as being interested in such things should be notified about it. This feature can be accomplished through the Cloud Functions feature from Firebase. It can be constructed in an if-this-then-that format. For the current project’s purpose, this format would allow specifying if certain data is added, then the appropriate users can be prompted to engage with the system.

User Engagement

As was just brought up, user engagement is a vital aspect of this kind of system. With it ranging from impossible to incredibly inefficient, the user’s devices cannot know the full state of the system at all times. To overcome this problem the server must be able to notify individual users of new data or required actions. To accomplish that the system can implement a feature known as push notifications. It allows data to be sent directly and instantly to a device. Incorporating this functionality into the system’s design contributes to fulfilling several requirements, such as user engagement.

4.3.3 Smartphone App

Early on in the design process it was decided that the main way for users to interact with the system was through a smartphone application. The reason for this decision was to reduce the barriers to accessing the system. If this component would instead take the form of a website it would require users to make a more active effort in accessing the system and its data. A smartphone is generally always with you and can prompt the user to interact with it through notifications. The choice of a smartphone was also made easier by the circumstances of the host company. That being the fact that all employees are issued an iPhone for work purposes. This situation had the added benefit of only needing to develop for one platform, and a few specific models on top of that. The rest of this section will cover the design of the individual features of the smartphone component.
Surveys

When it comes to creating a system with the aim of changing a user’s behavior through a tailored experience, data collection becomes a central concern. For determining the content a user should receive and for measuring its impact, it was decided that subjective surveys would be the best approach. For the information we want to collect there are two different types of surveys, static and dynamic. Static surveys represent a survey that is answered one time and the questions do not change over the lifespan of the system. With respect to the system, these can easily be stored on the device allowing for a relatively simple design. Examples of this kind of survey are the surveys done at the start of the user experience, such as the motivational factor survey and the demographic survey.

The other type of survey, dynamic surveys, requires more setup because of their nature. These are surveys that can change or be created over the lifetime of the system. This requirement means that hard coding the surveys in an app release is not an efficient method of delivery. To solve this problem, we can store the survey data in the server described earlier and have the application pull the appropriate questions when relevant.

An inherent advantage of using the smartphone platform over a website is the simple way to reengage users. If a survey has gone unanswered on a website there is no unobtrusive way to remind the user to complete the survey. On a smartphone the platform provides several different avenues to remind users. For regular surveys distributed on a schedule the application itself can send notifications about the new surveys available. For dynamic surveys that can be distributed at any time the platform allows for push notifications to be sent from a server and received on targeted devices.
### Requirement Description

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Activity creation</td>
<td>Any user should be able to create an activity in the system.</td>
</tr>
<tr>
<td>Read access</td>
<td>All users with access to the system should be able to view all upcoming activities.</td>
</tr>
<tr>
<td>User responses</td>
<td>All users should be able to reply to an activity with whether they are attending.</td>
</tr>
<tr>
<td>User engagement</td>
<td>Creation of an activity should allow the system to notify other users.</td>
</tr>
</tbody>
</table>

Table 4.4: Functional requirements for activities.

### Activities

As the centerpiece of the behavior change method for the current project, designing activities to work correctly is crucial to the fulfillment of the system’s requirements. As described previously, an activity describes some single event created by an employee and attended by other coworkers. From this description we can extract several requirements, see table 4.4 for a full list.

With a primary goal of the system being driving users to start events themselves, the system must allow the users to create activities. Which requires the smartphone application to be able to create an instance of an activity and upload it to the server. Within the context of the current project, the scope of what event types are available for activities is limited. Their primary purpose should be to foster small and relatively short interactions during or directly after work. For the design this restriction means that each attribute of an activity is selected from a static list. See figure 4.7b for an example of activity creation. This limitation also has the benefit of making the application work more smoothly in multi-lingual workplaces, such as the host company in which the current project’s experiment was conducted in. Activity information taken from a static list can easily be abstracted and then be presented in the appropriate language for any user of the system.

To then actually be useful to other users of the system it must sit in a universally readable part of the server that other users can access. This access can now allow any instance of the application to present a list of upcoming activities to the user, as can be seen in figure 4.7a. From this list any user should be able to respond to the activity and indicate whether or not they are attending. These responses should also be recorded in the server for other users to see and for analysis to be done later on.
Overview and Goals

One of the core elements in achieving behavior change is to set goals and show progress over time. This element leads many systems to adopt a version of user goals and progress indication. Displaying this kind of data to the user allows them to have a more concrete grasp of the tasks in front of them and feel good about the progress they have made. The way the application is realizing this feature is by displaying an overview panel with goals and progress. The overview panel can be seen in figure 4.8. What is required for this to work is an appropriate design of the other aspects of the system. Surveys available to the user need to be stored in a simple way to allow counting. Finally, activity participation should be stored in a way that can be measured efficiently and quickly. From this the overview feature has all of the information it needs. Now the work left is to the behavior change design to determine the best way to present this information. For the current project this layout is a simple goal and progress interface depending on the state of the user.

Development Framework

Shifting focus to a more development oriented perspective. In the realm of mobile development there are many different approaches for how to build good experiences. One possibility is to go with the straightforward approach by creating a native codebase for each platform that you want to target. The other end of the spectrum involves creating a progressive web app, a method for allowing a web app to behave more like a native app [47].
While the scope of the current project only called for development of an iOS application, allowing for future flexibility is very important. For this reason, it was decided to use the development framework known as Flutter. This framework allows for a single code base to build native apps for both iOS and Android. If future development is made on the system created during the current project, then using the flexibility of Flutter could be incredibly valuable in expanding to other platforms.

### 4.3.4 Public Information Display

The aim of priming is to present a subject with some piece of information in an attempt to elicit a specific reaction later on. For the current project the experience we want is for the users to react more positively about the system and the activities presented. The way to accomplish priming was to present information to the users in different contexts. As discussed in the previous section, the activities and goals are shown in the smartphone application. To prime the users for the system we will show information on a public display in the workspace.

With the goal of priming users for what they will see in the application, the content shown on the public display must be relevant to the overall goal of the system and the state of the system at the time. As can be seen in figure 4.9, the public display has two main types of information. The first is a preview of activities happening soon. The goal of this feature is to act as a reminder
for the users to engage with the application to seek more information, without them needing to actively check for updates. The second feature is tied to the system in a less concrete way. The goal of this feature is to present information and images to the user that makes them more receptive to increasing team cohesion and communication. If these are presented to the user in a positive way the hope is that they are primed to think more positively about the system and be more likely the engage with it and therefore other group members.

This use case could be implemented in many different ways, ranging from physically printed posters to a dedicated hardware and software solution. Like with many other aspects of the current project’s design, one of the requirements and goals is to be as flexible as possible. To accomplish this goal, it was decided that the public display would be implemented as a website. This solution would allow almost any device and display to be able to show the content. This solution also gives the real world flexibility in where it can be placed. Obviously, this goal could be accomplished in many different ways and be hosted on any of the hundreds of providers. To maintain consistency with the rest of the system it was decided to also host this feature on Firebase so that integration with the other aspects of the system would be seamless.
4.4 Implementation and System Flow

With the design of each component and the overall architecture covered, this section will go over the implementation of those ideas.

4.4.1 User Experience

When creating a system that is trying to modify the user’s behavior, being upfront and transparent with the intentions is crucial. Revealing the goal to the users may also encourage more use of the system if they see a value in what the system is offering. To accomplish this transparency, like most applications, the first screen shown to new users is a brief explanation of the application and the overall goal of the current project. Due to the potentially sensitive nature of the surveys the user will be completing, emphasizing the anonymous aspect of the system is important. Screenshots from this part of the application can be seen in figure 4.10.

With the user introduced to the application and the system, the first task for
the user is to complete the required surveys. See figure 4.11 for an example of a survey in the system. These surveys include a short demographic survey and a survey of what motivational factors are important to them. See Appendix A for a full list of survey questions. This feature is just a simple implementation of surveys that saves the user’s responses on the server for analysis.

Once the demographic and motivational factor surveys are complete there is a gap of time before intervention can begin. This period of time is for collecting wellbeing data so that there is a baseline to compare to after the intervention is started. For the current project accomplishing this task takes the form of a weekly survey that is released every Thursday. There are 5 different surveys, each with questions relating to different facets of overall wellbeing. When a user completes a wellbeing survey then they get the next one in line the following week. Once all 5 surveys have been completed the chain of surveys repeats.

For the experiment in the current project, the completion of all 5 wellbeing surveys marked the beginning of the intervention being distributed. The first step in this process was to create the groups that the users would belong to.
(a) User goals and progress
(b) Onboarding for activities

Figure 4.12: Onboarding for activity intervention. This figure has two screenshots from part of the UI of the smartphone app.

based on their needs. See Section 4.4.2 for a full explanation of how the grouping is done. With the participants sorted into groups based on their needs the activity intervention was rolled out. To introduce users to this new feature another set of onboarding was done to explain the activity and goal setting features. See figure 4.12 for screenshots.

Now that the activity feature is rolled out, all users are free to create and join activities. For the remainder of the experiment the participants wellbeing would be measured by the weekly surveys while participating in the activities. The users who were identified as benefiting the most from an increase in social interaction would receive the most re-engagement and targeted intervention by the system. This point of the experiment also came with the deployment of the public display which would act as another way to engage the participants with the system. The public display would, as discussed in Section 4.3.4, display general information and relevant details about activities as a way of priming users to increase the participation with the system.
4.4.2 User Grouping

A core aspect of the current system is to determine an individual’s needs and provide intervention to match that need. One method of accomplishing this matching is to manually map the different motivational factors to an intervention method. While this approach could be effective for certain more straightforward factors, it can lead to missing underlying clustering. A subjective analysis may group certain factors together because of an intuition that they are associated. While factor analysis allows for a more objective grouping of factors that are statistically correlated with one another. The approach the current project utilizes a semi-automatic method of grouping the participants.

The approach used was factor analysis, a method by which correlations between factors can be revealed. The first step in this process was to determine the number of groups to be used in the factor analysis. To get this number Guttman Criterion was used to calculate the eigenvalues of the correlation matrix. The eigenvalue in this context represents to what degree a factor, or group, describes itself with 1 being the optimal value. Any larger number means that a group could be representing more than itself. Which means the number of groups to be used should be the smallest whole number with an eigenvalue
greater than 1. This value would then be used for the number of groups in the factor analysis. The resulting groups generated by the factor analysis would then need to be manually labeled based on the subjective need they represent. Using the generated groups and labels, intervention can be developed to match the needs of each group. The grouping can only be performed when data has been collected from the participants’ motivational factor survey. Sorting the users into these generated groups could be done in many different ways. The way it was done in the current project was simply to add up the scores given to each factor in a group. Then if an individual had an above average score for a given group they were added to that group.

There is an additional layer to the targeting of intervention. Just belonging to a group associated with an intervention method does not necessarily mean that the individual needs help. The decision of whether to target them with engagement notifications and other methods is augmented by their wellbeing scores from the weekly surveys. Those with the lowest scores get the highest level of assistance because they are the ones in need of it the most. This focus does not mean that others are excluded from the intervention features, but that they are not as actively encouraged to join through engagement methods.

### 4.4.3 System Diagram and Data Flow

Section 4.3 outlined the design of the individual components for the system. It presented the purpose of each component with a short description of how they would be implemented. This section, figure 4.14, and figure 4.15, are meant to more explicitly describe the implementation and interaction of all the system components. The way the system will be presented is by describing the flow of data through the system based on the major types of actions that can be performed by a user.

The first feature to be inspected will be the primary piece of data that drives nearly all other features of the system. That being the survey feature. Surveys are accessed exclusively on the smartphone app by the user. These surveys can be stored in one of two ways. For the required static surveys, like the demographic and motivational factor survey, they are stored directly on the device. While the wellbeing surveys and miscellaneous surveys are kept in the Firestore central database. The responses to surveys must be kept private, this requirement is accomplished by completed survey data being passed through the Firebase authentication feature to ensure only the appropriate user can access their private directory of the database.

As for the activities the whole system is much more involved. Their pur-
pose is to be visible and interacted with by other users. What this purpose requires is that an activity’s creation needs to trigger several different features. From an activity’s creation on the user’s device, they are validated by the authentication feature and saved to a public area of the database. When the new activity hits the database, a series of events get triggered. First, the Cloud Functions feature detects the new data and sends out engagement notifications to those in the group identified as needing increased social relationships. The second thing that occurs is that the public display is able to read from the public part of the database and prepare a method to prime the users to receive the activity on their device. Once all of these automatic events have happened all users are able to view the new activity on their device and respond.
Figure 4.14: System diagram showing the interactions of the three main components of the design: the central database, based on Firebase, the iOS smartphone app, based on the Flutter framework, and the public display, based on the React web framework. The components communicate seamlessly and are all possible to extend as needed, both to new platforms, like Android, and additional viewing surfaces.
Figure 4.15: Class diagram of the system. This figure shows a simplified breakdown of the data classes for the different components of the system.
Chapter 5

Results

The content of the results chapter will cover the two main areas of the current project, the system itself and the behavior change method. First the evaluation of the system will be given. Up next, the results of the behavior change intervention will be covered.

5.1 System Evaluation

The evaluation of the system will be approached from two directions. The first is a design focus by going through the stated system requirements and evaluating if they are fulfilled or not. The next approach is on the practical side of things; once the system was built, did it work as expected.

5.1.1 Fulfillment of System Requirements

From the chapter on system design, Chapter 4, several requirements were given for the overall system. These were then brought up in the actual design section when relevant, but no argument for how all the requirements were satisfied was given clearly in one place. For the first part of the system evaluation we will go over each of the system requirements and justify how they are satisfied. See table 5.1 for the full list of functional requirements and table 5.2 for the list of quality requirements.

5.1.2 Practical Evaluation

As was brought up in the method chapter, the current project would include a practical evaluation of the system. The way this evaluation was conducted
CHAPTER 5. RESULTS

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Evaluation explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>User profile</td>
<td>The server provides this functionality and the use of a smartphone keeps profiles consistent for each user.</td>
</tr>
<tr>
<td>User anonymity</td>
<td>This guarantee is provided by the type of authentication used on the server and supported by the smartphone.</td>
</tr>
<tr>
<td>Dynamic content</td>
<td>The smartphone application has the ability to pull content from the server and present it to relevant users.</td>
</tr>
<tr>
<td>User engagement</td>
<td>Scheduled notifications and push notifications enables user engagement.</td>
</tr>
<tr>
<td>System consistency</td>
<td>All of the different components are connected through the server which allows for a consistent state to be maintained.</td>
</tr>
<tr>
<td>Data collection</td>
<td>The smartphone application is able to upload any relevant data to the server for further analysis.</td>
</tr>
<tr>
<td>Content targeting</td>
<td>Using the survey feature on the smartphone allows for users to be grouped and individually targeted.</td>
</tr>
</tbody>
</table>

Table 5.1: Functional requirements evaluation.

was distributing the system to the group members at the host company. The process of deploying the system varied for each component. For the server, because its features were provided by Firebase, it was as simple as enabling the appropriate features. Setting up the public display was a bit more involved because it required physically placing large TVs in visible areas in the host company workplace and connecting computers to them. Finally, distribution of the smartphone application was done through Apple’s *ad hoc distribution* method, which allows apps to be installed on individual devices instead of going through the App Store.

Through the course of the experiment time frame, overall the system performed all necessary features. From a design and setup perspective all users were able to use the system correctly and interact with it as intended. There were some minor issues relating to implementation bugs that came up, but due to the design of the system were relatively easy to fix. The next aspect of the system to look at is the actual engagement statistics.

The experiment started with 13 participants from the group members at the host company. Before the implementation of the activity feature one of the par-
<table>
<thead>
<tr>
<th>Requirement</th>
<th>Evaluation explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ease of access</td>
<td>With all participants having a smartphone, this platform allowed for easy access to the system.</td>
</tr>
<tr>
<td>Performance</td>
<td>The features required did not need high performance hardware so the user experience was smooth.</td>
</tr>
<tr>
<td>Flexibility</td>
<td>The three major components of the system are built so that they can be modified without impacting each other. Updates to multiple components would need to be made for core changes but they can happen independently.</td>
</tr>
<tr>
<td>Maintainability</td>
<td>The design of the system is relatively clean and abstract. For the implementation choices, common and widely accepted practices were used.</td>
</tr>
<tr>
<td>Usability</td>
<td>Interaction with the system followed general convention that users should expect based on their use of other systems and platforms.</td>
</tr>
<tr>
<td>Security</td>
<td>From a design standpoint the data of the users can be protected and the technical implementation allows for this guarantee as well.</td>
</tr>
</tbody>
</table>

Table 5.2: Quality requirements evaluation.

participants left the group and the experiment. Due to this fact, that participant’s data will be removed from any analysis. Looking at overall engagement, which can be seen in table 5.3, over a 28-day period 100% of users engaged with the system. A more important statistic to look at is the 7-day usage. The average over the course of the experiment was 75%. This result means that in any given week a majority of users interacted with the system at least once. Moving to a more specific metric, table 5.4 shows the engagement level with activities. During the first week about a third of users participated in at least one activity. This rate increased over the next two weeks and by week 3 two thirds of users had participated in at least one activity. The final aspect of engagement that will be shown in this section is the rate at which people completed the weekly wellbeing surveys, as seen in table 5.5. All participants completed the first few wellbeing surveys, but a drop off occurred over time. This kind of trend is to be expected with any task that takes place over a longer period of time. Fortunately, a majority of users completed all of the wellbeing surveys. What these results indicate is a willingness to use the system and return to it. Not just when prompted to do the weekly wellbeing survey, but to view activities
5.1.3 User Grouping

To provide targeted intervention, users must be classified based on their needs. The way this problem was solved for the current project, was to use factor analysis to create groups that have an association with each other. The first step is to figure out how many groups the data supports. Using Guttman Criterion it was determined that the ideal number of groups was 7. With this value we can perform a factor analysis that groups the various motivational factors into one of 7 groups based on their correlation to each other. Once this process is completed, manual labeling is required to determine what each group represents and for the current project’s purpose what intervention matches that group’s needs. The labels given to each of the groups can be seen in figure 5.1

The group of interest for the current experiment is the one labeled open communication which contained the following motivational factors: fair evaluation, relationship with colleagues, scope of decision making, relationship with managers, and promotion opportunity. For a full breakdown of the fac-
<table>
<thead>
<tr>
<th>Wellbeing survey</th>
<th>Completion rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wellbeing 1</td>
<td>100%</td>
</tr>
<tr>
<td>Wellbeing 2</td>
<td>100%</td>
</tr>
<tr>
<td>Wellbeing 3</td>
<td>91%</td>
</tr>
<tr>
<td>Wellbeing 4</td>
<td>83%</td>
</tr>
<tr>
<td>Wellbeing 5</td>
<td>75%</td>
</tr>
<tr>
<td>Wellbeing 1 repeat</td>
<td>75%</td>
</tr>
<tr>
<td>Wellbeing 2 repeat</td>
<td>66%</td>
</tr>
<tr>
<td>Wellbeing 3 repeat</td>
<td>58%</td>
</tr>
<tr>
<td>Wellbeing 4 repeat</td>
<td>58%</td>
</tr>
<tr>
<td>Wellbeing 5 repeat</td>
<td>58%</td>
</tr>
</tbody>
</table>

Table 5.5: Wellbeing survey completion.

1. Rewarding  
2. Treatment  
3. Open communication  
4. Environment  
5. Flexibility  
6. Management  
7. Merit system

Figure 5.1: Labels given to the groups created from the factor analysis results.

Figure 5.1: Labels given to the groups created from the factor analysis results.

It is important to note that the grouping of the motivational factors using factor analysis does not mean there is a true association between them. This method was used to find trends to aid in the manual labeling and assigning of intervention methods.

5.2 Behavior Change Evaluation

This section will cover the behavior change related results and evaluation. The way it will be broken down is in two parts, first a basic overview and then a more in-depth analysis of the results.

5.2.1 Overall Results

The basis for determining the behavior change intervention the current project went with was what motivational factors employees valued. The results from the literature review gave great insight into the approach to take but it was still
### Table 5.6: Top 10 motivational factors. Data from the pilot study with 40 people (left side) and from the main experiment survey with 13 participants (right side).

<table>
<thead>
<tr>
<th>Pilot ranking</th>
<th>Factor</th>
<th>Main ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Sense of achievement</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>Relationship with management</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>Quality of supervision and leadership</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>Challenging work</td>
<td>6</td>
</tr>
<tr>
<td>4</td>
<td>Self-growth</td>
<td>2</td>
</tr>
<tr>
<td>6</td>
<td>Relationship with colleagues</td>
<td>10</td>
</tr>
<tr>
<td>7</td>
<td>Fair evaluation</td>
<td>2</td>
</tr>
<tr>
<td>8</td>
<td>Working environment</td>
<td>8</td>
</tr>
<tr>
<td>9</td>
<td>Employee empowerment</td>
<td>6</td>
</tr>
<tr>
<td>9</td>
<td>Independent/flexible work</td>
<td>13</td>
</tr>
</tbody>
</table>

important to validate in the host company. From this need a pilot study was conducted on 40 people to give their subjective opinion of the importance of 27 motivating factors. The results can be seen in table 5.6. These findings generally followed the literature and was the basis for focusing on social relationships. During the actual experiment with the system a similar list of factors was surveyed again and a similar order emerged. The new survey was not done to validate any previous findings but was used for the system to group users and target those in need of intervention.

Shifting over to the wellbeing measurements taken during the experiment. The average and median value from the three times the survey was conducted during the experiment is presented in table 5.7. This survey was taken from the satisfaction with life scale survey [41]. Looking at the scoring guide, values below 20 represent a dissatisfied person and scores above 20 indicate satisfaction with life. With higher and lower values indicating higher or lower levels of satisfaction respectively. The first two scores, from the beginning of the experiment and before the activity feature was implemented, are very similar. Which is to be expected because no intervention by the system has been done at this point. However, this trend does not seem to change by the end of the experiment. The average and median scores of the survey remain about the same. This trend was also true for the other four wellbeing surveys that were repeated.
### Analysis

Beyond the surface level results shown in the previous section, there is a more detailed view that can be taken. The main way this analysis will be done is for this section to explore the correlations between wellbeing and the usage of the system.

The first aspect that will be looked at is whether a user’s motivation impacted their usage of the system. Overall people that scored high and low on the life satisfaction survey engaged with the system and participated in the activities. When looking at the users that participated with the system the most the correlation was not with their life satisfaction, rather with their motivational factor rating. These users placed a higher importance on the motivational factors relating to social relationships. Or put another way, those who engaged with the most activities were the people that indicated a desire for that type of intervention.

One important aspect of the behavior change part of the system that was able to be validated is the correlation between life satisfaction and motivation. As was suggested by the literature review [48] the users that had high levels of life satisfaction were also those with higher levels of motivation. The multiple correlation coefficient method was used which resulted in a value of 0.955. This result indicates a strong correlation between life satisfaction and motivation. The validity of this data is reliable to $p = 0.05$, which means the result is reliable.

From the participant observation and the follow up interviews, there is a positive tone about the system. Members that engaged with the system seemed more likely to speak with each other informally and more likely to do activities outside of the system. The observed behavior being one of the major goals of the intervention strategy, this outcome is seen as an initial step in lasting behavior change. It is important to note that these findings are subjective by their nature but could indicate a possible trend not seen in the wellbeing survey data.

<table>
<thead>
<tr>
<th></th>
<th>Start</th>
<th>Before activities</th>
<th>End</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average</td>
<td>19.8</td>
<td>20</td>
<td>20.5</td>
</tr>
<tr>
<td>Median</td>
<td>22</td>
<td>19.5</td>
<td>21</td>
</tr>
</tbody>
</table>

Table 5.7: Satisfaction with life survey results. Survey was conducted at the start of the experiment, right before activities were implemented, and finally at the end of the experiment.
Chapter 6

Discussion

This chapter will cover the implications of the results brought up in the previous chapter. The first two sections will cover the system architecture itself and the behavior change design. Up next, the following section will discuss the ethical and social implications of the current project. The fourth section will discuss the work of implementing the design. Finally, some consideration for possible future work is given.

6.1 System Architecture

Looking at the performance of the system and the usage statistics, the design accomplished what it was required to do. Overall this result leads to the conclusion that from an architecture design perspective the current project was a success. However, there are aspects to take a closer look at. When conducting experiments with a known group, there is always the risk that usage is exaggerated from what it would be in the real world. This behavior tendency will be something to consider in future iterations with a larger group of users. Although that is more a question of implementation of the engagement rather than a full overhaul of design.

There is an area of the design that was not able to be fully vetted in a practical manner. That is the grouping of users based on their data and answers to surveys. Using the data gathered from the system, factor analysis was able to be done and emergent groups were able to be found. These were used in compliment with the manually created groups for users to fall into. So, while these groups existed and the system was able to sort people, practically they were not fully utilized. This decision was made due to the small number of users participating in the experiment. It was decided that fully implementing that
design would have cut down the number of active people in the experiment. With this context the implementation was relaxed and more people were included in the targeting of the system to actually be able to fully test the system. The length of time that the experiment took place and the lack of a significant change in survey scores over time, led to the reevaluation aspect of the sorting not being able to be practically tested. These two parts will be an important aspect to test in future experiments with a larger number of people to see if real world results can mimic the artificial tests performed.

From the ground level with the system requirements all the way to the resulting system, it is important to make a judgement of the architecture created in the current project. With all of the requirements being satisfied in the design process and all synthetic tests working as intended, the system architecture aspect of the current project is a success.

6.2 Behavior Change Design

Simply looking at the wellbeing data from the experiment could lead someone to brand the behavior change design as a failure. There are a few caveats that makes the outcome not entirely dire. The first point is the length of time the experiment was run for. The intervention with activities was only run for a month and a half. It is possible this experiment could not be enough time for any significant changes to show up in the data that was collected. True behavior change is a long process. With the participant observation presented in the results chapter, it seems like several users are in the beginning of this process. There is also a risk of misapplication of the wellbeing surveys at its core. While it is an important aspect of grouping people based on need, its usefulness may end there. The idea was that a general measure of wellbeing would be a good way to measure the impact of intervention done by the system. This may not be the case after viewing the results of the system. For further experiments it would be important to review this aspect of the system further with a psychologist or another expert in the field.

With these conflicting results, the outcome of the behavior change design specifically is that it is inconclusive. There are indications that point to the potential of the design working given enough time, but only further experiments could confirm this potential. The foundation set out by the current project should be considered a valid starting point for further work. That being the grouping of users and administering intervention based on need.
6.3 Ethical and Social Impact

For any project dealing with human participants, the subject of ethics must be discussed to some extent. This fact is especially true for the current project, with it dealing with the subject of behavior change and trying to nudge people toward a different state of mind. From the literature on BCSS [14], there are several elements that must be considered for a system to be deemed ethical. The first major component is the voluntary nature of the system. Not just in the simple opt-in or out context, but it must be obvious when any behavior change intervention is occurring. The second major aspect for ethical consideration is that users should be informed of the purpose and function of the system. This information is a crucial aspect of the user’s ability to give informed consent about their involvement with the system. Each of these issues have been addressed in the system created in the current project. The goals of the project are explicitly layed out and all features of the system are optional. Additionally, whenever intervention is being administered to the user it is obvious to them because they must actively engage with it.

Including these ethical considerations in the design is just the first step to creating an ethical system. For conducting experiments with human participants outside approval is often required. Within the scope of the experiment conducted in the current project, the host company approved of the human trial because it involved a closed group consisting solely of researchers familiar with the current project. With any expansion to more participants in the experiment a formal application and review by an ethics board would be required. Such a process would also become necessary if the system was ported to a commercial form that would be exported to other organizations.

Shifting focus from the ethical implications of the current project to the social impact. The very nature of the current project is to impact people directly. The magnitude of that impact is, however, directly tied to the effectiveness of not only the intervention but how well it is delivered. The goal of the system isn’t to directly change massive parts of a user’s life, but rather make concentrated nudges to put the user in a position to improve their own life and overall wellbeing. In its ideal form, the system would in its effort to increase motivation result in a group of participants that overall have a higher level of life satisfaction and sense of motivation about their work. Fully realizing the goals set out in the current project would be a great benefit to the members of society using the system and hopefully lead to a greater focus of employee wellbeing.
6.4 Implementation

When working on a full software system there are many different types of development that needs to happen. For this reason the platforms and frameworks used were selected partially for their speed in prototyping and getting a working system up and running. During the implementation process this assessment turned out to be true for both Flutter and Firebase.

For Firebase the main appeal was the description that many of its core features could simply be enabled and implemented with a few lines of code. This description was at least true for the database and authentication solution. From there the implementation on the other components of the current project was relatively simple. The only code needed for the server side of the current project was the Cloud Functions implementation to react to events in other parts of the system. Making the decision to utilize a back end as a service provider was a good choice due to its easy integration.

On the mobile side, Flutter allowed for development to focus on the important aspects of the system. Aside from its main selling point of allowing a single code base to generate native apps for both iOS and Android, which was not utilized for the current project, Flutter makes user interface work easy. This property made it possible to create the easy to use and relatively nice looking UI present on the smartphone app. Overall the language of Flutter, Dart, was easy to use and the community support with tools and tutorials made it a good choice for the current project.

Overall the process of realizing the software architecture and bringing it into the real world was a relatively smooth process. While the actual work of implementing the components in unfamiliar platforms and frameworks was a significant challenge those practical decisions resulted in a well working system.

6.5 Future Work

Reflecting on the work done during the course of the current project, there are several extensions that should be considered if future work is undertaken. Coming from the previous section the first recommendation should come as no surprise. The most basic change to make is to increase the time that the behavior change experiment runs for. With the primary purpose of the current project being to validate the system architecture, time for the experiments was purposely limited. But for future work with a greater focus on behavior change
more time should be allocated.

With a system in place that can handle the basic functionality required, the next step is to expand the features. The basic goal of the system is to be able to provide intervention based on individual need. The current project consciously achieved this goal by only providing one method of intervention. Future work on the system and the behavior change design would see great benefit from expanding the features available so a wider range of people could be helped. These changes may require shifts in parts of the design of the system, but that all depends on the type of features required. Though, at its core the architecture should be able to provide for most needs.

The final suggestion that will be provided falls on the behavior change side of the current project as well. The user data collected during the course of the experiment gave great insight for developing the behavior change design, but inevitably did not give the desired results. Whether this outcome is because the method is flawed or if the intervention is badly designed is hard to say. To put this point to rest, future work on the system should include close collaboration with an expert in the field to develop a better suite of surveys to measure the impact of the system.
Chapter 7
Conclusions

The core goal of companies has never been to intrinsically care about the employees working for them. If it was possible to have a miserable workforce while seeing continuously growing profits then that is what you should expect the company to do and allow. However that is not the world we live in; depressed and unmotivated employees have a direct and measurable cost. Employee life satisfaction and motivation are linked to each other and both of these have an impact on the performance of the employee. While the whole world is starting to face the problem of depression and dissatisfaction, Japan is in a unique position. Not just in the severity of the problem but also that employers have a much higher influence on their employees.

One avenue for potentially relieving the problem of unmotivated and dissatisfied employees is to create a software solution. This is where the research question for the current project came from: What is the design of a software system that can improve employee motivation through behavior change? To answer this question, the current paper presented a novel system for determining individual need and administering behavior change intervention. To determine the level of success of the current project in answering the research question, this chapter will approach it in three ways: system architecture, behavior change, and finally implementation.

In constructing a software system, first an architecture design method and evaluation strategy was presented. This method was utilized in producing the software system design for the current project and over the course of the current paper this design has been evaluated. Comparing the current system to those found in the literature review, the approach taken by targeting intervention is unique and a novel approach for this domain. The application of this system was tried through a three month experiment that performed all required
functionality at a high level of quality.

As for the behavior change design presented in the current paper, the outlook is more mixed. From a utility perspective the approach was able to be used to validate the system. When looking at the observations and subjective analysis the intervention seemed to have positive effects on those in the participant group. In the end though, due to the lack of positive data, the behavior change design in and of itself must be viewed as unsubstantiated but showing potential. For future experiments a larger focus on the intervention design is crucial for achieving the goal of better worker wellbeing and motivation.

Moving to the practical side of the current project, the implementation of the software system. The choice of platforms and frameworks used were good choices because they allowed for the quick development of a working system. Future work would benefit from using the system produced by the current project as it can be easily iterated on due to its modular design and implementation.

With the primary purpose of the current paper being a software system design project, the conclusion of the current project should be heavily weighted by that component. While the behavior change was a crucial part, the true judge of the current project is still the system design that was produced. From this criteria, the system architecture aspect of the current project, and therefore the current project as a whole, can be viewed a success.
Bibliography


[34] M. Sutherland and N. Maiden. “Storyboarding Requirements”. In: IEEE Software 27.6 (Nov. 2010), pp. 9–11.


[44] Kin Lane. “Overview of the backend as a service (BaaS) space”. In: API Evangelist (2013).


Appendix A

Surveys

This appendix contains all of the surveys distributed as part of the experiment. Which includes the demographic survey, motivational factor survey, and the 5 wellbeing surveys.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Age</td>
</tr>
<tr>
<td>2</td>
<td>Gender</td>
</tr>
<tr>
<td>3</td>
<td>Are you a manager?</td>
</tr>
<tr>
<td>4</td>
<td>Native or foreigner?</td>
</tr>
<tr>
<td>5</td>
<td>How long have you been working at KDDI?</td>
</tr>
</tbody>
</table>

Table A.1: Demographic survey.
|   | Company’s growth prospects |   | Job advancement |   | Amount of responsibility |   | Challenging work |   | Sense of achievement |   | Company brand |   | Work/job recognition (status or image of the job) |   | Self-growth |   | Quality of supervision and leadership |   | Company policy and administration |   | Employee empowerment |   | Job security |   | Salary |   | Working environment |   | Fair evaluation |   | Relationship with colleagues |   | Relationship with management |   | Independent/flexible work |   | Ability to work remotely |   | Merit-based rewards |   | Collaboration within and between groups |   | Having a place and opportunity to relax |   | Work life balance |

Table A.2: Motivational factor survey for the main experiment. Questions are answered on a scale of 1 to 7. 1 being no impact on motivation and 7 being high impact on motivation.
Table A.3: Motivational factor survey for the pilot study. Some questions were removed for the survey in the main experiment. This was because they were seen as too specific or were not valued by employees during the pilot study. Questions are answered on a scale of 1 to 7. 1 being no impact on motivation and 7 being high impact on motivation.
In most ways my life is close to my ideal.
The conditions of my life are excellent.
I am satisfied with my life.
So far I have gotten the important things I want in life.
If I could live my life over, I would change almost nothing.

Table A.4: Wellbeing survey 1. Questions are answered on a scale of 1 to 7. 1 being strongly disagree, 4 being neutral, and 7 being strongly agree.

<table>
<thead>
<tr>
<th></th>
<th>Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Did you enjoy what you were doing?</td>
</tr>
<tr>
<td>2</td>
<td>How well were you concentrating?</td>
</tr>
<tr>
<td>3</td>
<td>Did you feel good about yourself?</td>
</tr>
<tr>
<td>4</td>
<td>Were you learning anything or getting better at something?</td>
</tr>
<tr>
<td>5</td>
<td>Did you have some choice in picking your activities?</td>
</tr>
</tbody>
</table>

Did you enjoy what you were doing?
How well were you concentrating?
Did you feel good about yourself?
Were you learning anything or getting better at something?
Did you have some choice in picking your activities?

Table A.5: Wellbeing survey 2. Questions are answered on a scale of 1 to 7. 1 being not at all, 4 being neutral, and 7 being very much.

<table>
<thead>
<tr>
<th></th>
<th>Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>For me, life has been a continuous process of learning, changing, and</td>
</tr>
<tr>
<td></td>
<td>growth.</td>
</tr>
<tr>
<td>2</td>
<td>I am not interested in activities that will expand my horizons.</td>
</tr>
<tr>
<td>3</td>
<td>I gave up trying to make big improvements or changes in my life a long</td>
</tr>
<tr>
<td></td>
<td>time ago.</td>
</tr>
<tr>
<td>4</td>
<td>I think it is important to have new experiences that challenge how you</td>
</tr>
<tr>
<td></td>
<td>think about yourself and the world.</td>
</tr>
<tr>
<td>5</td>
<td>I do not enjoy being in new situations that require me to change my</td>
</tr>
<tr>
<td></td>
<td>old familiar ways of doing things.</td>
</tr>
<tr>
<td>6</td>
<td>When I think about it, I haven’t really improved much as a person over</td>
</tr>
<tr>
<td></td>
<td>the years.</td>
</tr>
<tr>
<td>7</td>
<td>I have the sense that I have developed a lot as a person over time.</td>
</tr>
</tbody>
</table>

Table A.6: Wellbeing survey 3. Questions are answered on a scale of 1 to 7. 1 being strongly disagree, 4 being neutral, and 7 being strongly agree.
<table>
<thead>
<tr>
<th></th>
<th>In general, I feel I am in charge of the situation in which I live.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>The demands of everyday life often get me down.</td>
</tr>
<tr>
<td>3</td>
<td>I do not fit very well with the people and the community around me.</td>
</tr>
<tr>
<td>4</td>
<td>I am quite good at managing the many responsibilities of my daily life.</td>
</tr>
<tr>
<td>5</td>
<td>I often feel overwhelmed by my responsibilities.</td>
</tr>
<tr>
<td>6</td>
<td>I have difficulty arranging my life in a way that is satisfying to me.</td>
</tr>
<tr>
<td>7</td>
<td>I have been able to build a living environment and a lifestyle for myself that is much to my liking.</td>
</tr>
</tbody>
</table>

Table A.7: Wellbeing survey 4. Questions are answered on a scale of 1 to 7. 1 being strongly disagree, 4 being neutral, and 7 being strongly agree.

<table>
<thead>
<tr>
<th></th>
<th>I am not afraid to voice my opinions, even when they are in opposition to the opinions of most people.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>My decisions are not usually influenced by what everyone else is doing.</td>
</tr>
<tr>
<td>3</td>
<td>I tend to be influenced by people with strong opinions.</td>
</tr>
<tr>
<td>4</td>
<td>I have confidence in my opinions, even if they are contrary to the general consensus.</td>
</tr>
<tr>
<td>5</td>
<td>It’s difficult for me to voice my own opinions on controversial matters.</td>
</tr>
<tr>
<td>6</td>
<td>I tend to worry about what other people think of me.</td>
</tr>
<tr>
<td>7</td>
<td>I judge myself by what I think is important, not by the values of what others think is important.</td>
</tr>
</tbody>
</table>

Table A.8: Wellbeing survey 5. Questions are answered on a scale of 1 to 7. 1 being strongly disagree, 4 being neutral, and 7 being strongly agree.
Appendix B

Factor Analysis

This appendix contains the factor analysis done on the motivational factor responses received from the experiment in the current project.
Figure B.1: Results of factor analysis.
Index

Ad-hoc Distribution, 51
Android, 40, 60
Anonymity, 35
Anonymous Authentication, 35
App Store, 51
Architecture Simulation, 22

BCSS, 10, 12, 23, 59
Behavior Change, 1
Bullying, see Ijime

Cloud Functions, 36
Communitarian Capitalism, 6

Dart, 60
Depression, 5, 62

Eigenvalue, 45
Employee Motivation, 4, 8
Ethics, 59

Factor Analysis, 45, 53
Firebase, 35, 51, 60
Firestore, 35
Flutter, 40, 60
Fogg Behavior Model, 10
Functionality Based Design, 21

Germany, 8
Guttman Criterion, 45, 53

Happydonia, 17
Herzberg’s Two Factor Theory, 5
Human Trial, 59

Ijime, 7
Individualism, 8
Informal Communication, 31
Interpersonal Relationships, 31
Intervention Design, 63
iOS, 40, 60
iPhone, 36

Japan, 4, 8, 29, 32, 62
Japanese Work Culture, 5
Job Embeddedness, 7

Karoshi, 1, 7
Likert Scale, 8

Mathematical Models, 16
Mathematical-Based Evaluation, 16
Merit-based Rewards, 9
Motivation, 4, 5

O/C Matrix, 12

Persuasion Context, 13
Persuasive System Design, see PSD
Power Distance, 8
Privacy, 35
Program Decomposition, 14
Prototyping, 60
PSD, 10, 13, 23
Psychology, 2
Public Display, 40
Push Notifications, 36
Requirements Engineering, 15
Satisfaction With Life Survey, 55
Scenario-Based Evaluation, 15
Security, 35
Simulation-Based Evaluation, 15
Social Impact, 59
Storyboard, 20, 25
Team Cohesion, 29
Technology Acceptance Model, 11
Theory of Planned Behavior, 11
Theory of Reasoned Action, 11
UI, 60
Uncertainty Avoidance, 8
Unipos, 16
United States, 8
User Profile, 35
Web App, 39