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Triggering the next nudge

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“Live as if you were to die tomorrow. Learn as if you were to live forever”
–Mahatma Gandhi

“I am so clever that sometimes I don’t understand a single word of what I am saying”
–Oscar Wilde

Abstract

The aim of this thesis is to establish if a smart nudging system using triggers could be used to better understand the user and their situation as well as aiding in selecting a target activity as part of a complete smart nudging system. Explore how such a system can be used to determine when a user should be nudged and how it can learn from feedback from the user to make changes to itself and make better predictions in the future. By looking into the advantages and disadvantages of triggers the thesis aims to provide insights into the potential for triggers to be used in future smart nudging systems.

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Introduction

Nudging is a term and process that stems from economic and political theory and can be used to influence the behavior and decisions of people by using suggestions and other non-coercive means [7]. With knowledge of the environment a person is in when they make a decision (i.e., the choice architecture[7]) it is possible to create nudges to influence people towards better decisions that are beneficial to both them-self and others. For example, nudging people to be more active in their daily lives might get them to partake in more physical activities and thus improve their health and well-being. while at the same time spare the healthcare system from the costs related to treating preventable lifestyle illnesses.

The term was first introduced by Thaler and Sunstein who defined nudging as

"...any aspect of the choice architecture that alters people's behavior in a predictable way without forbidding any options or significantly changing their economic incentives" [7]

As stated in the definition the nudges cannot influence a person by significant positive or negative economic incentives. Nudges cannot take away options from the person that is being nudged. The goal of nudging someone is to increase the chance of that person making good choices by ethical means and not taking away their options in any way, but by providing the person with the information they need to make an informed decision.

Since Thaler and Sunstein first introduced nudges in 2008 the concept has been integrated with modern computer systems and other technologies to create digital nudging and then smart nudging. Digital nudging is nudging that happens within a digital environment[6]. Digital nudging allows for automation of the nudging process. The nudging process is made more effective by having computers do the data and information processing required to be able to nudge a person.

Smart nudges build upon digital nudges by allowing the nudges to be tailored to a specific person[8]. If done right tailoring a nudge to a person can make them more likely to have a positive response to the nudge. When tailoring a smart nudge to a user the important elements that can be tailored are what the nudge contains, how it is presented and when it is presented. A problem with smart nudging is figuring out when to present the user with the nudge

A trigger is a simple mechanism that activates some process when a certain condition is met. This mechanism is used in everything from kitchen appliances and guns to buttons on a website. A trigger can have one or many conditions that must be met. Some might require all the conditions to be met before

the trigger will fire and some might only require a subset of all conditions. Since most situations have the potential to be broken down into many small elements these elements have the potential to be tested as a condition in a trigger. This allows for the simple mechanism of triggers to be used in situation detection.

1.1 Motivation

Life is full of situations where people have to make difficult decisions. In order to make a good decision the person making it must be as informed as possible about all the advantages and disadvantages of the options available to them. This can however be difficult due to a wide range of reasons including a lack of time or interest. We as human beings are not perfect and will not always have the ability or capacity to process all the information needed to make the best choice when a decision must be made. We are also prone to being swayed by our biases or our previous experiences[1]. Therefore, we can benefit from tools that assist us in the decision-making process. Nudging is such a tool.

Personal health is one area that has a lot of potential for improvement if people are aided in their decision making. Smoking, low levels of physical activity and obesity are common health issues. These are issues that the person that has them is aware of most of the time. Unlike other health issues that require professional assistance from a doctor and or surgery like for example a bone fracture or diabetes, the problems related to smoking and obesity can be treated through improved decision making and behavioral change. Nudging can help people help themselves and improve their health and their lives. With the assistance of nudging people can improve their health and save themselves from lifestyle diseases and at the same time save society from the associated costs.

The emergence of digital and smart nudging makes it possible to nudge people on a large scale. This can allow for the benefits of using nudges to assist in decision making to be available to more people. Smart nudging in particular shows great promise in helping people improve their lives by altering their behavior as it allows for the use of personalized nudges that can be tailored to the user and therefore be more effective.

1.2 Problem definition

A smart nudging system has many specific requirements that must be fulfilled in order to successfully nudge a user. A smart nudging system is required to use personal and contextual data from a user to be able to create personalized nudges when they are needed. One of the main problems is determining when a user is susceptible to being nudged. To be able to determine if a user is susceptible, a system needs to have collected and processed data about the user, their personality, their preferences, and lots of data regarding their current situation. It is not possible to absolutely determine if a user is currently susceptible to being nudged but it is possible to estimate if a user is more susceptible in one situation compared to another. For example, it is highly likely that a user is more likely to perform a nudged activity if they are relaxing at home compared to if they are at work. When making such an estimate there must be some room for the different preferences of the users. This allows smart nudges to both personalize what is presented to a user when they are nudged and when they are nudged.

A trigger is a simple mechanism that checks if a set of requirements are fulfilled and if so, the trigger will fire and start a process connected to that trigger. By carefully deciding what requirements need to be satisfied a trigger has the possibility to be used as a method for determining the situation of a user. Determining a person's situation is a complex process, but any situation can be broken down into different elements. Some of these elements can be made into the requirements that a trigger needs to verify before it can fire and thus be used to estimate the current situation of the user. If these requirements are set on an individual user basis and allow them to be tweaked, this can allow for the ability to detect nuanced situations where some users are susceptible to being nudged and others not.

By combining practical software development and research of nudging and behavioral change, this thesis aims to answer the following research question:

Can triggers be used to support nudging in a smart nudging system?

This Thesis will evaluate the contributions that triggers can have in a smart nudging system and present an implementation utilizing a Trigger based system to detect potential nudging situations and discuss the benefits, challenges, and potential that trigger might have in a smart nudging system.

1.3 Goal

The main goal of this thesis is to establish if a smart nudging system using triggers can be used to better understand the user and their situation as well as aiding in selecting a target activity as part of a complete smart nudging system as described by [8] and explained in section 2.1.3. Explore how such a system can be used to determine when a user should be nudged and how it can learn from feedback from the user to make changes to itself to make better predictions in the future. By looking into the advantages and disadvantages of triggers the thesis will provide insights into the potential for triggers to be used in future smart nudging systems.

The goal for the implementation of the system is to serve as a proof of concept that triggers can be used in smart nudging systems to detect user situations and aid in activity selection. The implementation will also give insights into possible benefits and challenges of implementing such systems.

1.4 Approach

To begin with this thesis will look at information about nudging and smart nudging systems to determine if and where a smart nudging system might benefit from triggers and then determine the possibilities of a trigger based smart nudging system. Then a prototype will be implemented. This prototype will focus on using triggers as a base to detect a user's current situation and determine if they are susceptible to being nudged. The prototype will also explore the possibility of using the triggers to aid in activity selection when a nudge is created. Finally a discussion about research and the prototype will be had. this discussion will focus on the design and implementation of the prototype and how it might be further improved

1.5 Assumptions and Limitations

Recommendations with a nudge [8] outlines the requirements for a complete smart nudging system. With many distinct steps needed to make a make such a system function. Due to time constraints and the complexity and size of any complete smart nudging system, this thesis will focus on the potential for using triggers to understand the user and their situation. This means some of the functionality that would normally be an integral part of a smart nudging system will either be missing or be simplified to allow the prototype to be implemented within a reasonable time-frame.

Privacy and protection of personal data is an important aspect in any system and especially smart nudging systems as they deal with lots of user data and often have access to real time data from the user. This requires that smart nudging systems have normally adequate security measures in place. Since the focus of this thesis is the use of triggers the use and discussion of security measures and mechanisms will be limited. The thesis will discuss the effect triggers might have on privacy, but the prototype will not include any additional security measures.

1.6 Methodology

There are two main ways to categorize research methods. These are Quantitative and qualitative. Quantitative research methods are concerned with experimenting on large data-sets to reach a conclusion [2]. These methods should not be used to reach conclusions without proper evaluation of data-sets. The qualitative method is a more descriptive approach and involves collecting, analyzing and understanding non-numerical data. This understanding is used to develop hypotheses and computer systems or reach theories.

In this thesis the qualitative method[2] is used because the evaluation is not based on measurements and experiments on numerical data, but on understanding and analyzing the non-numerical data gathered from experimentation.

This thesis follows the applied research method. The applied research method tries to solve a known and practical problem, making it easier for people to be more physically active by making a system that can more accurately determine when a person in a situation where they can be nudged to be more active. Research done using the applied research method often builds upon existing research and this thesis builds upon existing research from (Karlsen and Andersen 2019) [8]

The research has an indicative approach[2]. A research approach is used to find out how a conclusion can be drawn from collected data. The data in this research consists of observations and analysis from the data gathered from the work done.

1.7 Contributions

This thesis makes the following contributions:

Explored the potential of using trigger when designing smart nudging systems as well as provide a discussion of the benefits and limitations of triggers.The implementation of a system that is capable of using triggers to make better determinations on when users are more susceptible to being nudged. A discussion on presented implementation as well as how it can be further improved

1.8 Outline

The rest of the thesis uses the following structure

Chapter 2 - Technical background: Presents theoretical information about nudging and smart nudging. As well as describe the differences between nudging, digital nudging, and smart nudging. It also gives an explanation on how to design smart nudging systems.

Chapter 3 - Method: Presents the research methods used in this thesis.

Chapter 4 - Approach: explores the use of triggers in smart nudging systems.

Chapter 5 - Design: Presents a design for a trigger based smart nudging system.

Chapter 6 - Implementation: Presents an implementation of the proposed system .

Chapter 7 - Discussion: presents a discussion on the choices made during the design and implementation of the system. in addition it presents areas for future research into the topic of trigger based systems.

Chapter 8 - Conclusion Concludes the thesis.

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Technical background

This chapter gives a thorough theoretical overview of the concepts that are relevant to the research, development and evaluation of the system. Section 2.1 Nudging gives a brief introduction to the concept of nudging and its utility for influencing human behavior. 2.1.1 explains how the concepts of nudging can be integrated into digital systems and be used to influence its users. 2.1.2 smart nudging gives a look into how smart nudging differs from digital nudging by tailoring the nudges to the user. 2.1.3 explains how a smart nudging system can be designed.

2.1 Nudging

A nudge can be any attempt to steer a person towards a desired decision without removing their freedom of choice. Nudges aim to use knowledge to help users make decisions that benefit the decision-maker. The term nudging was first introduced by Thaler and Sunstein [7] and they define it as

"...any aspect of the choice architecture that alters people's behavior in a predictable way without forbidding any options or significantly changing their economic incentives[7]."

Choice architecture refers to the environment and situation a person is in when they make a decision. By making alterations to the choice architecture people can be nudged to make better decisions that are in their best interest. It is important that the alterations made to the choice architecture do not take away a person's options or attach an unreasonable burden to them. If a person wants to drink alcohol and eat unhealthily, they are allowed to do so as the option should not be taken away from them. They can however be nudged toward making better choices regarding their own health. One example method for doing this is to make the consequences of the unhealthy behavior apparent to the person. A great example of this is how many countries require that all packaging on cigarettes and other tobacco products contain information about the dangers of smoking. This type of packaging has an impact on a person's decision-making process but adds no undue burden for people who want to smoke.

Thaler and Sunstein [7] states that there are 6 key principles of nudging.

- Incentives: providing the right incentives to any given person is a good method to influence behavior. Incentives do not only have to be monetary or other material incentives but can instead be physiological benefits.

- Mapping: Refers to the process of making hard to understand and abstract outcomes of decisions easier to understand by mapping it to an easier concept.

- Defaults: Default choices are a powerful tool to influence decisions for two reasons. People often go with the default decision because they are too lazy or don't want to make hard decisions. There is also a sense of trust that the default decision provided is provided in the user's best interest

- Feedback: Giving people feedback on their choices can help them make better choices in the future. This works for both negative and positive feedback.

- Error: people are prone to make errors and bad decisions. Therefore, everything from nudges to consumer products should be designed with this in mind. One should design systems in a way that foresees possible errors people could make and gives a warning when an error is about to be made or it should be designed to make human error less likely

- Structure complex choices: structuring complex choices is a process of gathering information about a set of choices and presenting it in such a way that is easy to understand and evaluate.

In Thaler and Sunstein[7] they also present a few other examples of how effective nudging can be and how it can be used. One example is how the way food is displayed in a cafeteria determines what people buy and eat. Depending on what the cafeteria wanted to achieve they could use different arrangements of all the products to induce certain behaviors. If they wanted people to eat healthier, they could make healthy food more visible by having it displayed at eye level while at the same time reducing the visibility of unhealthy food by putting it in less visible places. Another example showed that when people are faced with difficult decisions, giving them a good default option. Thaler and Sunstein[7] showed that when people are faced with decisions that are hard and require a lot of effort, to be able to make a good decision they tend to make bad decisions and uninformed decisions, or they take no decision at all. They tendency showed itself then Thaler and Sunstein investigated people's behavior when deciding retirement plans. People would either make bad decisions on how to allocate their retirement plans or hold off on making the decision at all,

which would be detrimental to their future financial interests. They found out that giving people a good default option would result in a reduction of poor decisions and indecisiveness.

2.1.1 Digital nudging

Digital nudging aims to bring nudges into the digital world. Digital nudges aim to influence the behavior and decision-making of people just like regular nudges. Schneider et al. (2018) [6] defines digital nudging as: “The use of user interface design elements to guide people’s behavior in digital choice environments”[6]. By presenting choices in certain ways digital nudges can be used to guide the choices of users. Digital nudging influence the decision of a user at the moment the user is to make a decision. For example highlighting price reductions or displaying reviews are some known methods of digital nudging that are known have a substantial effect on the users’ decision[6]

2.1.2 Smart nudging

Karlsen and Andersen (2019) [8] introduce the term smart nudge. Smart nudging is a further development from digital nudging. Smart nudges are digital nudges that are tailored to a specific user and situation. Karlsen and Andersen define smart nudging as: “digital nudging, where the guidance of user behavior is tailored to be relevant to the current situation of each individual user[8]

2.1.3 Designing a smart nudge

Karlsen and Andersen (2019) [8] describes a multi-step process for designing smart nudges. Figure 2.1 is a visualization of the different steps in this process

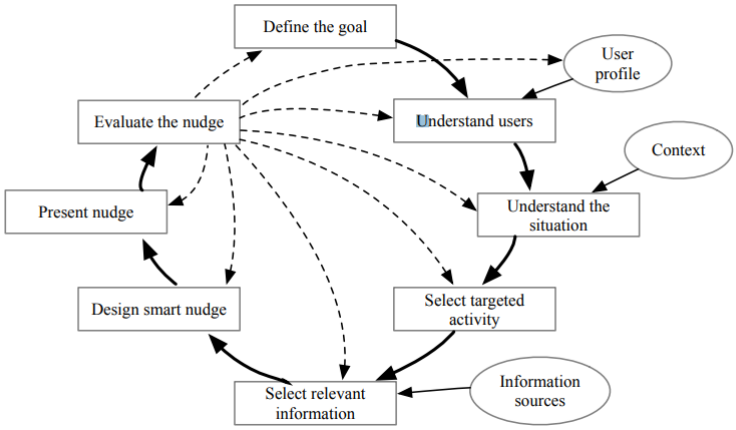

Figure 2.1: Designing a smart nudge [8]

- 1. Define the goal: The first step is to define the goal. The goal relates to the behavior or behavior change in the user that the system hopes to accomplish. The goal should be something that would push the user towards a better situation for them self and for the "greater good", Examples of goals are eating more healthy or being more active.

- 2. Understand the user: Understanding the user involves understanding the personality of the user and other traits that the user has. Understanding the user also includes understanding the psychological effects that can influence people's behavior and decision-making. This step will be connected to a data-set containing the information about the user that is required to understand them

- 3. Understanding the Situation: Understanding the situation is about knowing the contexts for the decision-making and what situation the user is currently in. Some of the factors that play into the user's situation include but are not limited to Location, time of day, weather or if the user is busy.

- 4. Selecting targeted Activity: Depending on what the nudging goal is there will be a set or related activities. This step chooses a target activity that can be used to create a smart nudge.

- 5. Select relevant information: After an activity has been selected the information that is relevant to designing the smart nudge for the targeted activity is collected. This information usually comes from many different sources that include GPS, clocks, Weather services, a calendar. This information is used to inform the user about the target activity, but

it may also include information that encourages the user to perform the activity.

- 6. Design the nudge: After the activity is selected and the information is collected, they are combined so that the recommended activity can be presented to the user as a nudge. The nudge will provide practical information to the user about the relevant activity to make it easy and convenient for the user to make the choice that the nudge is suggesting. While also motivating the user towards the goal.

- 7. Present the nudge: After a nudge is designed it is presented to the user. The nudge should be presented in a timely manner and in such a way that it reaches the user when the decision must be made

- 8. Evaluate: When the user has been presented with a nudge the response the user has to the nudge must be evaluated. If the user follows through and selects or performs the target activity the nudge can be considered a success. The target activity selection is determined through monitoring the user's response or through direct feedback. The user's response to any given nudge can potentially influence all the other steps in the process. The nudge and the chosen activity is recorded so that information from the response can be used to update the user profile and/or make adjustments to how the system understands the situation of the user. If a nudge is not followed this can indicate that the changes should be made to upcoming nudges to make them more appealing to the user. The evaluation of nudges can also lead to evaluation if the nudging goal should be changed

2.2 Trigger programming

A trigger is a simple mechanism that checks if a single or a set of requirements are fulfilled and if so, the trigger will fire and start a process or action connected to that trigger. This mechanism is used in everything from kitchen appliances and guns to buttons on a website. This versatile mechanism is used in everything from kitchen appliances and guns to buttons on a website. A trigger can have one or many conditions that must be met. Some might require all the conditions to be met before the trigger will fire and some might only require a subset of all conditions. (Ur et al., 2014)[4] shows that trigger action pairs are a useful mechanism for detecting specific conditions and that they are easy enough to create that even end-users of beginner level can start using trigger action pairs. This ease of use allows trigger to be used in a wide range of situations and a diverse set of conditions.

3

Method

This chapter presents the methodology used to answer the research question, "Can triggers be used to support nudging in a smart nudging system?" As mentioned in 1.6 the qualitative research approach is used. This is because it relies on non-numerical data to draw conclusions. The research method used in this thesis is the applied research method [3]. This is because the thesis tries to solve a known practical problem by implementing a computer system that builds on existing research from (Karlsen and Andersen 2019) [8].

The thesis follows the inductive research approach [3]. This approach helps formulate arguments for design choices in Triggering the next nudge system. By gathering research on nudging and smart nudging systems the thesis aims to identify possible benefits and challenges of using triggers in smart nudging systems. The research aims propose data and a proof of concept to provide a solution to the stated research question.

This thesis follows the exploratory research design. This design aims to provide a basis for general findings by obtaining relationships between variables and getting insight into the problem. Exploratory research rarely provides a definitive answer to specific issues but identifies key insights [3]. The thesis aims to provide a basis for general findings by obtaining a relationship between the use of triggers as part of a smart nudging system and the ability for the system to predict if a user is in a situation where they can be nudged. A key insight the thesis hopes to attain is if the use of trigger are a useful tool for detecting user situations.

4

Approach

4.1 Trigger

The system described in this thesis relies heavily on a concept called triggers, so it is important to understand what they are and why they are used. A trigger can be viewed as a situation check. The trigger will look at the current situation of the user to figure out if the user is currently in a situation where they are susceptible to being nudged. Each trigger monitors a separate situation. For example, there can be a trigger for good weather that if fired would nudge the user to do some outdoor activity or there could be a trigger that looks for work breaks that could nudge the user to go for a short walk. Since there is a trigger for pleasant weather there could also be a trigger for harsh weather that would present the user with a nudge to go to the gym.

4.1.1 What functionality does triggers provide

One of the core parts of triggers is they are adaptive and can be personalized. The conditions for each individual trigger can be changed and tweaked in response to user feedback and monitoring of nudge successes and failures. They can be altered to push the boundary of what situations the user is nudged in and depending on the responses, keep or revert the changes. An example of this could be a trigger related to pleasant weather because what someone considers pleasant weather differs so much from person to person. Being able to customize the trigger to the user is a huge benefit. In this example the adaptability could be utilized by having a default that most people would agree to consider pleasant weather and as users interact with the system and give it feedback then system can then make slight changes to what is considered pleasant weather and slowly push It towards increasingly harsh weather. If the user still gives possible feedback this process can continue, but in this example, there will eventually come a point where the user refuses to do outdoor activities. When it reaches this point the system will now know the limit for when this particulate user is willing to perform outdoor activities and can therefore use this data to make better predictions on when to nudge. This type of adaptability is also present in many other situations. Some users might find it pushy if the system tries to nudge them for being inactive after they have been sitting on the couch for an hour, but might be okay if it has been three hours instead. This adaptability allows the system to learn from every nudge and over time make the system able to better serve the user

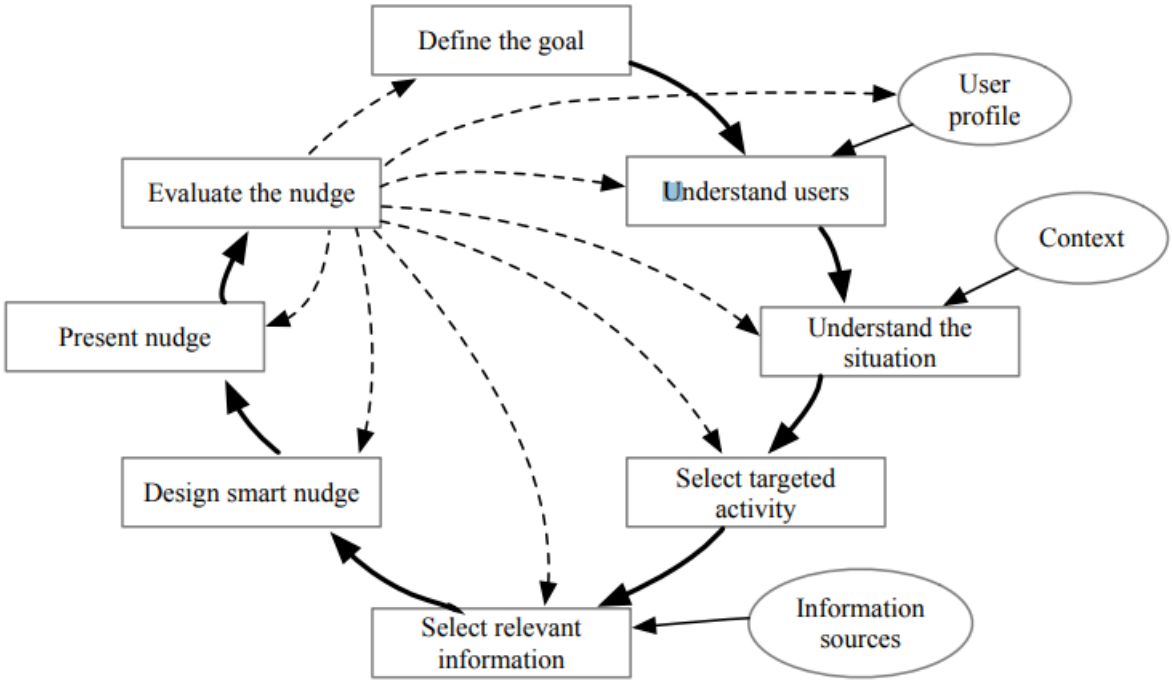

Figure 4.1: Smart nudging architecture as presented in [8]

How do adaptive triggers fit into a smart nudging system

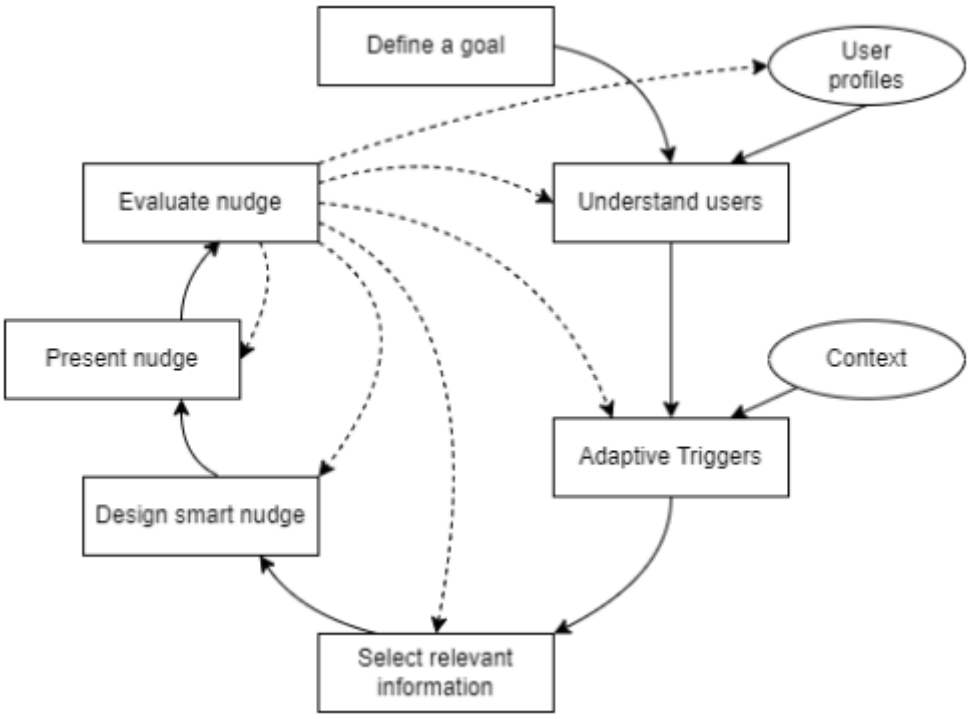

Figure 4.2: Visualization on how trigger fit into a smart nudging architecture

4.2 How does the trigger architecture fit into a wider smart nudge system architecture

Adaptive triggers are an innovative approach on how to make some of the components needed for a smart nudging system. The adaptive triggers serve mostly to understand the current situation of the user and when the user is in a situation where they are susceptible to being nudged a nudged activity is chosen for them.

4.3 monitoring user responses

Comparing a user to other similar users is a good starting point when predict what the response to any given nudge is. But since all users are different this approach is not perfect and the data to make those comparisons have to come from somewhere. that is where the monitoring of user responses comes in.

Every time a user is presented with a nudge it is critical to extract as much information as possible from how the user interacts with the presented nudge. Some of the important data that can be gathered includes how much time the user interacted with the nudge. How long it took before the user interacted with the nudge. If and how the user performed the nudging activity. This data can then be used to learn more about the user and how they interact with the system. monitoring the responses is also a very important because it shows that the user is responsive to this exact nudge. monitoring the feedback only is the guaranteed way to figure out if a nudge will be effective on a particular user.

4.4 utilizing user feedback

To make the system more adaptable some feedback has to be gathered from the user. This feedback can be gathered by asking the user directly for feedback or monitoring how the user interacts with the system. This data can then be used by feeding it back into the user profile and trigger system so that the system can become better adapted to the individual user.

4.4.1 Trigger Personalizing

Another advantage of triggers are they are adaptive and can be personalized. The conditions for each individual trigger can be changed in response to user feedback and monitoring of nudge success. They can be altered to push the boundary of what situations the user is nudged in and depending on the responses, keep or revert the changes. An example of this could be a trigger related to good weather because what someone considers good weather differs so much from person to person being able to customize the trigger to the user is essential. The default could be that good weather trigger would only fire if the sun was out and the skies where clear, but after some time it could be altered to include all conditions the user is comfortable doing outdoor activities in. This is done by pushing the boundary of what is considered good weather and monitoring the users feedback. A similar process could be used to personalize all types of situation triggers. To allow for this type personalizing the triggers have to be made adaptive. to do this each trigger has to be

4.5 Choosing a nudge activity

Since each situation trigger has multiple possible nudges and presenting the user with 10 nudges at the same time would make them disinterested, a choice has to be made. When choosing what nudging situation to go with the idea is that you want to use nudges that you know have worked in the past as much as possible, but also from time to time change the nudge up a bit or present the user with a nudge for a different activity. This is to avoid it becoming to repetitive and stale and the only guaranteed way to figure out if a nudge will be effective on a particular user is to present it to them and monitor the feedback.

4.6 Triggers for low activity

An example trigger that should be an example written about and discussed in the thesis is the inactivity trigger. An inactivity trigger is a trigger that monitors the activity of the user over time. If the user has a low amount of activity over a given amount of time the trigger would fire to push the user to do some sort of activity. The inactivity trigger would be relevant for people with a sedentary work and/or lifestyle. And inactivity could use many diverse sources for its input data depending on the system. The easiest way to gather this information would be step counters on phones as most people always carry a smart phone with a built-in step counter. An example of how this trigger could be used is if the user works an office job and the system detects that the user has had little to no movement during the first half of the workday it could nudge the user to go for a walk during a break to get some activity and steps in. A similar nudge could also be presented at the end of the workday. Another approach could be to nudge the user more often with less demanding activities. For example, the user could be nudged to stand up and do some stretching every time the system detects that the user has gone an hour without any activity. Both approaches can be used when the user is at work or at home and they can even be used at the same time.

The inactivity triggers must be adapted to the user especially if the second approach is used since many more nudges are presented with this approach it makes it more likely that the user will find the nudges annoying and inconvenient if there are too many and at the wrong times. This means that the system will have to be aggressive in the initial stages when adapting to a new user to determine what approach works best for that user while their motivation is still high.

While step counters are the most available method for data gathering for

determining inactivity there are others as well. One interesting piece of data that could be gathered is heart rate. This data could be gathered by using smart watches with built-in heart rate monitors that are becoming prevalent as an accessory to smartphones or by using dedicated heart rate monitors. Heart rate is a better indicator of the user's activity level than steps are. This means that the system can be more precise when deciding to present a nudge.

4.7 GPS as a tool for nudging

One of the most essential elements to make the trigger system work is having accurate information about what the user is doing. This is to make sure that the system is not nudging them when they are busy with something else. If they are busy, it is good to know what they are busy with as in some situations they could still be nudged. For the system to get this information it would require that the user keep a detailed calendar and make it available to the system or that the user informs the system about what they are doing during the day. It is fair to assume that most people do not keep an incredibly detailed calendar of their daily activities and that most people are not motivated enough to manually inform the system of their every daily activity.

This is where GPS provides a solution. GPS can provide the system with a lot of the same information that the system wants from the users without any input from the users themselves. That makes it easier for the users and the system gets access to more consistent and reliable data.

There is a lot of information that could be extracted from the GPS data and used to improve the system. For example, it would be easy for the system to determine when a user is at work using GPS and it could account for things that would normally be overlooked like unplanned overtime, if the system only had the users schedule available. Knowing that the user is at work allows the system to better select nudging activities that are relevant to the user's situation. GPS also makes the system more able to detect when the user is in a situation where they should not be nudged like when they are driving. It can also be used to detect situations when they can be nudged but should not be. If, for example, a user is currently at the gym or taking a walk they can still be nudged but should not since they are already performing a physical activity. Using more static data sources like calendars can prevent the users from being nudged in these types of situations if they are properly maintained, but GPS provides a more reliably source for this data as it does not require any addition input from the user.

4.8 When are users susceptible to nudges

When a user is susceptible to a nudge depends a lot on the nudging activity. For any given activity, there is no binary answer for if a given user is susceptible to being nudged in the current situation. The user is always on a spectrum between highly likely to be successfully nudged and highly unlikely to being successfully nudged. One of the goals of adaptive triggers is to figure out where on this spectrum the user current is. This is not an exact science, and the system can only give an educated guess on where the user falls on the spectrum.

The system uses a few different methods to make the best possible guesses. The simplest method for this is trial and error. When a user has been presented with a nudge, how they respond to it can be monitored and since the system knows the situation of the user when they were presented with the nudge, the system can make changes to when and where to nudge next time. This is what makes triggers adaptable.

While trial and error will eventually give users nudges in the correct situations most users will only allow for a given number of errors before they stop using the application. So, some things must be done to decrease the number of wrong guesses. The triggers are adaptable but each of them must have a set of starting conditions and then they are adapted to the individual user. So, setting good starting conditions is important to decrease the number of wrong guesses. What could be considered good starting conditions differs for each individual trigger, but some general rules (work in progress) can apply to most triggers. The person designing the triggers can with tools like user testing gain the knowledge needed to understand the situations the user will find themselves in. The nudge designer can then make judgments on what situations the users are likely to be susceptible to a nudge are. The starting conditions for a trigger can also be adapted based on other similar users.

4.9 Availability of being presented a nudge vs ability to carry out an activity

A large part of this thesis focuses on determining when a user is in a situation where they can be nudged to perform an activity, but it can still be effective to nudge users with activities that they are currently unable to do perform. This is because the nudge can prime the user. These priming nudges have two separate ways to succeed. The first is if the user receives a priming nudge, then goes out and performs the nudging activity on their own later when they have time. The second is if the user receives a second nudge later in the day for a

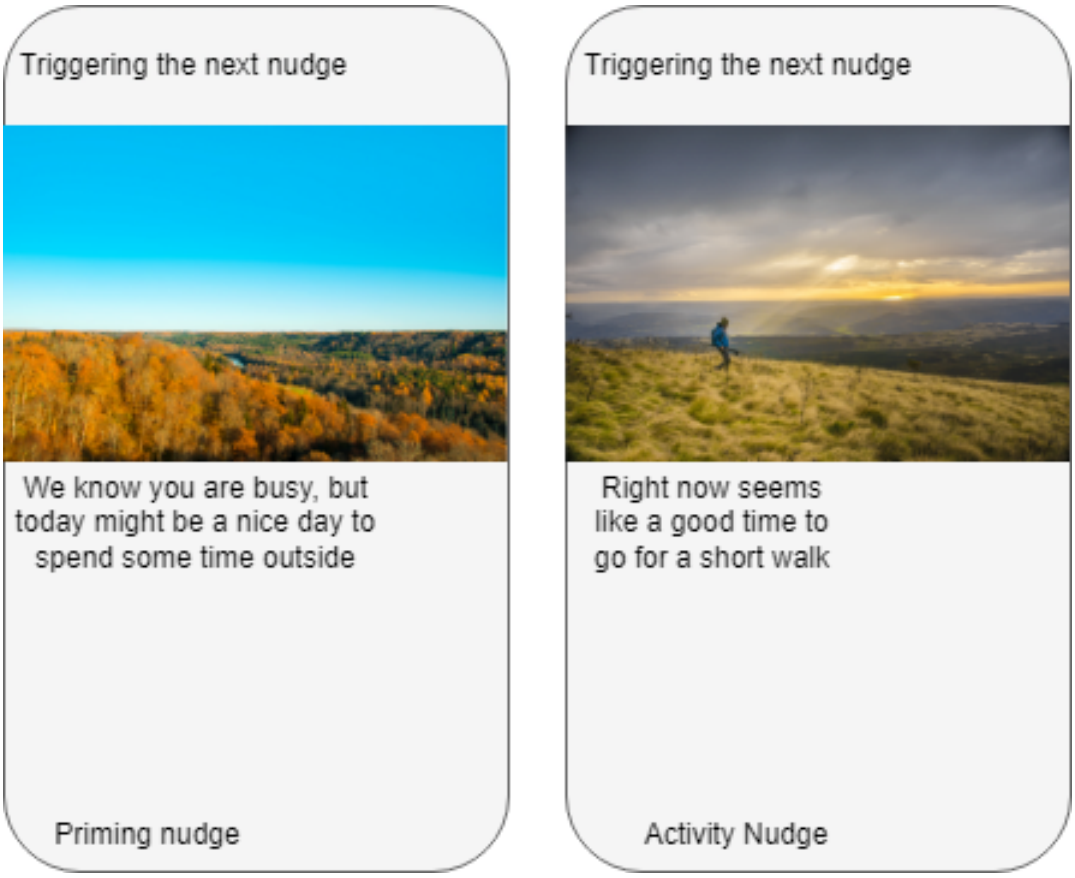

Figure 4.3: Example illustration of a priming nudge followed by an activity nudge

specific activity and performs it.

4.9.1 priming

Priming is a psychological effect where a stimulus, usually words or images, can be used to affect a person's behavior. It is believed that units of information or so-called schemas are stored in long term memory. With careful presentation of different stimuli, it is possible to make these schemas more accessible. A subject's behavior will change depending on which schemas a have had more activation recently. [1] showed that priming subjects with words related to old people made them move slower. So, an assumption can be made that this method change can also be used to alter peoples behavior in other ways.

4.9.2 How long before the activity should the user be primed

Priming can affect someone's behavior even when it relates to long term decisions or decisions that are not taken until months later as shown in [7]. Even though it might be possible to start priming users to skiing already in august, it is not in the best use of the user's attention span. Therefore, the usage of the priming for the nudging system should be short term. The most effective and relevant time-span from when a user is primed to an activity is presented is just a few hours. Like is (ref image above) the user would be presented with a priming nudge while they are at work and then later when they are home, they can be presented with another nudge that includes a target activity. The goal is that the user is more likely to perform an outdoor activity because they were presented with stimuli that they associate with outdoor activities and thus change their behavior. Priming can also be used to prepare users for bigger activities that take some time and effort to prepare. A good example of this is longer mountain hikes or similar. It is not the sort of activity that a user can or should perform on short notice as they tend to take many hours to perform and should be planned so that it can be done safely. Even if it is feasible for the user to go for the hike, presenting the user with an activity that requires so much effort unexpectedly is unlikely to succeed. If on the other hand the user has been primed for taking a longer hike over the course of a week it will be a lot easier to nudge the user to take a hike during the weekend. This also gives the user time to plan and prepare for more demanding types of activities.

4.10 Limiting unnecessary user interaction

While many applications try to make their users interact as much as possible with the application this should not be the goal of a smart nudging system with one exception. Especially like in this thesis when the goal is to make the user more active the solution is not to make them spend more time interacting with the application the necessary. [5] states that exerting self-control is a choice, but it has a cost associated with it. Instead of having the user pay this cost interacting with the application, it would be better if the effort were used on the activities that are presented when the user is nudged.

As stated above an exception to the arguments stated would be if the goal of the smart nudging system were to make the users better at something that could be improved by looking at a screen for extended periods of time. An example of the could be games made to improve the user's short-term memory.

4.11 Allowing users to set available time

Allowing users to set dedicated times when they are available to being nudged sidesteps some of the problems addressed earlier. Some users have erratic availability over the course of the day for reasons that are out of their control. There are two main approaches such a system could have, and both have their own advantages and disadvantages.

4.11.1 Set time that is not available

The first approach is to have the users set the time periods where they are not available to be nudged. An example of this could be the user deciding that they are not available to being nudged from 8 to 16 Monday through Friday because their work does not make it possible to perform any nudging activities.

A major advantage of allowing the user to this approach of setting availability is that it stops the user from receiving unnecessary nudges that they might perceive as spam. Since they have allocated a time where they do not want to be nudged the system should respect that and no nudges should be presented in that period. Even if the system has determined that it would otherwise be a suitable time to nudge. A system using this approach should in theory have a higher success rate than one that does not since many situations where the system might have presented the user with a nudge that was doomed to failure have been removed.

Instead of setting unavailable time in a very static fashion like the Monday through Friday example there could be functionality where the user with the push of a button could tell the system that they are busy for the next X amount of time. For example, if the user were going into a meeting or had an appointment at the hairdresser, they could tell the system to not nudge them for the next hour. This could allow for extremely high nudging success, but it requires that the user interacts a lot with the system.

set unavailable time approach has a problem with it excluding a lot of potential nudging situations. This is a bit of a complicated tradeoff to balance, since as mentioned above the whole point of this functionality is to remove time that the user is not available. The problem arises because the user is likely to exclude time periods where they could still be nudged but they are not aware of all the possible nudging activities that are available to them. An example of this could be the user that blocked nudges during their working hours could still benefit from nudges the pushed them to minor activities such as stretching or going for short walks during breaks. Such nudges would no longer be a possibility if the users were given the functionality to block time periods.

4.11.2 Set available time

The alternative approach to having the user set when they are busy is having them set when they have available time. If such an approach were used it would be assumed that the user was always busy except those that are specifically allocated as available. Like the first approach this could be set as a static exception where the user has available time every week on Wednesday from 4 to 8 or it could be set dynamically where the user must interact with the system to say that they are available for the next two hours.

The upside to this approach is that a higher nudge success rate can be expected unless a bad nudging activity is chosen. This approach has the same problem as the first one in that it excludes so many possible nudging situations.

I would argue that this approach is potentially so restrictive that it can turn a smart nudging system into just an activity picker for the user. Instead of the system trying to nudge the user to reach a certain goal it has the potential to be just a tool that the user could turn on whenever they have the motivation to do something but are unsure what. Such a tool could be of use to some people, but it would not be considered a smart nudging system anymore.

4.11.3 Effect on transparency

All forms of nudging must take a stance on transparency. How aware should the user be that they are being nudged. Allowing the user to set dedicated time to being nudged would make any system that used it more transparent. Having such functionality would allow users to interact more with the system. Having the users set available time should be considered the user giving permission to nudge the user in the allotted times. It could also be argued that since the user has gone out of their way to use the system knowing that its core functionality is nudging that this additional transparency should not matter much.

4.12 Cold Start Problem

The system described in this thesis suffers from what I call a double cold start problem. While they are different smart nudging systems share some traits with recommender systems so, they also suffer from the cold start problem. The cold start problem is a widespread problem for recommender systems where the system is lacking data to make good recommendations. There are three common cases of the cold start problem, and this system suffers from two of them. The first case is the new user problem where every time a new user is

added to the system there is a learning period where the system must present the user nudges without really knowing their preferences. After some time, the system will adapt to the user as it is designed to do, but before that there is a period where the likelihood of presenting the user with badly designed nudges is high. Some of the problems with the new user case can be mitigated if the community of users is large enough because then the system can make better first-time assumptions based on the experience of users that are similar in character. But that leads on to the second case of the cold start problem that this system faces. The new community case. This happens when the user community is small, and the system therefore has a smaller amount of data to draw conclusions from. The low user count means that the system has had less opportunities to experiment with new adaptations and it is harder for the system to compare a new user to existing users to reduce the impact of the new user case.

/5
Design

This chapter contains the design part of the thesis. Information from the background and approach chapters is used to create a design and representation of the Trigger based smart nudging system. This chapter first discusses how the base triggers are used as the core of the system, then how these base triggers can be merged to create more complex triggers that are relevant to specific situations.

5.1 Triggers

Triggers are a structure that is used to check if a user is in a situation where they can be nudged. In its most basic form, the structure consists of a single situation check that can be used to determine something about the user's current situation. This trigger can then be bundled together with other triggers to create checks for more complex and specific situations. This concept will be further explained. The trigger structure can then be linked to a set of activities in such a way that when all the conditions in a trigger are true then the nudge creation process will be initiated around one of the activities in the linked set.

As shown in [8] there are eight key steps in the smart nudge creation process. These are in order. Define the goal, understand users, understand the situation, select target activity, select relevant information, design smart nudge, present nudge, evaluate the nudge. The goal of the triggers in this process are to be used to understand the situation of the user and by linking a set of activities to the trigger it can also aid in the activity selection process. but by using adaptability which will be explained later in section 5.1.2 as way to evaluate the nudges are integrated into the system allowing for better understanding of the user and the situation.

To make the trigger system more practical, triggers are split into two different types. Base and Complex triggers. First base triggers and how they are used will be explained followed by how they are used to create complex triggers

5.1.1 Base Triggers

Base Triggers are simple triggers that will only perform a single check and most of the time they only have a single data source as input. Examples of such a base trigger could be a trigger that checks for sunny weather. The data source for this trigger would be a weather API and would interpret the data from the API to determine if the conditional statement of sunny weather is true and in that case the trigger could fire. such a trigger would be useful when trying to

nudge users to go outside. Another example of a base trigger is the inactive trigger. this trigger uses the step counter on a user's phone to determine a user's activity. If the user has been inactive and not taken any steps for a given amount of time the condition would be considered true, and the trigger would fire.

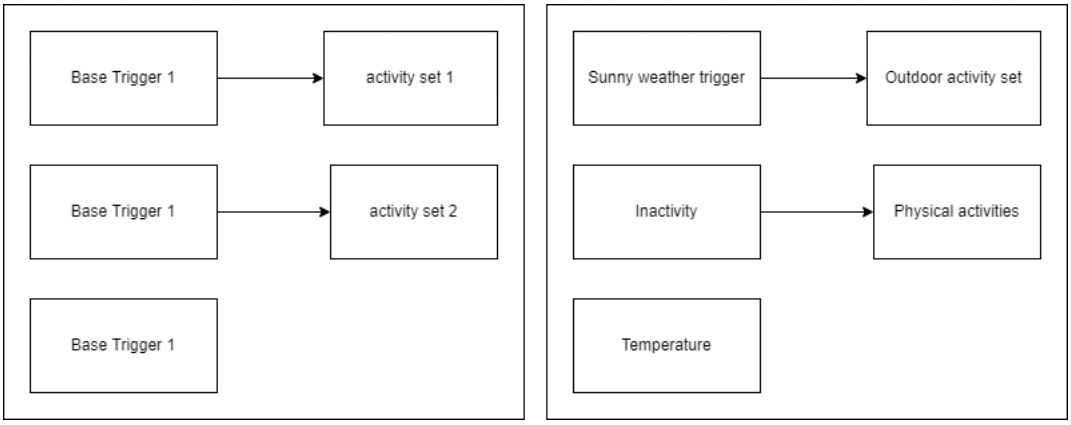

Figure 5.1: Base Triggers with linked activity set

Base triggers serve two purposes in this system. Firstly, they serve as components in complex triggers and secondly, they serve as standalone triggers. A base trigger is considered a standalone trigger if it has at least one linked activities and can, therefore start a nudge creation process. Linked activities are further explained in section 5.2, the short explanation is that linked activities is a set of activities where a specific nudge activity is chosen when a trigger fires and the nudge creation begins.

Consider for example a simple system where the only trigger in the whole system is an inactive trigger. This triggers cheeks if the user has been active by monitoring a step counter on the user's phone. If the step counter has not increased during the last seven hours, the user is considered inactive by the system and the condition on the trigger is considered true and the trigger can fire. This trigger is considered a base trigger because it only performs a single check. This example trigger has a set with one linked activity and this activity is just a short walk. So, what would happen in practice with this example system is that when the trigger detected that the user has been inactive for two hours the trigger would fire. Since there is only one activity in the set it will be chosen by default, a nudge would be created by the system and presented to the user nudging him to go for a short walk.

Base triggers that do not have any linked activities are not considered standalone triggers. Base triggers that are not standalone triggers are only used as

components in complex triggers. Base triggers are not exclusively standalone or component triggers. Triggers that are used as standalone triggers can also be used as a component in a complex trigger. A good example of this is the inactivity trigger used in the example above. Such a base trigger could be used as a standalone trigger like in the example or be used as a component in many other complex triggers where it is good to know that the user is currently inactive.

Complex triggers

Complex triggers are triggers that combine two or more base triggers. The goal of complex triggers is to create triggers for more specific situations that cannot be accurately detected with only the single checks allowed in base triggers. Complex triggers function just like base triggers but with more conditions that must be true for the trigger to fire. A complex trigger needs all its conditions to meet for it to fire. Figure 5.2 exemplifies a complex trigger that checks if the user is in a situation where he should be nudged for an outdoor activity. This complex trigger consists of three individual base triggers. The first trigger checks that it is sunny outside, the second checks if the user has been inactive for a set amount of time and the third checks if the temperature is above a certain threshold. This trigger would also have a set of linked activities that relate to outdoor activities like riding a bike or going for a walk.

Creating complex triggers in practice functions in a similar manner to multi class inheritance in objective oriented programming languages. So, to create a complex trigger first a few base triggers must be created. The complex class will then inherit from two or more base triggers. The complex trigger will receive the conditional statements that must be checked for the trigger to fire and the functionality to prove the statement true or false. Using the example above the outdoor activity trigger would inherit a sunny weather trigger with all the functionality that interacted with the weather API to determine if it was sunny. From the inactivity trigger it would inherit the functionality to monitor the activity levels of the user using the step counter. This way of inheriting functionality means that once a certain functionality is implemented in a base trigger it can easily be utilized by many different complex triggers.

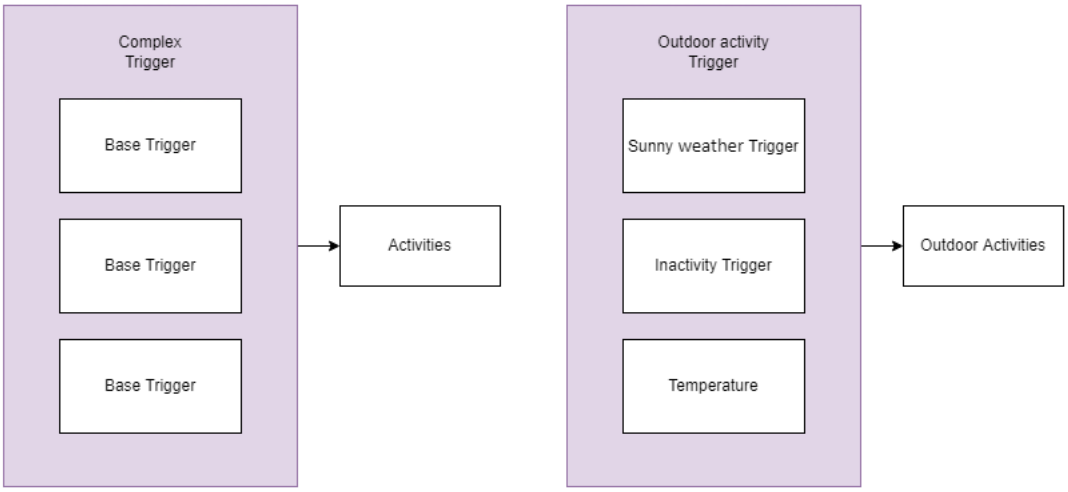

Figure 5.2: complex Triggers

5.1.2 Adaptable triggers

Evaluating the user's response is one of the key steps in the smart nudging process as explained in 2.1.3 and making the triggers adaptable is the way to integrate feedback from the user into the system. Adaptability regarding triggers is the ability to make tweaks to the conditional statements in the trigger and thus making a change to when the trigger will fire. To allow for the ability to adapt based on feedback after the user has been nudged, the condition in the triggers must be changeable. Since the conditions change so much from trigger to trigger, some triggers are more adaptable than others. The easiest triggers to adapt are those that only rely on simple numerical values. For example, a trigger that activates after a given amount of time of inactivity or one that activates on a specific temperature threshold. These types of triggers can be easily adapted by changing a single value in the conditional statement. However, most triggers are not this easy to change and require some forethought when they are designed so that they can adapt to the user later. A good example of this problem would be a trigger that checks if the weather is nice outside. For the user, the answer to this question will be yes, no or somewhere in between, but the problem is that the answer is subjective and changes from user to user. This means that there is a benefit to the trigger being adaptive, but there is no mathematical gradient that can be easily used to represent how good a user thinks the weather is. Another approach is needed. There is no one size that fits all approaches to these types of adaptability problems, but for this problem and other similar problems one solution is to make a set of states.

For this example specifically, the set of states would contain the various types of common weather. The weather set could contain sunny, light clouds, cloudy, rainy and so on. Using the set of these different states, the trigger can now adapt to what the user considers good enough weather for outdoor activities. How these sets are used can differ depending on the implementation, but one method is that when a new user first interacts with the system only sunny or light clouds would be considered good weather and satisfy the condition, but after several nudges related to the trigger have been presented to the user cloudy weather could be added to the list of weather that satisfies the condition. If the nudges are still successful, then this part of the set stays and next time light rain can be added, and this will then continue until either all the parts of the set are accepted, or the success rate of nudges drops after a part of the set is added. If for a specific user light rain was added to the set and they stopped interacting with the nudges after that it would show that this part of the set is not acceptable to the user, and it should therefore be removed.

5.1.3 Transferring adaptability between triggers

When using the ability to combine base triggers into complex triggers with adaptability a potential problem arises. A complex trigger is made up of multiple different base triggers that are all adapted individually. So, if a complex trigger uses 3 different base triggers, then there are 3 different parts of the complex triggers that can have adaptability changes made to it, but since one of the main benefits of using the system of base and complex triggers is that it allows for reusing the base triggers there is a high likelihood that the base triggers in our example complex trigger are being used in multiple other complex triggers. The issue is that if take an example base trigger like the inactivity trigger that can be used in many complex triggers. One of the complex triggers using the inactivity trigger can then fire a few times and create nudges to get feedback. Based on that feedback the system decides to reduce the amount of inactivity time required for this base trigger to meet its conditional statement. The question then becomes, should these adaptability changes stay local within this specific complex trigger or should it be transferred to the base inactivity trigger and all the other complex triggers that use it.

There are two approaches to dealing with this. Each with pros and cons. The first approach is to not let any of the adaptability changes transfer to other triggers. The pro of this approach is that it is very safe as there is no chance that adaptability changes that have transferred to other triggers can have an adverse effect on those other triggers. The con of this approach is that the system will be a lot slower to adapt to the user. This is because it will have to learn the same lesson multiple times. Take for example the good weather trigger used to explain adaptability earlier. This trigger starts with only a narrow set of

acceptable weather conditions that can expand over time based on user input. It is also a trigger that is likely to be used by many complex triggers related to most outdoor activities. So, for each of these complex triggers using this base trigger many nudges must be presented and evaluated just for each of the triggers to learn something that might already be known to the system. This greatly slows down the rate at which the system can adapt to new users

The alternative approach is to let the changes transfer through the different triggers. The pro approach would greatly speed up the adaptation process as it removes the need for all the duplicated learning. The con with this more aggressive approach is that there are so many possible different base and complex nudges there will be situations where the changes made to improve one complex trigger will transfer through the triggers and have an adverse effect on another complex trigger. There are situations where a user can have different opinions on a specific situation depending on what activity they are presented with. For example, a user might be fine with going for a walk if there is a bit of rain but would not go for a bike ride in the same conditions. Allowing adaptability to transfer means that situation like this one will not be possible to detect for the system.

I believe that the first approach of not letting the adaptability transfer is the better option and allows for a more stable system. An argument can also be made that the adaptability transfer problem can be decided on individual basis where for each base trigger it is decided if the adaptability is transferable.

5.1.4 Safety Triggers

Safety triggers are not a new type of trigger but are principles for designing good complex triggers. In most of the examples of triggers presented in this thesis the focus is on triggers that check if the user is in a situation where they can perform a certain activity. Safety triggers are there to detect situations where the user can perform a certain activity, but they should not do it. An example of how these triggers are used in practice can be the outdoor activity trigger. This complex trigger will have multiple triggers that check for the user's activity levels and how the weather and such is. In this case a safety trigger could be a base trigger that check the local air pollution levels. If they were particularly high on a given day, it might not be in the user's best interest to spend much time outdoors even if they could have. So, in this example all the other conditional statements could have been met and the trigger would have fired, and the user would have been nudged to go outside if it was not for the safety trigger that was added specifically to stop these kinds of situations from happening. Another example could trigger that related to nudging the user to go for a longer hike. The base trigger of this complex trigger would include

functionality to check for weather conditions, the state of the trail and that the user was not busy with something else. These triggers are used to check if the user is in a situation where they could perform the hike. For this example, the safety trigger could be a base trigger that checks how many hours of daylight are left. Even if the user can go on the hike, doing so when it is about to get dark can put the user in a harmful situation.

Safety triggers are identical to all other base triggers in functionality and only differ a bit in design. The use case for safety triggers is very situationally dependent. Most complex triggers don't need safety triggers while some might need multiple. Triggers must always be designed with the user's safety and well being as the most important aspect.

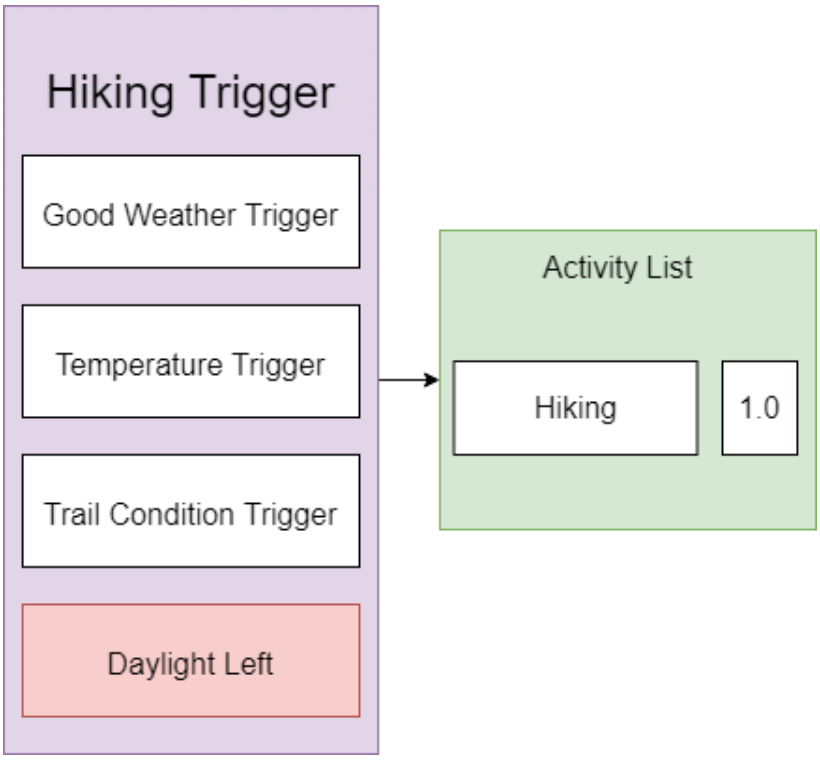

Figure 5.3: Safety Triggers

5.2 Linking activities to triggers

As explained in section 5.1 one of the key steps in the smart nudge creation process is the selection of an activity. This section explains how linking a set of activities to the trigger helps in this process and how it can be done in

practice. Section 5.4 goes more into detail on how the actual selection process is done.

The main goal of linking a set of activities is to limit the number of activities that the user can be nudged toward based on their current situation. Instead of selecting an activity from a pool of all activities known to the system an activity is chosen from a narrow set of activities that are relevant for the situation the user is currently in. The way this works is that when a base or complex trigger is created, it contains a list of linked activities. These activities are pulled from a master list of all the activities that the system can present to the user. What activities are linked to any given trigger depends on what situation the trigger is trying to detect. For example, the outdoor activity trigger would contain outdoor activities like walking and cycling plus other outdoor activities while a trigger that checks for longer periods without physical exercise would link activities like going to the gym. Base triggers are not required to have linked activities unless they are used as standalone triggers. complex triggers must always have a list of linked activities, but this list only needs to include at least one activity

An important aspect of how linking activities work is that is that if a base trigger has an activity list this list is not inherited together with the rest of the base trigger if it is used as a component in a complex trigger. If the inactivity base trigger has an activity list, the activities in this list will not be added to the activity list of the complex outdoor activity trigger, even though it is being used as a component. The reason for doing this is that since the inactivity trigger or some other example trigger can be used in many different complex triggers to detect very different situations. These situations might not be very similar so should be linked to different types of activities. An example of this could be a base trigger for inactivity. The task of this trigger is to check if the user has been inactive for a given amount of time. This is a very flexible trigger as it can potentially be linked to very many different activities. So, if the activity lists where inherited with the base triggers this leaves two options. One option is that the complex trigger the inherited all the activities from the inactivity trigger will receive a lot of unnecessary activities. Or the other option is that the inactivity trigger can either be only linked with activities that all potential complex triggers it might be used in can inherit. This creates a lot of difficulty when designing the base triggers, as all potential future complex triggers must be taken into consideration. Or as the second option the inactivity trigger can have no linked activities at all meaning it can't be used as a standalone trigger.

This is especially important because if the activity list were inherited by the complex trigger it would be very hard to prevent situations where the complex triggers inherited activities that are not necessarily relevant to the situation

that the trigger is targeting. An example of this could be a base trigger for inactivity. The task of this trigger is to check if the user has been inactive for a given amount of time. Now if this base trigger was used as a component in a more complex trigger that checks if the user is in a situation where they can do some physical exercise. This complex trigger would consist of multiple base triggers where the inactivity trigger would only be one of them. The problem is that natural target activities for this trigger would be higher intensity activities like a session at a gym or jogging. The low intensity activities of the inactivity trigger go against the goal of the complex trigger it is now part of and this now unnecessarily expanded activity list makes the activity selection process worse. The problem compounded by the fact that all the other base triggers in the complex trigger would all bring their own activities further diluting the activity selection process

5.3 Activity selection

The activity selection process is tasked with choosing which of the activities from a triggers activity list that will be used as base when creating a nudge presented to the user. This process is important as which activity the user is presented with has an impact on the chance of the presented nudge being a success.

The activity selection process is not overly complex, but it has a prerequisite for the process to function properly. For the activity selection to function the triggers with their linked activities must be designed in such a way that if the trigger fires, then all the activities linked to that trigger must be viable for the user to perform. if this prerequisite is not met there can be situations where the user is nudged to perform activities that are not possible for them to perform. Such nudges will always be failures.

The activity selection process uses weights where each activity in the list is given a score that determines the activities' chance of getting selected. The activities are given a weight as opposed to being random because this allows for the system to adapt the chances of an activity being selected based on the users' preferences. Since it would not be feasible to add the different activities to the triggers based on a specific user's preference if the user base is large, it is better to have the option for the system to learn what activities a specific user prefers and adapt to these preferences. When a user has been presented with a nudge, they will either perform the activity or not and depending on the feedback the scores on the activities will change. A successful nudge will increase the chance of an activity being selected again while an unsuccessful nudge will decrease the chance. If the user repeatedly shows disinterest in an

activity that activity will eventually reach a score of zero and will no longer be selected as a nudging activity. The starting scores are set when the activity list is created. If there is only one activity in the list, it will always have a score for one.

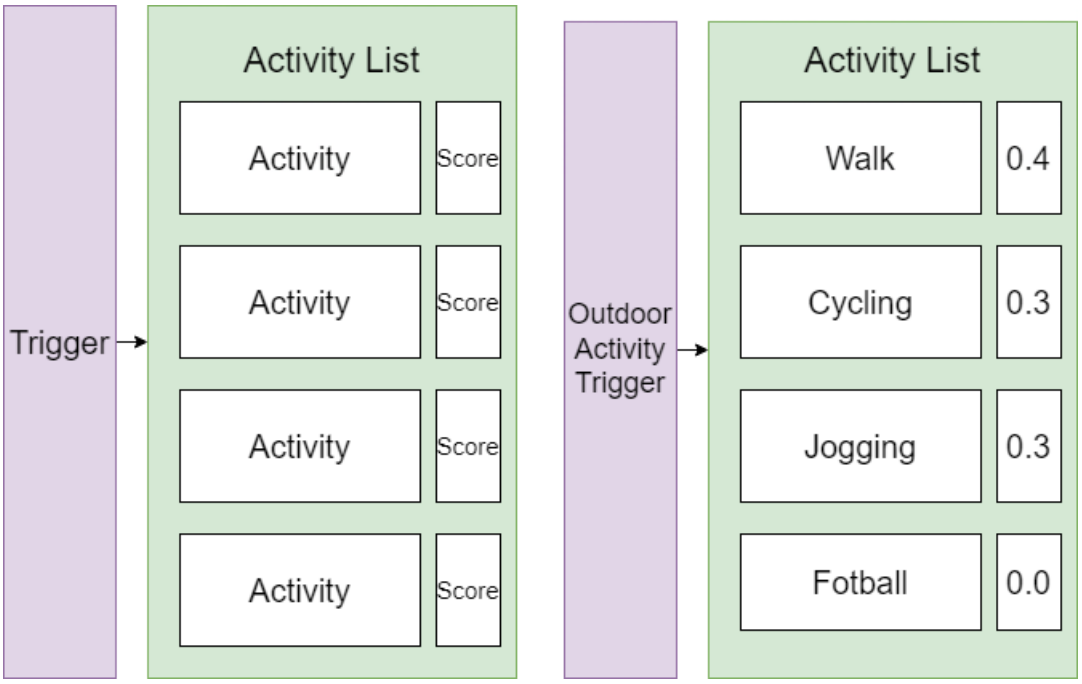

Figure 5.4: Activity Selection

6

Implementation

This chapter will present an implementation of the "Triggering the next nudge" system. This implementation has been made as a proof of concept on how trigger can be used when creating a smart nudging systems. The prototype consists of a mobile application that uses the approaches proposed in the previous chapter to determine when to nudge users. The application also includes the activity selection system proposed.

6.1 Triggering the next nudge Prototype

6.1.1 Assumptions

Because smart nudging systems are so complex some assumptions must be made, these assumptions are there to help narrow the scope of the implementation to the specific problems that the thesis aims to address. These assumptions also serve as a disclaimer of functionality that is not included in the prototype but should be included in a complete smart nudging system. The goal for this prototype is not to serve as a real world and user ready smart nudging system but to show a possible way of implementing a trigger based smart nudging system. The assumptions made for this implementation are.

- User profiles and user Profile storage The system does not include proper user profile functionality. In a user-ready system there should be functionality to allow users to log into their unique profiles and infrastructure for these profiles to be stored centrally so they could be accessed from different devices. In this implementation most data related to the user profile is assumed and only stored locally.

- Nudging goal The nudging goal would otherwise be related to the user profile and since they are assumed so is the nudging goal. The nudging goal in this implementation is always to make the user more active.

6.1.2 Specifications

Listed below are the specifications for the Triggering the next nudge prototype based on the design proposed in chapter 5 Design. The specifications serve as the minimum expected functionality of the system.

- The system should present the user with nudges at appropriate times

- The system should detect situations when the user is susceptible to being nudged based on what triggers are active.

- Nudging activity should be chosen from the activities linked to the trigger.
- The probability of an activity being chosen should be increased or decreased based on the user's response to the nudge
- Triggers should be adapted based on the user's response.

6.2 Application overview

The triggering the next nudge system Is implemented as an android OS application. This application serves as both the front and back end of the system. The goal of this application is to increase the activity of the user. To achieve this goal the system uses smart nudges to try and nudge the user to perform some form of physical activity. The system will try to determine when the user is inactive and if so, send the user a nudge in the form of a notification as shown in figure 6.1. This notification will include a short text message to the user about the importance of staying active or the health benefits of an active lifestyle. The message is there to motivate the user to actually perform the given activity. Included in the message is an activity suggestion. Instead of just nudging the user to be active in general, presenting a specific activity makes it so that the user has to make fewer decisions.

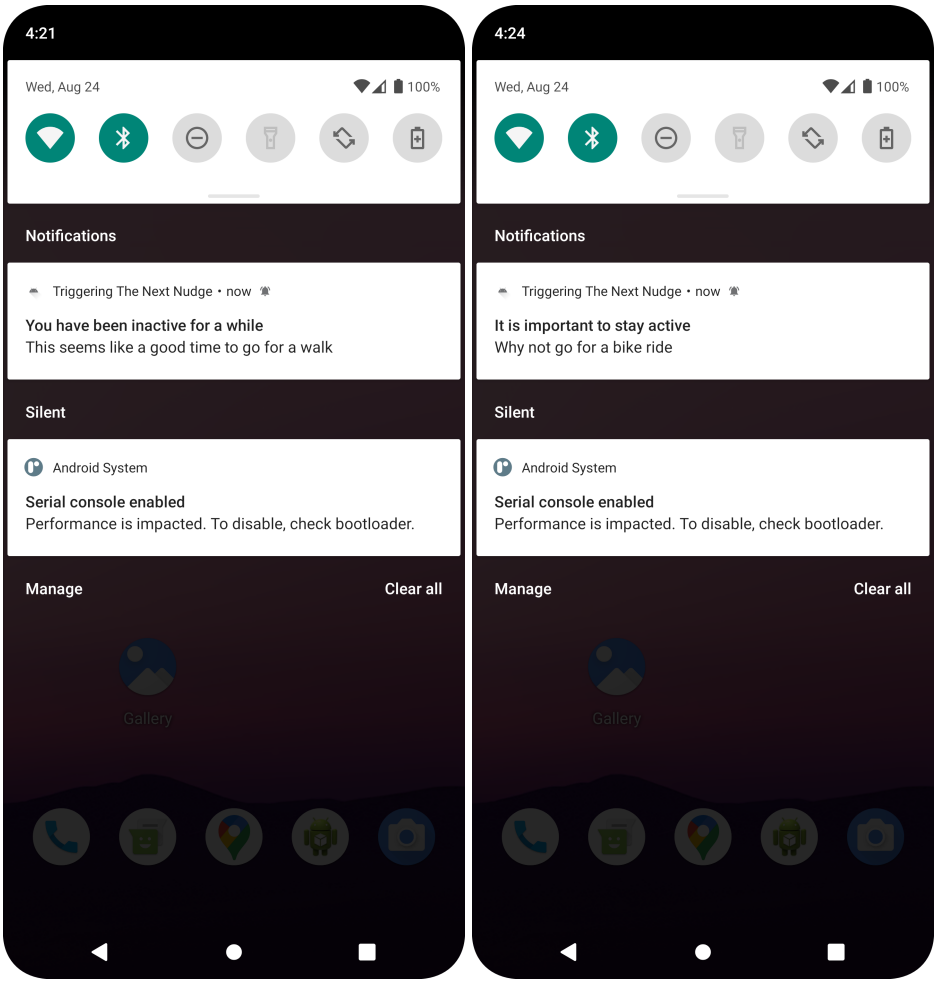

Figure 6.1: Nudge Notification

The application will present the user with nudges at appropriate times even if the application has not been opened by the user recently. If the user opens the application when there have not been any resent nudges it will show the home page like it is presented in figure 6.2. This home page is meant to inform the user that there is currently no active nudge trying to influence the user to perform a specific activity. When the home page does not have a nudge present it does include some text to motivate the user to be active on their own initiative, but without any activity suggestions. At the bottom of the screen on the application there are two buttons that can be used to take the user to the profile screen and back to home screen again.

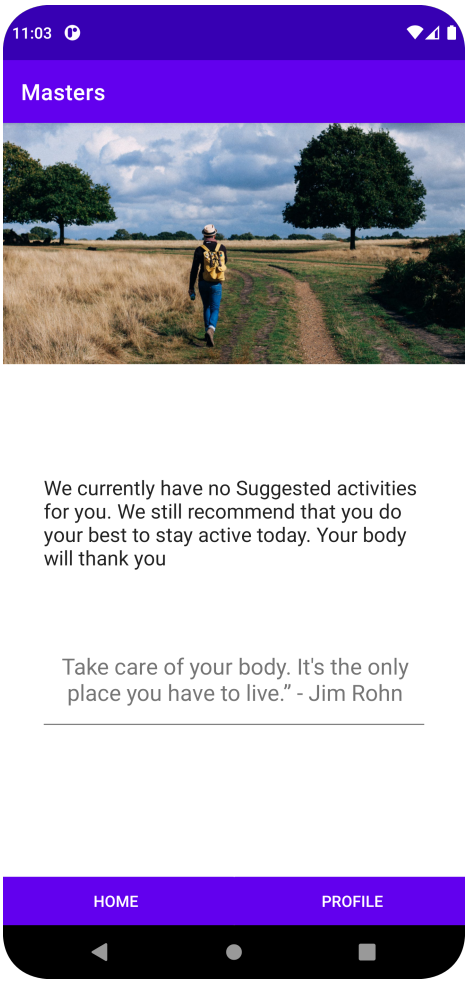

Figure 6.2: Application home screen

When the application has recently presented the user with a nudge the home screen is changed. This change can be seen in figure 6.3. The home screen will now include a suggested activity. The suggested activity is the same one that was presented in the nudge the user received through the notification. The home screen will now include the suggested activity as well as some additional information about the activity that was not included in the nudge. The user now has the option to perform the activity or not. If the user wants to perform the activity, they can indicate to the system their intent by pressing the "perform activity" button. This will take the user to a new page where they are applauded for dedicating to the activity. On this new page the user will be asked if they want any route suggestions for their given activity. If the user wants this, they will be redirected to a third-party site for this functionality. Making the user commit to performing the activity serves two purposes. The

first is that by pressing the button the user pledges to perform the activity and this might improve the chance of them following through with the activity. The second purpose is that by having the user commit to the activity the system can determine that the user had a positive interaction with the nudge. This information can then be used to better adapt the trigger and the activity selection system.

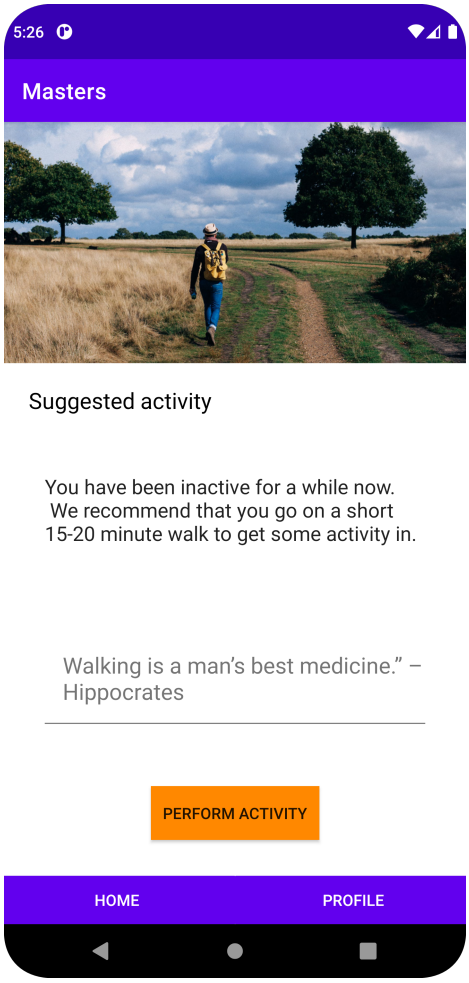

Figure 6.3: Home screen when nudge has been presented

6.3 System Overview

An illustration of the system can be seen in figure 6.4. The system is an android OS application and all the logic in the system resides within it.

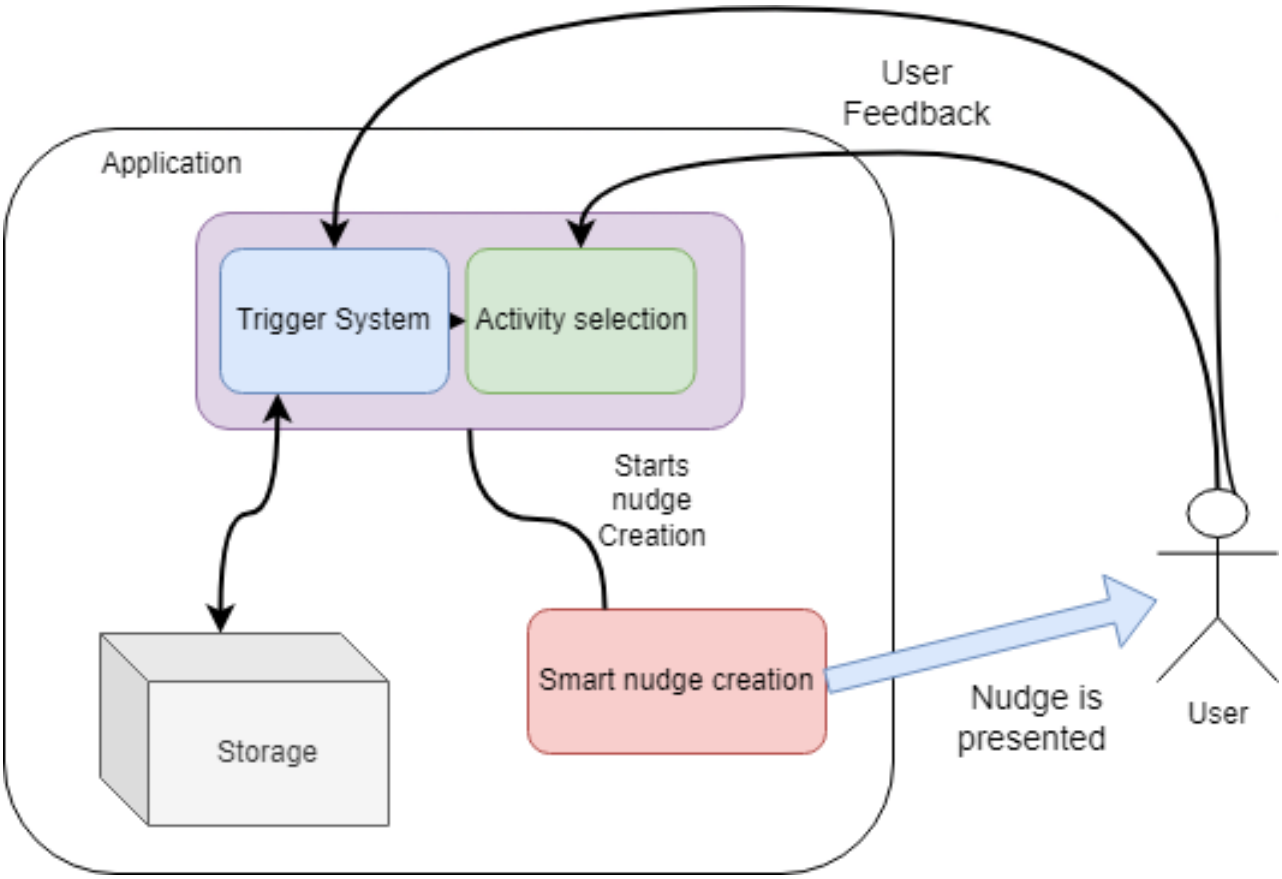

Figure 6.4: Illustration of system

6.3.1 Triggers and activity selection

Trigger Overview

The trigger system is the component in charge of detecting situations where the user is susceptible to being nudged. The trigger implementation has a few core elements that make it work. These are the trigger conditions, the adaptability and feedback system, storage system and the activity selection system. Each trigger will have either one or a few trigger conditions depending on if it's base or complex trigger. These conditions are the logic the trigger uses to determine if it should fire or not. The trigger condition needs to be something that the system can check. For example, the inactivity trigger that is a part of the implementation will periodically send a request to the mobile device to get data from the step counter. The trigger will then use this data to determine if the user has recently been active. This is done by comparing the step counter data to a threshold set in the trigger conditions. If the conditions

are met the trigger can fire.

Adaptability

The triggers can have adaptability programmed into them. Adaptability works by having a set of rules for making alterations to the trigger conditions based on feedback from the user. Continuing with the example of the inactivity trigger. If for example this trigger currently had a trigger condition that it would fire if the user had been inactive for more than seven hours. Then depending on if the user has a positive or negative interaction with the nudge this limit can either be increased or decreased. there must be a rule-set for this programmed into the trigger. For this example, that could be if the user has a positive interaction with the nudge, then the trigger condition of seven hours can be decreased by ten minutes so that the trigger I likely to fire more often. If the user had a negative interaction with the nudge, then this rule can be applied in reverse to decrease the likelihood that the trigger will fire. These alterations must then be stored so that adaptability is maintained even if the system is closed. In this implementation this data is kept in local storage, but in a user-ready service this would most likely be done with a local plus server storage solution.

Activity selection

The triggers also include an additional element used for activity selection. Triggers have the option to include a set of activities that are linked to the specific trigger. The activity set is a structure that contains a set of activities, a score that is associated with each individual activity and some additional information about the activity. The score is used in the activity selection process. The higher the score, the more likely an activity is to be selected. The activity selection process is also adaptable. When an activity has been selected and is part of a successful nudge, that activity has its score increased and therefore a higher likelihood of being selected the next time. This also works the opposite way where an activity that is part of an unsuccessful nudge has its score decreased. The additional information that is stored with each activity is used in the nudge creation process.

Base and complex triggers

As explained in 5.1.1 one of the key aspects of triggers is that they can be combined into more complex triggers. By making all triggers have the same general structure and functionality. This makes it easier to integrate basic triggers into more complex triggers. This complex trigger allows the system

to detect more specific situations by combining the logic and functionality of the already implementation base triggers. This allows complex triggers to be created with minimal additional work. Continuing with the example of the inactivity trigger from before. This trigger will only fire if it detects that the user has been inactive for a specified amount of time. This means that the trigger is likely to fire in the middle of the night because that is usually when people are inactive for the longest period of time, which is a problem. The inactivity trigger is still a very useful trigger, but as a component of more complex triggers. Instead of waking the user in the middle of the night the inactivity trigger can be combined with another trigger to limit when it can fire. For example, it can be combined with a trigger called daytime the detects if the clock is between two given times. These two triggers can then be combined into a new complex trigger. This complex trigger will inherit the trigger conditions from both as well as the logic required for the adaptability changes. The new trigger will however not inherit the activity set from the base triggers it is made from. The activity sets must be created specifically for each trigger. This is to prevent the new triggers from inheriting activities from the base that are not relevant. Since the activity sets must be created for each trigger, this means that some extra effort must be put into creating each trigger, but at the same time I meant that the designer does not have to predict what trigger this base trigger will be a component off in the future and plan for it.

Nudge creation process

The nudge creation process starts when a trigger that has a set of linked activities fulfills all its trigger conditions. then the activity selection system must decide on an activity. This selection process will select a random activity from the activity set, but the selection process favors activities with a high score. When an activity has been selected, data on what activity was selected and some additional information about the activity is sent to be used in the nudge creation. The nudge is created with the selected activity and sent to the user as a notification and the homepage of the application is altered to include information about the current nudge.

7

Discussion

Discussion

This chapter presents a discussion around the design and implementation presented in this thesis. This chapter will also investigate some changes that could have been made to the design and implementation, and how that would have impacted the system. There will also be a discussion around functionality that is not included in the current design or implementation but that could potentially improve the system through future research.

7.1 Design and implementation discussion

This section discusses some of the more interesting observations that were made during the design and implementation of the Triggering the next nudge application

7.1.1 How the use of adaptable triggers can affect the privacy of user data in a system

System security and data protection in a smart nudging system is not a focus for this thesis. However, the potential effect on privacy from using adaptable triggers in a smart nudging system should be addressed. From a privacy perspective, the main difference between a smart nudging system using triggers and one that does not, is the data related to adaptability stored in the triggers. What kind of data is stored in a trigger will differ a lot from trigger to trigger and system to system so there is no way of stating definitively that the data in triggers will be a risk to personal privacy or not. An assumption can be made that the data in most triggers will relate to personal preferences and this type of data would normally not be the most concerning type of data if it was leaked. There is of course no good reason to take the risk of user data getting leaked. All systems that utilize triggers should take steps to ensure that the data relating to users that is stored in the triggers is properly secured in the same fashion as all other user data.

7.2 Direct feedback from the user

In the current implementation presented in this thesis, triggers are only adapted based on if the user interacts with the presented nudge or not. If the user has a positive interaction with the nudge this can be seen as a success. This implies that either the trigger is currently well adapted to the user and does not need

to change or that the trigger is currently already well adapted and the system can try to be more aggressive with the trigger to find the limits for what the user will accept. If the user has a negative interaction with the nudge, then this can indicate that the trigger is not well adapted, and changes should be made. These changes are there either to find the situations where the user is more susceptible to being nudged or in the worst case where there is a trend on negative interactions with a trigger. Make that trigger less likely to fire. The problem with this solution is that it can be considered slow

In 4.4.1 an example trigger is presented. The goal of this example trigger is to detect if the weather outside is good enough to perform outdoor activities. This trigger consists of two sets of different weather conditions ranging from sunny and clear skies to dark clouds and rain. One set contains all possible scenarios that could make the trigger fire and the other set contains the conditions that are acceptable trigger conditions for the current user. If this example trigger were included in the current implementation the way the adaptability would work is that there would be a standard starting condition for the trigger. In this case only fire if it is clear and sunny outside. If the user has multiple positive interactions with nudges created from this trigger, then another condition would be added to the set of acceptable weather condition until either all conditions were added, or the user started having negative interactions instead.

With this trigger example an alternative approach would be to ask the user what conditions they would be willing to perform a certain activity in. After a user has been presented with a nudge the system could ask the user if they would be willing to perform the same activity in another specified weather condition. This process could then be repeated every time a nudge was presented until all possible conditions had been presented to the user. This approach has some advantages and disadvantages compared to the currently implemented approach. The advantage is that the triggers can adapt a lot faster and with less trial and error. Trial and error will be reduced since there will be no need to try the same conditions multiple times just in case the user could not perform the nudging activity due to some unrelated and unforeseen factor. The disadvantage of this approach is that it requires a lot of user interactions and additional functionality to include the ability to ask users about how to adapt the triggers. The system would need to have functionality to ask the users about triggers, but each trigger individual would also need to include all the questions that would be presented to the user as they would be unique to each trigger. With the questions there would also have to be additional logic to determine how the adaptability would change depending on the answer to each question.

This approach of asking the user to accelerate adaptability could also work with the activity selection process. Using this approach on activity selection would

incur the same advantages and disadvantages as on trigger adaptability.

A more optimal solution for adaptability would probably be a mix of the two approaches. This would allow a system to make changes to the adaptability fast through questioning of the user but also allow for more precise tweaking of the trigger over time without needing user input.

7.2.1 Priming

Section 4.3 addresses the concept of priming and how it can be useful for a smart nudging system. While priming has the potential to make a smart nudging system more effective it is not utilized in the design or implementation presented in this thesis. Priming is not a concept that is needed to make the trigger system work. The trigger system, however, can potentially be used to implement priming nudges. This has yet to be tested and proven, but an assumption can be made that since a trigger can be utilized to determine when a person is susceptible to being nudged, then it should be possible to construct a trigger that can determine when a person is susceptible to being primed for a nudge. These hypothetical priming triggers can utilize the same structure that is presented in this thesis but will require new logic in the trigger conditions to determine when to present a priming nudge.

Future work

The work done for this thesis has revealed potential areas for future research that can be used to create an even better system for triggering the next nudge. The most interesting areas are explored below.

7.2.2 Or logic

The Triggers presented in this thesis all operate on AND logic when they are combined into complex triggers. For example when trigger one and trigger two are combined into a new complex trigger this new trigger needs to fulfill the conditions from both trigger one AND trigger two to fire. The current trigger system does not allow for creating complex triggers that require the conditions from either trigger one OR trigger two to be fulfilled. This lack of OR logic restricts the ways trigger can be designed, especially when dealing with large trigger containing many different base base triggers. Further research into this topic can lead to a more flexible trigger system in the future.

7.2.3 Scalability

The aim of the prototype implemented for this thesis was to serve as a proof of concept for the use of triggers when detecting nudging situations. The prototype does, however, not provide data on the performance of a system using triggers on a large scale. Since all triggers in a system do their own periodic checks on their trigger conditions there is a possibility that having many triggers in a system could be a drag on performance. This could potentially become a problem since many mobile devices have limited processing power. Further research into how systems that use triggers scale and potentially how the performance of the system can be improved.

7.2.4 Priority when handling multiple triggers

A problem arises when multiple triggers have their trigger conditions fulfilled at the same time. If not handled this would lead to the user being presented with multiple different nudges at the same time. This would be detrimental to the user's experience. The current way to handle this is to have a trigger that detects if the user has recently been nudged. Using this trigger as a component in all complex triggers stops the system from presenting multiple nudges at the same time. This means that the triggers operate on a first come first serve basis. The potential problem with this approach is that if there are multiple triggers that regularly have their conditions fulfilled at the same time, then potentially the same trigger could always be the one to fire. This could be because it is a tiny amount faster than the others. This would make the system more repetitive. To solve this potential problem further research into a system for prioritizing triggers in this type of situation is needed.

8

Conclusion

The main goal of this thesis was to establish if a smart nudging system using triggers could be used to better understand the user and their situation as well as aiding in selecting a target activity as part of a complete smart nudging system. Explore how such a system can be used to determine when a user should be nudged and how it can learn from feedback from the user to make changes to itself and make better predictions in the future. By looking into the advantages and disadvantages of triggers the thesis aims to provide insights into the potential for triggers to be used in future smart nudging systems.

By designing and implementing a prototype smart nudging system using triggers, this thesis was able to show the potential of using triggers to determine when to nudge users. Figuring out when to nudge users is one of the major problems when creating smart nudging systems and this thesis provides one potential solution to that problem. Through the investigation and discussion of the benefits of using triggers as well as the downsides and limitations of a trigger-based smart nudging system, this thesis has shown how triggers can be used to Trigger the next nudge.

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