Interactive Technologies for Elderly Care

Alexander Pettersson and André Nilsson

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MASTER THESIS

Interactive Technologies for Elderly Care

Integrity-enhancing technologies that supports non-intrusive home care

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Department of Design Sciences
Faculty of Engineering LTH, Lund University
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Supervisor: Günter Alce
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Abstract

As the population is getting older, the demand for home care services is continuously increasing. According to industry forecasts, utilizing the current work methods in home care would probably not satisfy the future needs of older people.

A few critical areas in home care are the daily visits and the nightly supervisions. To be able to provide these types of services in the future, some technical assistance may have to be utilized. The goal of this thesis was to research the field of home care services and develop technical solutions that can assist the older people and the future work within home care. An iterative design process consisting of three phases was used to support the process of designing solutions with the end users in mind. By utilizing methods like interviews, scenarios, prototypes, and usability evaluations the technical solutions could be designed and developed.

The result of the design process was two user scenarios and one physical implementation. The first scenario, focusing on home care visits, resulted in a CRUD-based *(create, read, update, delete)* concept. The second scenario, focusing on nightly supervision, resulted in a system with integrated Internet of Things devices. This system was further evaluated in a final user test, conducted in a custom test environment.

In conclusion, the thesis has shown that there is a possibility to both make home care less demanding for caregivers and more secure and integrity-based for older people. In the process of designing technical solutions for elderly care, both the attitude towards technology and the cognitive ability of the older person must be considered.

Keywords: Interaction design, elderly care, home care, IoT, Node-RED

Sammanfattning

I takt med att befolkningen blir äldre ökar efterfrågan på äldreomsorgen. Enligt branschprognoser skulle en fortsatt användning av nuvarande arbetsmetoderna inom hemtjänsten inte tillgodose framtidens behov.

Några kritiska områden inom hemtjänsten är de dagliga besöken och nattliga tillsynerna. För att tillhandahålla dessa typer av tjänster i framtiden behövs det teknisk assistans. Målet med examensarbetet var att undersöka tekniska förbättringsområden och utveckla tekniska lösningar som bidrar till ökad integritet hos de äldre och främjar det framtida arbetet inom hemtjänsten. En iterativ designprocess bestående av tre faser användes för att stödja processen att utforma lösningar med slutanvändarna i fokus. De tekniska lösningarna designades med hjälp av designvetenskapliga metoder såsom intervjuer, scenarion, prototyper, användbarhetsutvärderingar och tester.

Resultatet av designprocessen var två utvecklade scenarier och en fysisk implementering. Det första scenariot, med fokus på hemtjänstbesök, resulterade i ett CRUD-baserat *(create, read, update, delete)* koncept. Det andra scenariot, med fokus på nattlig tillsyn, resulterade i ett system med integrerade Internet-of-Things-enheter. Detta system utvärderades vidare i ett slutanvändartest som genomfördes i en anpassad testmiljö.

Sammanfattningsvis har examensarbetet visat att det finns en möjlighet att både göra hemtjänsten mindre krävande för vårdgivare och samtidigt säkrare och integritetsfrämjande för vårdtagare och äldre. I processen att utforma tekniska lösningar för äldreomsorgen måste både äldres attityd till teknik, kognitiva förmågor och praktiska behov beaktas.

Nyckelord: Interaktionsdesign, äldreomsorg, hemtjänst, IoT, Node-RED

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Lund, May 2021

Alexander Pettersson and André Nilsson

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Chapter 1
Introduction

This section describes the background to this master's thesis, the intended problem definition that this thesis is aiming to address, the individual contributions of the thesis workers as well as the contributions to the current body of research regarding the subject of elderly care technology, and lastly, the related work this thesis builds upon.

1.1 Background

With an aging population, the demand of elderly care increases. Since the expected number of employed caregivers is far less than the demand [30], new approaches need to be considered if the elderly care is to maintain its current quality of service. One solution is to provide more home care to older people, as moving them to a nursing home is both more resource-intensive and against what the majority of older people want, as most older people prefer to feel independent and live in their home as long as possible [38].

At the same time the technology is advancing at a fast pace. Our society has already experienced a few examples of technology replacing or assisting human resources. To be able to handle the future challenges within elderly care there are incentives to rely upon technology.

1.1.1 Individualized Elderly Care

As humans get older it is common that some cognitive abilities change. Exactly when and to what degree these changes become obvious is different for each individual. There are some ability related changes that are more commonly related to aging, such as problem solving and general speed. In the case of changes in speed this is commonly related to how fast an individual is able to grasp a new concept or to process information. These factors are closely related to the general problem solving abilities. Apart from the common ability declines there are some fluid abilities that individuals can improve despite the ongoing aging. A few examples of fluid abilities are general knowledge and expertise that are not directly affected by aging. Furthermore, a group of older people in the same age group can have very different cognitive abilities and impairments. There are also other factors, such as dementia that will affect cognitive abilities to a certain degree. As these factors and ability declines are constant there is a great need to be able to adapt to the environment that these individuals are living in. Both the physical, mental and social aspects should be taken into account to make the environment as fitting as possible. Even though the process of cognitive aging is individual, there are some common ability declines that most individuals likely will experience. These ability changes can be seen as part of the normal aging process [2].

However, how these challenges, that cognitive aging presents for people, are addressed in different ways, in different countries. Looking at Sweden for instance, there are a few unique aspects that are worth taking into account. In Sweden, the municipalities play an important role when it comes to taking care of the older people. The municipalities are in charge of taking care of the long-term care and the home care services provided to the older people. What is worth taking into account in this specific case is that the population of Sweden is constantly aging, which affects the long term perspective on how to handle elderly care [35].

Whether the municipality wants to privatize a certain part of the care or hand over the responsibility to the public sector depends upon the specific area. The older people are welcome to apply for additional care, and the decision of this will then be handled by the municipality [33].

As the logistics of home care services varies depending on what country one is analysing, there is also a great degree of differentiation in the level of care a group is in need of. Apart from the individuals that are experiencing a substantial physical- or cognitive ability decline there are also a large group of older people that can be seen as rather active. As these active individuals are able to perform everyday activities rather well, the level of required care is obviously lower. What is worth mentioning is that individuals can perform well physically while experiencing cognitive difficulties, and vice versa. The diversity of abilities and opportunity to perform everyday tasks results in a varied need of care [34].

1.1.2 Assisted Living

The great impact that technology has on our modern society is hard to ignore. Technology is not only used by companies and industries but also by individuals in their private life. Many technical products assist us in one way or another. This can be anything from making it possible for us to communicate remotely or getting access to large quantities of information. One subgenre of this product group are technology products that are optimized to assist us in the home environment. The concept of utilizing technology at home for aid is called *assisted living* [22].

The key concept of assisted living is to provide security and health for the residents by utilizing technology. Looking more specifically at the type of technology that is commonly utilized in these systems, various sensors play an important role. Commonly the sensors collect data that is computed locally, which is an important aspect when it comes to security [22].

One major benefit of this concept is that the assistance will potentially aid the possibility of the residents being able to live at home for a longer period. The opportunity to be able to stay at home for a longer period is often appreciated by the residents and the healthcare, since this potentially decreases the health care costs. Preferably the decreased costs of direct care can be used for other critical parts of the health care [22].

1.1.3 The Role of Technology

The solution of increased home care puts further demand on caregivers as there, for instance, is a physical distance to be covered to fulfill the care. The following solution is to introduce more technology in the home of the older person to bridge this gap. This technology will allow more older people to get help, and in turn lower the demand of caregivers.

When it comes to supervision of older people in home care, there is a balance between security and integrity. In order to be able to achieve a safe environment without residents feeling observed, it is necessary to clearly identify technologies that benefit both parts of the spectrum.

In the case where this type of solution is to be implemented, namely in a home environment of an older person, it is relevant to look at different forms of smart home solutions. Typical of smart homes is Internet of Things (IoT), which includes the concept of creating a network of physical objects [7]. These objects include for instance cameras, sensors, digital locks and other appliances used to supervise and control the home, as well as to collect various forms of measurement data, spanning from more house specific, such as household energy consumption, to resident specific health values, such as breathing patterns and pulse rates.

This master's thesis in Information and Communication Engineering was conducted via the Department of Design Sciences at Lund University's Faculty of Engineering (LTH), in collaboration with a technology company based in Lund, Sweden. The thesis was conducted during the spring of 2021 with the overarching goal of finding and implementing a solution that fulfils the needs of older people while taking into account the pressure of effectiveness within elderly care, specifically home care, by limiting physical visits between an older person and a caregiver without compromising quality and necessity.

1.1.4 Terminology

The linguistics of healthcare, elderly care and its corresponding actors is quite ambiguous. Therefore, the terminology in the thesis had to be carefully specified in order to avoid any misunderstandings.

The following terminology, with the following definitions, is frequently used and referenced to in the thesis:

- ***Elderly care:*** any type of care related to older people, such as home care and assisted living.
- ***Home care:*** the type of care that takes place in the home of an individual.
- ***Assisted living:*** the type of housing facilities for people with disabilities or who cannot or choose not to live independently.
- ***Older person:*** also called senior or elders, with the approximate beginning of 55 years of age, but does not include any allusion to the cognitive capability of the person.

- ***Care recipient:*** (from the Swedish term "vårdtagare") a person who gets some sort of physical or emotional care and support within a home care context. The terms of older people and care recipients are sometimes used interchangeably in the thesis and often refers to an older person that acts as a care recipient.
- ***Caregiver:*** (from the Swedish term "vårdgivare") a person who provides the care and support for the care recipient within a home care context, sometimes referred to as "home care staff" or "home care workers" in the thesis.

1.2 Goal and Research Questions

The overarching goal this thesis aims towards is to find a solution where an older person seamlessly interacts with an IoT integration in a home care context that satisfies the needs of the older person whilst decreasing the demand of the caregivers.

In order to meet the desired goal, the following research questions needs to be answered:

- **What types of interaction are possible with current IoT devices?**
- **How can these interactions be designed to fit an older person's needs?**
- **What IoT solutions would decrease the demand of caregivers without compromising the needs of the older person?**

In-depth questions for the chosen scenarios (see section 3.2.1 for details):

- **How can a care recipient be more in control of home care visits?**
- **How can nightly supervision become more secure for care recipients and less demanding for caregivers?**

In order to facilitate an overall idea with the scenarios and the decisions taken in their development, the following visions was formulated:

- **Care recipients will have the possibility to influence their home care to get a custom-made solution**
- **Nightly supervision of care recipients will become more secure and less intrusive, whilst being more efficient for caregivers.**

1.3 Limitations

Due to the great variation of attitudes, physical and cognitive abilities of older people, the scope of the thesis was limited to a specific group of older people. Firstly, the individuals of the specific group that the thesis focused on, did not have any severe cognitive difficulties, such as dementia. To exemplify the level of cognitive abilities, the individuals of the intended group are able to live on their own in their own home, with some assistance from home care and relatives. The individuals are also able to move around independently in their home, either on their own or with a walker or similar tools. The attitude towards technology within the intended group is varying, with some individuals being more open to new technology and some being more sceptical.

Furthermore, there were some limitations of work related to the COVID-19 pandemic. Due to visiting restrictions and the recommendations of social distancing, the process of gathering data was affected. There were no possibilities to visit or conduct tests together with the group of users, being the intended group of older people and home care staff. In addition to the geographical perspective, the master's thesis was also limited to southern Sweden, with regards to the individuals that were involved in the process.

The technical domain of the thesis was fitted to a set of technical devices. The devices that the project revolves around were all internet connected with the purpose of gathering and presenting either audio, visual image or sensor data. The user scenarios, designs and implementations included in the thesis were all developed with these devices taken into account.

Finally, the thesis was also limited to a set time frame. Being part of a five year engineering program, the time frame of the thesis was limited to one semester, consisting of twenty weeks of full-time study.

1.4 Contributions

1.4.1 Research Contributions

This thesis contributed to the body of research within elderly care and technology with studies conducted on two scenarios in a home care context. Specifically, a tested and evaluated system implementation of nightly supervision of older people and an investigation about the opportunities and obstacles regarding giving more control and insight to older people about their care and visits. Furthermore, the thesis was realized in collaboration with a technology company in Lund and will therefore act as an addition to their existing body of knowledge within the areas of elderly care and technology. Lastly, the thesis methodologies, processes, implementation, testing and evaluation was filtered through the lens of interaction design and can thus be seen as an additional contribution to this field of research.

1.4.2 Sustainability Contributions

The thesis connects to mainly four of the the *17 Sustainable Development Goals* (SDGs), adopted by all the United Nations Member States in 2015, as a part of the *2030 Agenda for Sustainable Development* [23]. In essence, the thesis connects to the following goals:

- **Goal 3: Ensure healthy lives and promote well-being for all at all ages**
- **Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation**
- **Goal 11: Make cities and human settlements inclusive, safe, resilient and sustainable**
- **Goal 16: Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels**

Figure 1.1: The SDGs covered by this thesis

In detail, Goal 3 contains developing integrated systems of health to maximize the function in old age as well as making assistive technologies available. Goal 9 contains encouraging innovation that targets the changes that population aging brings. Goal 11 is connected to the thesis since it aims to recognize the wide range of capabilities and resources among older people and respect their lifestyle choices. Finally, Goal 16 appeals to the need of a paradigm shift in the way society understand aging, with for instance stereotypes and discrimination against older people (ageism) [26].

1.4.3 Individual Contributions

The individual contributions of the thesis workers has been divided as to fit the strengths and interests of the thesis workers in order to create a more streamlined process. In detail, André was mainly responsible for editing the video prototypes, designing graphical content and the implementation and integration of the system in Node-RED, whilst Alexander was mainly responsible for contacting and scheduling the interviews of the thesis, designing the final user test and structuring the collected data. Additional work, such as brain- and bodystorming interaction flows, testing IoT devices, recording and acting in video prototypes, conducting interviews and tests and writing the report was contributed more or less equally by both thesis workers.

1.5 Related Work

This thesis builds on findings and conclusions from mainly two previous theses within elderly care, conducted at the same technology company during spring and autumn of 2020.

- **Security creating technology for elderly care** [9]
- **Technology based solutions as enablers for active and assisted living - Development of a conceptual system to assist in aging** [38]

The first thesis, *Security creating technology for elderly care*, focused on designing a radar unit, fit for older people and caregivers [9]. The radar could scan for blood pressure, respiration, pulse and falls, and was complimented by a security camera. The aim was to address the increasing demand on elderly care, combined with taking the stance of the older people's perspective, needs and wants. How the aesthetics and placements of cameras and radars in home environments would affect integrity among older people was further investigated. Although the thesis resulted in a concrete design, the focus was on the perception of the radar and camera, namely, how older people would rate its aesthetics and how well it would fit into the interior design.

The second thesis, *Technology based solutions as enablers for active and assisted living - Development of a conceptual system to assist in aging*, took a broader approach, involving market research about technical systems within elderly care, and developed a conceptual model of a system, along with a booklet containing a compilation of tools to guide further development of elderly care technology [38]. The conceptual model consisted of a smart home hub and tablet connected to a radar and camera system that could address the most necessary needs of care recipients discovered by the thesis in conversations with older people, caregivers, and municipality workers in southern Sweden. The model was addressing different problem scenarios, such as fall detection and social needs of older people as well as information flows within the home care service.

Consequently, this thesis follows a series of theses previously conducted within elderly care technology. The previous work has not resulted in any concrete implementation, integration or testing of any IoT products, though they have rigorously been investigating the background, needs and potential use of such technology. Thus, the scope of this thesis is to make the wishes and wants of previous theses a reality, putting them into system context and real interaction that will be possible to test and evaluate.

Chapter 2
Theory

This section describes the underlying theory used in the thesis. In section 2.1, the background of interaction design, methods of the process and evaluation techniques are described. Furthermore, in section 2.2, the technologies used for development are presented.

2.1 Design Theory

2.1.1 Interaction Design

This thesis takes the perspective of *Interaction Design*, thus a description of this research field is necessary. Interaction Design is a process of designing prototypes and interactive products that people can use, understand and that contributes to a pleasant user experience [3]. Interaction design goes beyond merely user interface design and involves the creation of interactive products and services that assists the way people communicate and interact in their everyday and working lives. In essence, the design work within interaction design focuses specifically on what people *do*, what they *feel*, and what they *know*.

The process of interaction design can be outlined in three different phases:

- **The Conceptual Phase**
- **The Processing Phase**
- **The Detailing Phase**

The Conceptual Phase

Initially, most innovation and design starts with an unsatisfactory state, without any direct clue of what actually is going to be accomplished. Hence, the first phase of this design process is conceptual where the main focus is to explore and digest what is desired from different stakeholders. This is conducted by investigations, observations and analysis that leads to insights and intentions [3].

The Processing Phase

When a design team has grasped what needs to be done, a processing phase begins where the products or services main outlines are determined. The initial concept produced in the previous phase is adjusted to reality to fit both practically and technically [45].

The Detailing Phase

Once the overarching design is completed it will be refined in the last detailing phase. The product or service is specified in, for instance, different prototypes that the intended user can interact with and evaluate [20].

An Iterative Process

Although the three phases of the design process seemingly execute sequentially, in reality they are in many instances happening in parallel as the design process goes from great uncertainty and many alternative paths, to clarity and focus in a specific product and its design [3].

By iterating between different phases within the design process of interaction design, the likelihood of creating a product or service with a better user experience, more fit for the intended users, increases significantly.

2.1.2 Human-centered Design

The process of interaction design is centered around the human. Real value is created when the intended product or service is used in real contexts and situations [3]. If the design process results in something not usable, it fails to provide any value, hence resources put into the development is practically wasted.

Human-centered design is defined as an iterative process [16]. An iterative process is characterized by a development that benefits from several competences and perspectives to develop an holistic understanding for the users and the stakeholders, their experiences and situation. The ISO standard describes a design process that consists of an initial planning before entering a prototype-driven iteration, which starts exploring, understanding and specifying the use situation. It is all about gathering *insights* which then later is converted into *intentions* and *requirements*, before *ideas* of solutions is produced. Several design solutions are advantageously produced as they can then be compared to each other and be *evaluated* towards the needs and requirements of the users and stakeholders. After this evaluation there is likely a need to re-discover the use situation to gather new insights or intentions.

2.1.3 Universal Design

In the process of designing a product with the end user taken into account, there are some key characteristics that should be considered. As physical features and abilities vary among us humans, every design will not be able to fit everyone. With that in mind there are some methods for creating products that will fit a greater part of the population. The concept of considering variations of physical abilities during the design process is called *Universal Design*. The goal of this concept is to create products that can be used by as many people as possible [11].

Further, in the design process it is not unlikely that the designer forgets about the large spectra of physical variations of the users. To be able to create an universal design it is important to take the different end users into account during every step of the design process [11].

2.1.4 Agile Methodology

Agile methodologies is a collective name for a set of methods that are often utilized in software development projects. The agile mindset relates to working iteratively, i.e working with repeated processes to generate outcome. A few other key concepts of agile methodologies are; adaptive planning, centered communication and flexible response to change. One major advantage of this approach is the opportunity of reflective analysis as previous work is being continuously examined. Furthermore, by utilizing continuous delivery the goal is to satisfy the clients need in the shortest possible time. The client's feedback during the development phase will play a vital role in the upcoming phases of the project process. One popular agile methodology, often used in software development, is *Scrum*. The scrum methodology includes a few unique roles, like scrum master and product owner [19].

Additionally, a centerpiece of the agile mindset is the concept of *sprints*. In the agile sphere, the various stages are split up into different sprints, which basically represents a time slot (for instance two weeks) dedicated for some predetermined tasks. The content of a sprint can vary, but it is common that the different sprints in a project contain the same steps. By repeating these steps, and therefore working iteratively, there will be plenty of opportunities to optimize the final deliverable with the continuous feedback taken into account [19].

2.1.5 Brain- and Bodystorming

Brainstorming is a method conducted individually or in a group and focuses on generating ideas, stimulating creativity and finding solutions to problems [43]. The generation of ideas within the brainstorming method is driven by a quantitative approach above a qualitative approach, hence, a non-judgemental and encouraging attitude among the participants is crucial to fulfill the purpose of a brainstorming session [27].

Looking at the initial phase of creating a design solution for a user case where the user will be moving, there are some common difficulties to take into consideration. To be able to get a better understanding of the physical interaction there is a technique that can be utilized, called *Bodystorming*. By acting out the user scenario it is possible to gain some valuable knowledge and experience. The movements and action patterns that feel natural during the Bodystorming process will possibly feel natural for the user as well [32]. In essence, the Bodystorming technique differs from Brainstorming in the sense that it encourages doing and acting, before thinking and guessing. This often leads to more interesting results when generating ideas since the "body", in a way, might be more involved in the interaction than the "brain".

2.1.6 User Scenarios

User scenarios are illustrative stories that describe how a user or multiple users could interact with a system in a given situation to achieve an intended goal [14]. The reason to create user scenarios is to understand the motivations, needs and barriers in the context the intended user(s) interact with a potential product or service, to further iterate towards a desired interactive solution.

2.1.7 Prototyping

A prototype is a draft of a feature or product [3]. The level of details and accuracy depends on the specific goal of the prototype. A prototype can be a fully functional system or some scribbling on a piece of paper. One important function of a prototype is that it represents a design idea which gives the designers, users and stakeholders something concrete to consider, evaluate and develop further [10]. It is often difficult to forecast how different design choices affect the users and stakeholders experiences, prototyping is therefore essential to make sure a development project fulfills its intended goal and value [3].

In product design, it is common to utilize physical prototypes, for instance, made of clay or 3D-printed plastic. In case of developing software, it is more common to develop a dummy application that gives the user an illusion of a functional system [10].

Furthermore, a major benefit of using prototyping as part of the development process is that it makes it possible to utilize continuous testing and evaluation. By testing the various prototypes continuously and taking the feedback into account, it is more likely that you end up with a final implementation and product that satisfies the set goals and needs [10].

2.1.8 Personas

Personas are made up person descriptions that are based on collected data. The data that the personas are based on can, for instance, have been collected through interviews or surveys. The goal of the persona is to create a representation of an imaginary, but possible, user. By utilizing the collected data the personas needs and goals will most likely cover some of the actual users needs and goals [28].

The personas can help a design or development team to become more user-centered, by making it possible to focus on a few actual traits of the users. By creating fictitious individuals, instead of looking at raw data, the goal is to make it easier for the team to relate to the actual users [28].

2.1.9 User Testing

In order to identify potential shortcomings of a product, there are certain methods that can be applied. In *usability testing*, the level of usability is valued by gathering empirical data. By setting up an environment where the end users are able to perform tasks and answer questions, a lot of useful user related data can be collected. These tests can also be conducted in an iterative way, where the product is redefined and shaped continuously [29].

A central part of the usability testing process is the compilation of a *test plan*. The test plan should, for instance, explain the purpose, procedure and the data that is to be collected in the usability testing. The information contained in the test plan should be sufficient to carry through the whole test process. Another important function of the test plan is that it can be seen as a communication tool used by the team that is involved in the product development process. The steps of the test plan and the collected data will affect the further development of the product [29].

Furthermore, there are some key benefits of creating and utilizing a test plan during the product development process. As mentioned above it can be utilized as a communication tool within the team, as it acts as the blueprint of the usability testing process. By defining factors, such as the resources needed and the number of required participants, the logistics of the testing process will become more streamlined and repeatable. When conducting a usability test it can be beneficial to follow a test plan step by step. For instance, the process of finding the right test participants should probably start off in the early stages of the test process. During the actual test sessions, it is important to follow the plan carefully, since irregularities in the test formality can result in inaccurate data [29].

2.1.10 Quantitative and Qualitative Data

One important step of the planning process of testing is to define the types of data that is going to be collected. The collection process of data can vary and therefore also the nature of the data. One major subcategory of data is *quantitative data*. The quantitative data can be seen as facts, as it often represents numeric information related to preferences. Due to the numeric representation it is common to present this type of data utilizing graphs and tables. A common area of questions related to this specific subcategory of data is based upon percentages [17].

The second large subcategory of data is the *qualitative data*. Unlike the quantitative data, this category is commonly not suited for presenting utilizing visualizations and percentages. The deeper knowledge of motivation behind specific preferences and choices are central in this subcategory of data [17].

Furthermore, there are additional methods to categorize data. In addition to the quantitative and qualitative sectioning, a second layer can be applied. These two categories contain subcategories that are split up into *subjective* and *objective data* [8].

Starting off with the objective data, the category does not include any personal preferences. These objective measurements will not represent any individual bias, but rather what can be seen as the truth from every person. On the other hand, the second category, which is subjective, will take personal preferences into account. The subjective data can not be seen as the truth for every individual, but is rather based upon the personal perspective [8].

2.1.11 System Usability Scale

The *System Usability Scale* (SUS) is a survey containing a set of scale based questions. The goal of utilizing SUS is to gain insights into the level of usability of a certain product. The SUS survey is commonly handed out at the end of a test session, in the stage where the test participant has got the first impression of the product. The set of questions in the survey have mixed characteristics. Some of them are focused on positive aspects and some on negative. The result value that is calculated in the process of result summarization is then compared to a reference scale. Depending on the final result score, the level of usability can vary in the range of not acceptable to acceptable [1].

The formula utilized to calculate the score are the following:

- **SumPos = Sum of score of the odd numbered tasks - 5**
- **SumNeg = 25 - sum of score of the even numbered tasks**
- **SUS Score = (SumPos + SumNeg) * 2.5**

There are different ways to interpret the calculated score. Scores above 68 can be seen as above average, and anything below 68 below average [1]. As mentioned above, there is an advantage of using SUS as the quantitative characteristics of the questionnaire results in a comparable number. With this number it is possible to compare the level of usability with other tested products and thereby set it into perspective. Since SUS is a very common method of grading a product from a usability perspective, there is a great chance to find a similar product that has been evaluated using the same scale. This opens up the opportunity of rigorous evaluation [1].

2.1.12 Wizard of Oz

In the process of testing prototypes the level of technical implementation and the features that need to be tested do not always match. In the case where the product development team is required to gather test data with a system not fully implemented, there are alternative methods to improve the testing experience. By creating features that can be controlled by one of the individuals in the test team it is possible to give an illusion of a complete system. This testing method is called *Wizard of Oz*. The test participant will be under the impression that the system that they are interacting with is up and running, but the reality is that there is a person who is controlling some or all parts of it. The key benefits of this method is that it makes it possible to test a product concept in a realistic manner without the need of a full implementation. One potential drawback of this method is that the test team will have a larger amount of tasks to carry through the test phase [31].

2.1.13 Think Aloud

To be able to collect valuable insights and experience related information during the testing process, there are plenty of observation related methods. Commonly, cameras and microphones can be used to make it possible for the test team to go back and watch the events that occurred. Except from an integrity perspective or the participant, there are obviously benefits of this approach. However, there can also be benefits with aiming to extend the level of information that can be collected during the test session. One method of gaining a better understanding of the participants' experiences is to utilize the *think aloud method*. The basic concept of this method is to encourage the participant of the test to share every bit of relevant information that goes through their mind during the test process. By being able to take part of the reasoning and psychological obstacles related to going through the test task, the test team can possibly gain some valuable insights [18].

A common drawback with this method is that some individuals feel a bit awkward with the concept of speaking out loud while carrying out a task. One way of minimizing the risk of this interfering with the result in the test, is to give the test participant a few dummy tasks to practice with. Apart from this drawback, the benefits of the extended range of data is commonly seen as desirable and information that usually can be hard to collect is now presented [18].

2.1.14 Interviews

As the most traditional requirement-collecting technique, interviews have different approaches depending on the context and purpose. For instance, the process of asking questions can be more or less controlled and the questions themselves can have different formats [12].

In this thesis, semi-directive interviews with a rough pre-established guide were conducted with mostly open-ended questions, namely, questions without a predetermined format such as "yes" or "no". The reason for this choice of questions was because the interviews in the thesis were mainly used as part of gathering new insights and to evaluate the different prototypes created. Thus, predetermined formats would risk excluding important feedback from the interviewees.

2.2 Technology Theory

This section describes the various IoT technologies and devices used in the design process to prototype the scenarios. The concrete usage of these technologies and specific devices are further described in chapter 3.

2.2.1 IP Cameras

An *Internet Protocol camera*, or *IP camera*, is a digital camera receiving and sending data via an IP network. Contrary to analog *closed-circuit television* (CCTV) cameras, IP cameras require no local recording device, only a *local area network* (LAN) to function [39].

In the thesis, two different IP cameras were used. The first was an AXIS M1065-LW Network Camera (figure 2.1) and the second AXIS A8105-E Network Video Door Station (figure 2.2). By using the IP camera's API, data to and from the IP cameras could be fetched and controlled via HTTP-requests.

2.2.2 Radar

Radar, acronym for *Radio Detection and Ranging*, is a detection system for determining different variables of objects, such as range, angle and velocity, utilizing electromagnetic waves [41].

The basic principle of radar technologies consists of a *transmitter*, producing a signal that is sent out and reflected off an object, and then returned and detected by a *receiver*. It is common that the transmitter and receiver use the same device, called a *transceiver*, to get information about the object's variables.

Figure 2.1: AXIS M1065-LW Network Camera [6]

Figure 2.2: AXIS A8105-E Network Video Door Station [5]

The specific device used in this thesis is the Vayyar Home radar solution (figure 2.3). The device uses 72 transceivers across an ultra wideband (UWB) and mmWave frequencies from 3-81GHz to conduct radar algorithms for complex signal processing [36]. This enables the device to, for instance, detect human presence in a room size of about 4x4 meters and height of 3 meters from floor to ceiling. The device is also able to detect if, within these specified room measurements of x, y and z variables from the radar's positioning, a person falls. In detail, the x, y and z variables measured room length, depth and height respectively, as illustrated in figure 2.4.

Figure 2.3: A Vayyar Home radar sensor [37]

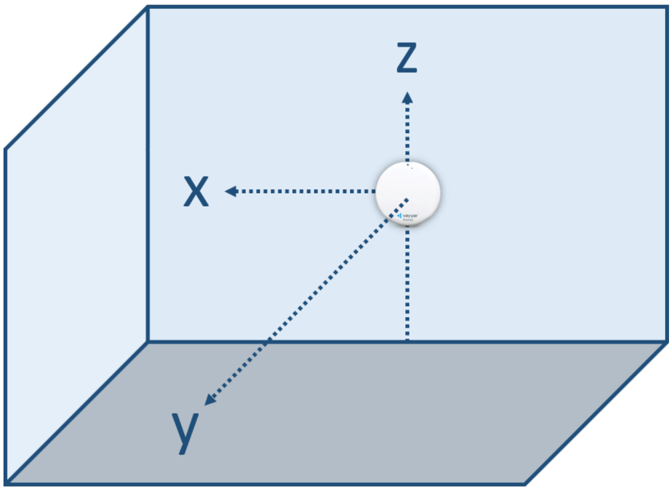

Figure 2.4: Illustration of the room measurement variables of the radar

2.2.3 Passive Infrared Sensor

Passive infrared sensors (PIR sensors) refers to electronic sensors that measure infrared light radiating from objects in its designated *field of view* (FOV). The main functionality of a PIR sensor is to detect movement within its FOV, with the limitations of not providing information about the source of the movement [40].

In contrast to a radar, a PIR sensor does not radiate any energy. The detection of movement is solely based on emitted or reflected infrared radiation from objects in the PIR sensors FOV, hence the term *passive*.

In this thesis, PIR sensors existed on various other devices, such as on the IP cameras and the network speaker. PIR sensors were used in conjunction with the additional functionality provided by those devices, hence no device with solely PIR sensor functionality was used.

2.2.4 Voice User Interface and VoIP

A crucial part of human interaction is related to the human voice. Utilizing software logic it is possible for an application to recognize human vocal phrases. This vocal interaction design between human and computer is called *Voice User Interface*. Depending on the vocal phrases that the application recognizes, different actions will be triggered [13]. Furthermore, it is also possible for the application to output vocal feedback. The output phrases are based on real voice recordings, which are then modified and matched depending on the given input.

The virtual assistant *Alexa* is a commercial service that utilizes a voice user interface. By giving vocal commands it is possible to interact with the voice assistant. One common way of interacting with Alexa is to request different types of tasks. One example of a task that Alexa can solve is to present the name of the first president in the United States of America [15].

Another way of enabling voice communication is by utilizing the method of *Voice over Internet Protocol* (VoIP) [42]. This method refers to various groups of technologies, using IP networks, in order to deliver voice communications.

In this thesis, VoIP was briefly investigated with the help of the network video door station (figure 2.2) and network mini speaker (figure 2.5) by integrating them in the software Node-RED (section 3.5.1). Since the network video door station provided the functionality of a microphone, the idea was to use that device for gathering vocal input and the network mini speaker to produce the vocal output.

2.2.5 Other Technologies and Devices

In this thesis, a number of other technologies and devices were also used in different stages of the process and to various extent in the development. The devices investigated and used to a notable extent, worth mentioning in this section, includes an AXIS C1410 Network Mini Speaker, IKEA Trådfri gateway and light bulb, and a Facebook Portal tablet (figure 2.5).

Figure 2.5: Other devices used: a) AXIS C1410 Network Mini Speaker, b) IKEA Trådfri light bulb, c) Facebook Portal tablet

Specifically, the speaker was used for two purposes - generating auditory feedback and using a PIR sensor. The IKEA Trådfri devices used were an IKEA Trådfri gateway connected to a router, and an IKEA Trådfri light bulb that was in turn connected to the gateway. The Facebook Portal tablet was used for showcasing different interactive graphical user interfaces (see section 3.5.1 for more details).

Chapter 3

Design Process

The design process in this thesis was structured according to the three phases of interaction design (see section 2.1.1). The design process was conducted over three iterations. As illustrated in figure 3.1, the iterations both contained and constituted the three phases. Each iteration lasted approximately between two to four weeks and resulted in a final user testing of the system, further described in section 4.

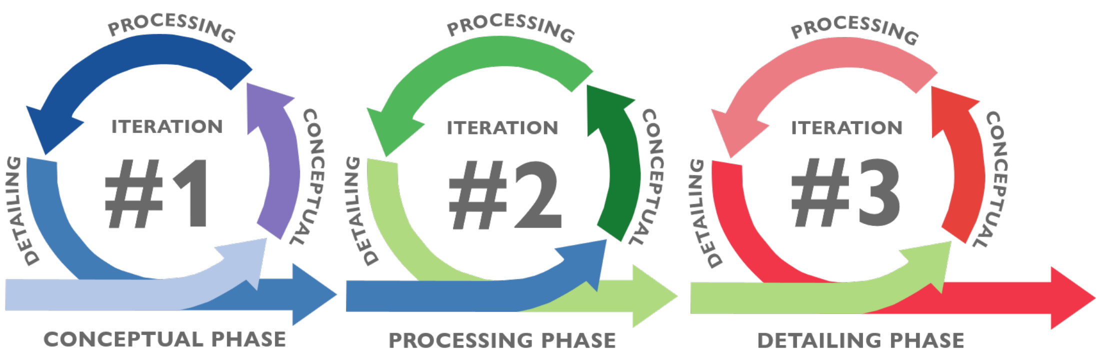

Figure 3.1: Interaction design process with three iterations

3.1 Preparatory Work and Methodologies

Initially, related work from previous master's theses in the field where studied (see section 1.5), previous insights and experiences from the thesis supervisors were shared as well as a research into the technologies and implementation alternatives for different IoT devices. Since the previous thesis work was highly relevant for this thesis, valuable parts could be reused and further developed, such as user personas and problem scenarios.

The first phase of the thesis also consisted of getting familiar with the technical entities that were provided by the technology company the thesis was conducted on. With the goal of creating a physical prototype utilizing these entities, the process of reading up on the technical domain was essential. Furthermore, the system was also set up with a designated router, a Raspberry Pi computer and the open-source software Home Assistant (see section 3.5.1 for a full system overview and further details).

3.1.1 An Iterative Interview Process

As an essential part of the design process, interviews with municipalities, home care staff and older people were conducted in the iterations. Unlike the interviews executed in the final user testing of the prototype, the goal of these interviews was to support the process of implementation. By filtering the generated ideas and concepts through feedback from experienced individuals within the related fields, the goal was to end up with the most valuable aspects of the concepts.

Set-up

The goal of the initial interviews was to collect valuable information related to home care and technology. The question scope changed during the iterations, in parallel with the prototype evolving. The first iterations focused on identifying potential points of improvement in the home care and getting a better understanding of the domain. The following iterations focused to a greater degree on collecting the feedback related to the prototypes that were presented.

Participants

The background and field of expertise of the participants were different in each interview iteration. Initially, people within the health and social care sector from Swedish municipalities and researchers related to home care were interviewed. In the following interviews, home care staff and coordinators as well as older people as potential users of the system were interviewed. In total, 10 people were interviewed (7 women and 3 men), for about 45-60 minutes each.

Processing the information

After each interview cycle was completed, the feedback and information gathered was processed. The information was mainly used to further improve the scenarios and prototypes and to narrow down the scope of the thesis. Since each iteration of interviews had their unique group of participants, each step can be seen as a filter. The idea was to filter the work through each of these participant groups with the goal of having a solid base of knowledge and understanding to further develop and implement the prototype at the end.

3.1.2 Weekly Sprints

In order to follow up the prototype iterations and make sure the thesis was executed on time, weekly sprints were conducted with the supervisors where three questions where recurrently answered:

- *What has been learned (from the last sprint)?*
- *What are the obstacles (in the upcoming sprint)?*
- *What is planned (for the upcoming sprint)?*

The purpose of the sprint meetings was to facilitate the continuous adaptation and iterative process of the thesis. When working with technical exploration there are many potential sidetracks and turns. Therefore, updating the supervisors of the state of the thesis regularly helped narrowing the scope and decreased any risk that the outcome of the thesis would be insufficient or lack relevance for the technology company.

3.1.3 Goal of the Design Process

The design process was constructed to facilitate a solid foundation of knowledge and understanding of the domain and the technical possibilities of the IoT devices. The goal with the design process was to implement a system that could be tested and evaluated in a physical space with potential future users of such a system. For that reason, discovering what is truly valuable for the stakeholders related to the thesis and its context, as well as what is actually possible to accomplish in regards to the provided technology, was an essential part of the design process to create a legitimate basis for implementation. For further details about the final implementation see section 3.5.

3.2 1st Iteration (Starting Out)

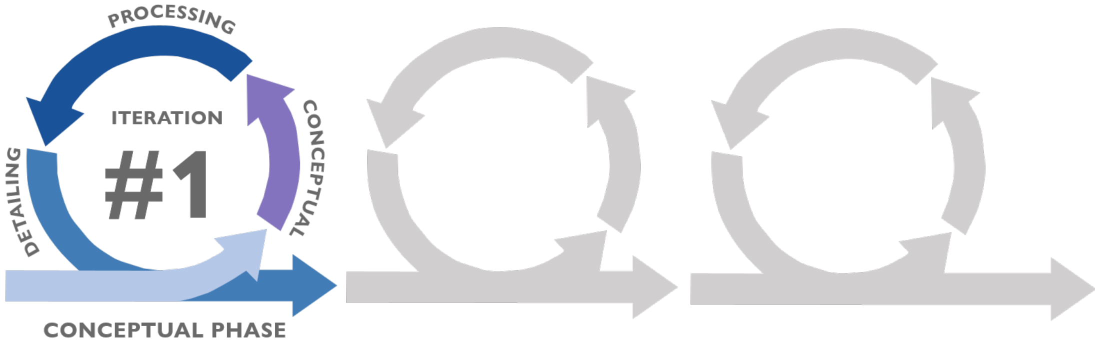

Figure 3.2: Conceptual phase and first iteration

3.2.1 Conceptual Phase (Finding Scenarios)

Choosing Scenarios

From the initial research and a brainstorming session, two main scenarios were chosen. The brainstorming session was conducted in collaboration with the supervisors from the technology company, with the purpose of finding a starting point for the thesis. The two chosen scenarios were deemed by the thesis workers and supervisors as most interesting from a technical and value-creating standpoint to investigate further. The chosen scenarios had both been explored briefly in the theses by Westin and Hay [38] and by Bengtsson [9], hence inspiration could be drawn from there to start prototyping. The previous theses were conceptual and the starting point of this thesis was to combine the previous conceptual work with some existing technical devices.

The two main scenarios chosen were the following:

- **Home care visits**
- **Nightly supervision**

The scenario for **home care visits** consisted of making the visits more secure for the older person. The problem identified from the initial research was that home care staff could enter the home of a care recipient without permission as long as they had key access. To address this, the idea was to give the care recipient the power of deciding who is admitted by getting an overview of who was standing outside the door.

The scenario for **nightly supervision** consisted of making nightly supervision less intrusive for the older person and less demanding for the home care staff. The problem identified from the initial research was that home care staff had to visit the care recipient during the night in order to make sure everything was OK. This results in more workload for the home care and more disturbance for the older person. Also, the care recipient could have an increased risk of falling if they did not bother to turn on the lights when, for instance, visiting the toilet during the night.

First Persona

In order to facilitate the development of the scenarios and adopt a human-centered design process (see section 2.1.2), a first persona called *Lennart Persson* was created (see figure 3.3). This persona was based on the personas from a previous thesis and represented a care recipient which desired independence and undisturbed sleep [9]. Part of the personas main characteristics was having as little physical visits from home care as possible during the night, even though it is necessary to some extent, as well as peace of mind regarding who had access to his home.

Furthermore, the persona of Lennart Persson was created to represent a care recipient with some minor cognitive impairments. Specifically, the persona was not created with more severe impairments in mind, such as dementia. Although care recipients with more disabilities not covered by this persona could benefit from parts of the system, they were not the main scope.

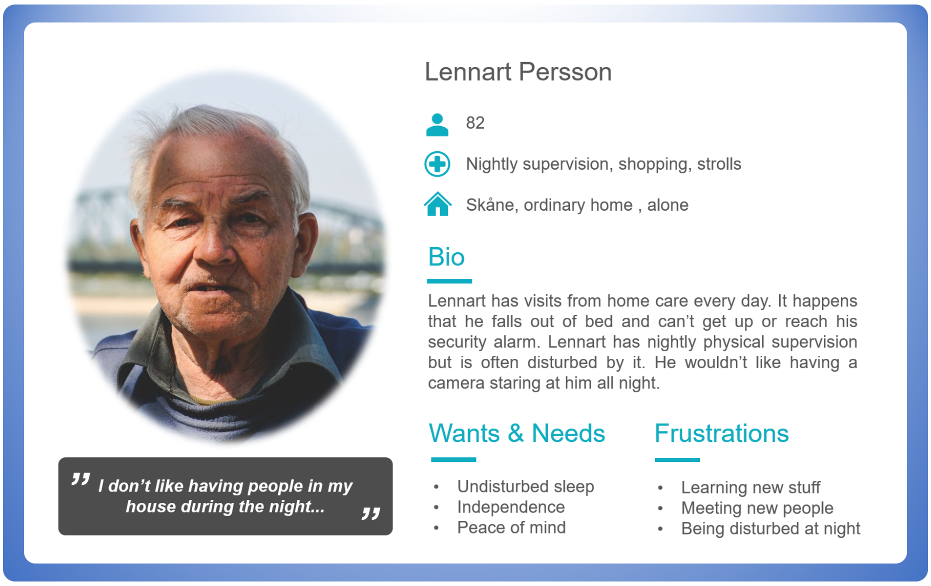

Figure 3.3: Lennart's persona - a potential user of the system

3.2.2 Processing Phase (Designing the Interaction)

Creating the Interaction Flow

The first concepts had to be realized into concrete flows of interaction with the intended persona. To accomplish this, a bodystorming session was conducted by the thesis workers in order to get the feel of the experience of the scenario concepts, whilst the persona's needs, wants and frustrations were taken into account, such as getting insight into who was visiting and providing some form of remote supervision. The body storming sessions resulted in two interaction flows, one for each scenario.

The scenario for home care visits was outlined in the following order:

1. *The caregiver arrives at the door*

2. *PIR sensor triggered and snapshot taken*

3. *The care recipient gets a notification on the tablet, displaying that someone was at the door with the snapshot visible*

4. *The care recipient can decide via the tablet if the door should open or not*

The scenario for nightly supervision was outlined in the following order:

1. *The care recipient leaves the bed*

2. *PIR sensor triggered, light turned on and snapshot taken*

3. *The caregiver gets notified that the care recipient has left the bed and can decide from the snapshot if everything is OK*

Integrating the First IoT Devices

For the home care visits scenario the idea was to have the network video door station (see figure 2.2) and Portal tablet (see figure 2.5) connected. When the PIR sensor on the door station was triggered by a caregiver arriving at the door, a snapshot could be taken and displayed on the tablet controlled by the care recipient. The care recipient could then decide via the tablet if they would like the person to enter or not.

For the nightly supervision scenario, the first solution identified was to have a light bulb (see figure 2.5) connected to a PIR sensor and network camera (see figure 2.1). When the care recipient left the bed during the night, the PIR sensor was triggered. The light was turned on and the network camera took a snapshot which was sent to the home care staff. In that way, the home care staff would get a notion every time the older person left the bed and the older person would also have a better visibility since the light was automatically turned on.

3.2.3 Detailing Phase (First Prototypes and Evaluation)

Video Prototypes

In order to showcase the first iteration of the scenarios, video prototypes for each scenario were created (see figure 3.4). The videos were recorded and edited at the technology company and showcased the interaction flow and the technology used, as described in the previous section.

The videos were further provided with subtitles describing what happened in each step of the interaction. Hence, highlighting the benefits of the solution and what problems that were addressed.

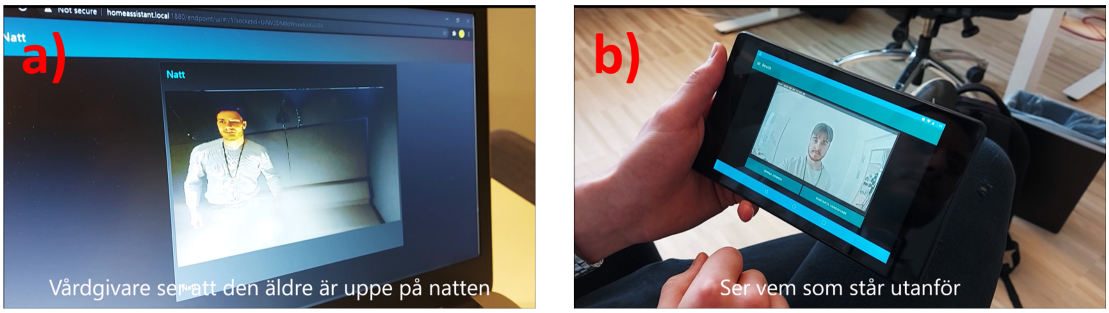

Figure 3.4: Screenshots from the first video prototypes: a) nightly supervision b) home care visits

Interviews with Municipalities and Researchers

To evaluate the first video prototypes, interviews with digitization managers in healthcare from Lund and Kävlinge municipalities and a researcher within elderly care from Jönköping's University were conducted. These individuals were chosen because they both had insights in what is desired within home care on a regional level and had also been involved in the previous master's thesis research, hence they already had some insights into what had been accomplished within this area so far.

The interviews consisted of two parts. In the first part, general information and background about the scenarios for home care visits and nightly supervision was discussed and explored. In the second part, the video prototypes were shown and the interviewees gave their feedback and ideas for further development.

The first part of the interview resulted in the following lessons:

- Care recipients would often want to know if the caregivers show up on time or not.
- Care recipients would often want customized care with the same caregiver they like, but due to high staff turnover this is difficult to provide.
- Shift perspective from what the care recipient is not able to do, to what they are able to do in order to provide motivation and a positive attitude.
- Physical nightly visits are usually not preferred either by the care recipient or the caregiver, but are sometimes necessary.
- Remote supervision is preferred in terms of cost and integrity.
- As a caregiver, it is beneficial to get crucial information about a care recipient before visiting.

In summary, the feedback for each scenario was the following:

- **Home care visits**
  - It could be difficult for some older people to use a tablet. Other ways of interaction should also be possible.
  - The home care staff should not show up and not be granted access as this would be a waste of resources. They should get the information before arriving at the care recipient.
  - It was not especially realistic that the care recipient could decide if the caregiver was able to enter or not as granted visits are always decided upon beforehand.
- **Nightly supervision**
  - Prevention and detection of fall accidents at night is by far the most important issue as it often results in costly consequences and causes a great deal of suffering for the care recipient and their relatives.
  - The possibility to detect deviating movement patterns is very desirable, but the system should only give notification if something is abnormal.
  - Camera supervision is tricky as it affects the integrity of the caregiver, however, if acute situations arise you would like to get an image of the situation.

3.3 2nd Iteration (Expanding the Scenarios)

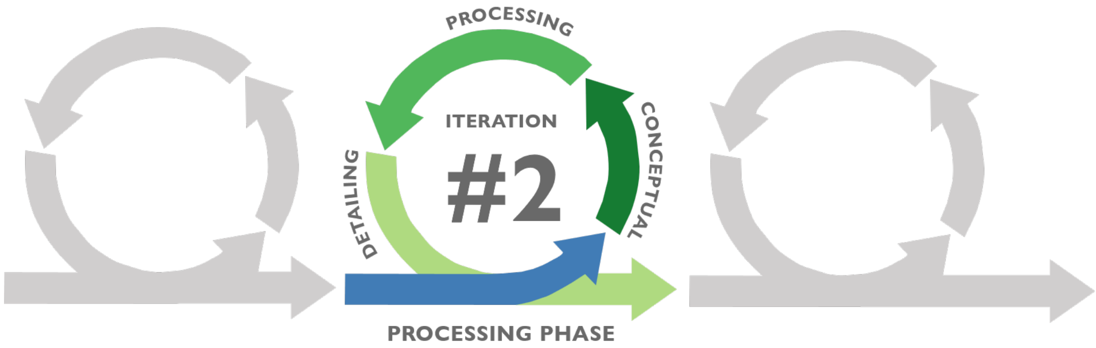

Figure 3.5: Processing phase and second iteration

3.3.1 Conceptual Phase (A Broader Approach)

Updating Scenarios

The lessons from the first iteration yielded new functionality and broadened the scenarios for home care visits and nightly supervision. As an additional way of interacting, voice control was added to both scenarios. For home care visits, the scenario was extended to include the possibility for the care recipient to CRUD, *create, read, update and delete* [21], visits from home care. Specifically, this included the possibility for care recipients to be able to book visits (create), get notifications about coming visits and if they were delayed (read), the possibility to reschedule visits (update) and also to cancel visits from home care via the system (delete). This extension was chosen with the vision in mind of giving care recipients more control of their home care visits.

For the nightly supervision, the scenario was extended to include fall detection, the possibility to get a camera view if something acute happened as well as the system's ability to discover deviating movement patterns during the night with a preventative purpose for the care recipient. This extension was chosen with the vision in mind of making nightly supervision less intrusive for the care recipient and less demanding for the caregiver.

New Personas Created

Since the scenarios were updated from the feedback received in the first iteration and expanded to include more functionality and features to explore more use cases, two new personas were created in order to cover the updated scenarios. Both of these personas were created with inspiration from the previous theses [9] [38].

The first persona, *Klara Axelsson* (see figure 3.6), represented a different type of care recipient in comparison to Lennart Persson (see figure 3.3). Her main characteristics of being kind minded towards technology, enjoying the company of home care staff and having the will of being in control of her home care, was deemed as interesting as the scenario for home care visits leaned towards giving the care recipient more control of the technology and their home care. The persona of Lennart was not taken into consideration when developing the home care visits scenario further because of his resistance towards learning new technical devices and interacting with them. Although, his characteristics would fit some parts of the nightly supervision scenario that did not include more hands-on interaction with the system and were more automatic in nature. For the persona of Klara, the nightly supervision was developed with her characteristics in mind. For further discussion about the different layers of interaction in each scenario that could fit different older people's needs, see section 5.2.1 for home care visits and section 5.3.1 for nightly supervision.

In summary, the persona of Klara Axelsson would represent a care recipient with minor to none cognitive disabilities that would like to benefit from the system by keeping the initiative.

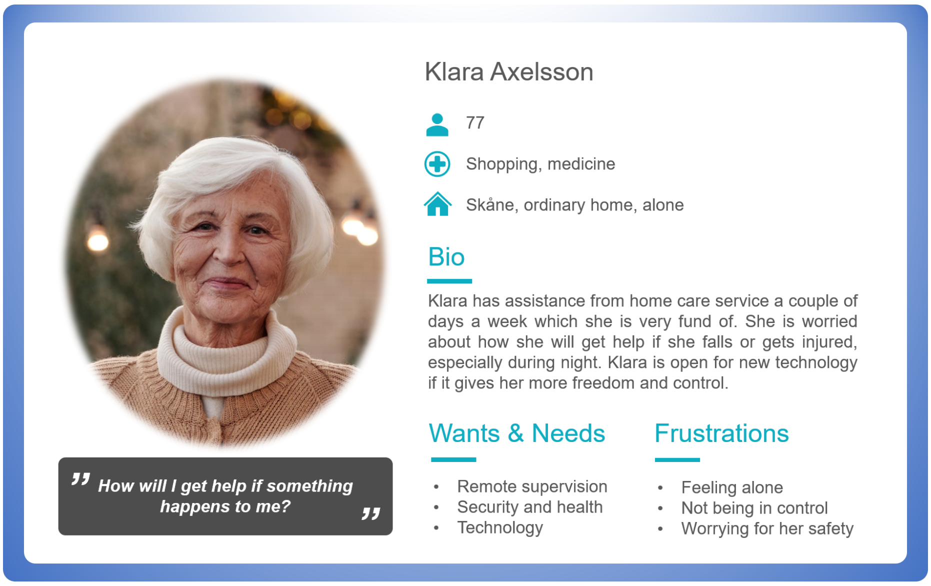

Figure 3.6: Klara's persona - a potential care recipient interacting with the system

The second, persona *Per Lennartsson* (see figure 3.7), represented a caregiver working for the home care in Sweden. His main characteristics, such as frustrations with nightly supervision, the need of trustworthy systems and the desire to be more effective, were important traits to take into account as both the scenarios expanded in the second iteration of the design process to include the caregivers interactive parts in the system.

3.3.2 Processing Phase (Enlarging the Interaction)

Updated Interaction Flows

The interaction flows for each scenario were split up into different use cases. Since the scenarios functionality expanded, one interaction flow was not deemed sufficient enough for describing an entire scenario, hence there was a need for outlining several interaction flows with each scenario.

The scenario for home care visits was split up into three different use cases with two different ways of interaction. The interactions were voice commands and a graphical user interface via the tablet.

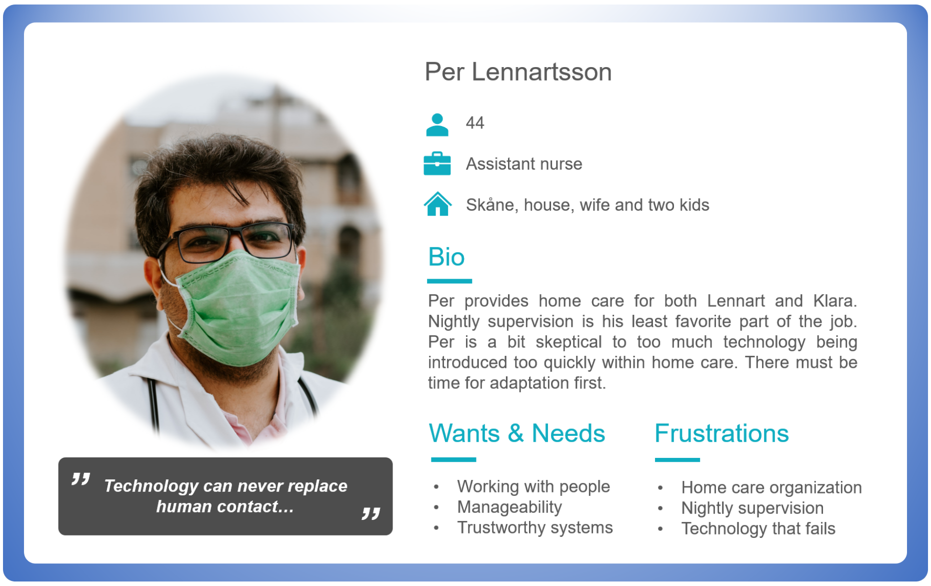

Figure 3.7: Per's persona - a potential caregiver interacting with the system

- **Use case 1: Book and cancel visits**
    1. *The system notifies the care recipient via speaker or tablet about a visit from home care in 30 minutes*
    2. *The care recipient cancels the visit by voice command or by using the tablet*
    3. *The system confirms the cancel via speaker or tablet and asks if a new visit should be booked*
    4. *The care recipient declines by voice command or by using the tablet*
    5. *The care recipient later books a new visit by voice command or by using the tablet*
    6. *The system responds via speaker or tablet with a specific time for the visit which the care recipient confirms*
- **Use case 2: Contact other care recipients**
    1. *The care recipient wants to visit his friend which also has the same system installed in their home*
    2. *The care recipient calls his friend via the system by using voice command or by using the tablet*
    3. *The care recipient and his friend have a call and schedule a visit*
    4. *The system registers that the care recipient will visit his friend and the home care staff is informed*
- **Use case 3: Notification about delays and caregiver comes to visit**
    1. *The system notifies the care recipient via speaker or tablet that a scheduled cleaning from home care will be delayed*

2. *The care recipient leaves his home to visit his friend, which the system notices*
3. *The caregiver arrives to the care recipients home and identifies himself with an ID-tag*
4. *The system confirms the identity and allows entrance since a visit from home care was booked*
5. *The system notices that the care recipient has entered the care recipients home for cleaning and also notices when the care recipient leaves*
6. *When the care recipient comes home again after visiting his friend, the system informs the care recipient via speaker or tablet that his home has been cleaned by the home care*

The scenario for nightly supervision was split up into three different use cases with several different ways of interaction.

- **Use case 1: Deviating movement patterns**

  1. *The care recipient wakes up during the night and goes to the bathroom*
  2. *The system notices that the care recipient leaves the bed and turns on the light automatically*
  3. *The system notices that the care recipient visits the bathroom*
  4. *The system notices that the care recipient goes back to the bed and turns off the light automatically*
  5. *The system gives an alert to the home care since this was the forth time the care recipient left for the bedroom during this night, which is deemed as a deviating behaviour*

- **Use case 2: Absent from bedroom**

  1. *Same steps 1-3 as Use case 1*
  2. *The system notices that the care recipient has been in the bathroom unusually long*
  3. *The system asks the care recipient if everything is OK via the speaker*
  4. *If the care recipient responds the use case ends, else, the system gives an alert to the home care*

- **Use case 3: Fall detection**

  1. *Same steps 1 and 2 as Use case 1*
  2. *On the way to the bathroom the care recipient falls*
  3. *The system notices that the care recipient has fallen and does not manage to get up*
  4. *A camera is turned on and a caregiver from home care gets an overview of the situation*
  5. *The caregiver is able to communicate with the care recipient to create an understanding of the situation and whether help needs to be sent*

Additional IoT Devices Integrated

In order to accomplish the extended scenarios, additional IoT devices were integrated in the system. The first addition was to use the Vayyar Home radar device for monitoring room presence and fall detection (see figure 2.3). The Vayyar Home radar was added to both scenarios.

For the home care visits scenario the network mini speaker (see figure 2.5), was added in order to make auditive responses from the home care. However, microphones or devices for registering audio from the care recipient were not integrated in the system because of technical difficulties when trying to implement a service of VoIP.

For the nightly supervision scenario, both the network mini speaker and IKEA Trådfri light bulb were added to the system (see figure 2.5). The light bulb was a smart device and could be turned on, off or dimmed by the system which were necessary functions for accomplishing the use cases.

3.3.3 Detailing Phase (Second Prototypes and Evaluation)

Updated Video Prototypes

A second version of the video prototypes was created for both scenarios (see figure 3.8 and 3.9). Each use case for each scenario had a designated video prototype which showcased the interaction flow with the care recipient, the caregiver and the system in the specified contexts.

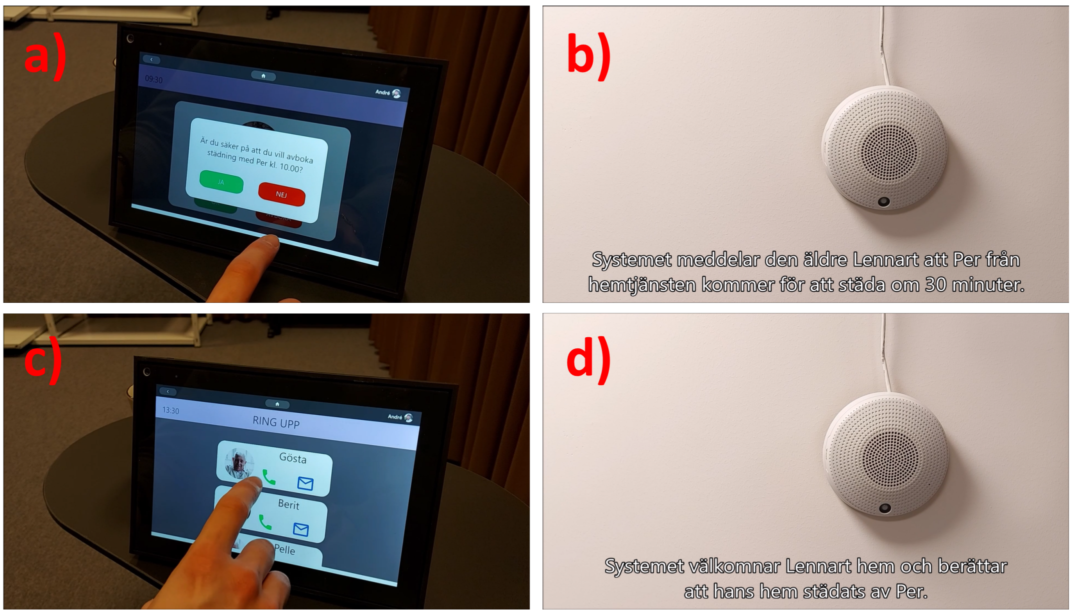

Figure 3.8: Screenshots from the second iteration video prototypes with the scenario for home care visits: a) cancel visits via tablet b) system notifies via speaker about a coming visit c) call via tablet d) system notifies via speaker about an accomplished visit

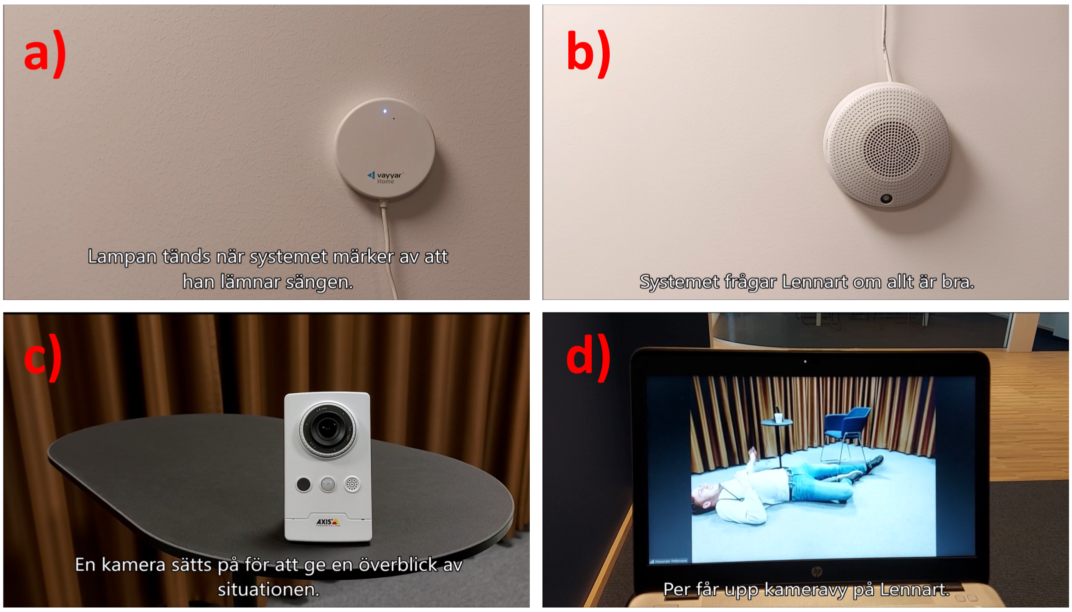

Figure 3.9: Screenshots from the second iteration video prototypes with the scenario for nightly supervision: a) system notice room presence b) system notifies via speaker after long bedroom absence c) camera activated when a fall is confirmed by the system d) the caregiver gets a camera view of the care recipient when a fall has happened

Interviews with Caregivers and Home Care Staff

To evaluate the second video prototypes, interviews with one home care coordinator and two experienced home care workers from Kävlinge municipality were conducted. These individuals were chosen because of their expertise and work experience. The home care coordinator had been working for more than 10 years and was both responsible and interested in digitizing the home care in Kävlinge municipality. Both the home care workers had also been working within home care for well over 25 years and had been through different digitization phases of the home care service for the past decades.

Similarly to the interviews in the first iteration, these interviews also consisted of two parts. In the first part, general challenges and possibilities with home care visits and nightly supervision were discussed and explored. In the second part, the video prototypes were shown and the interviewees gave their feedback and ideas for further development.

The first part of the interview resulted in the following lessons:

- Apart from urgent situations, the home care administrator (biståndshandläggaren) decides if there is a possibility to extend the number of home care visits for a care recipient. However, smaller and less demanding visits such as supervision and to heat food can easily be booked on the fly.

- It would be beneficial if a care recipient had the freedom to book a visit with the coordinator at will, however, home care workers often have full schedules, thus, it is difficult to have time for additional visits than what is determined in advance.

- The care recipient often knows when a visit is happening but seldom who is visiting. The schedule for the daily home care visits is displayed on a piece of paper, given to the care recipient on the first visit of the day. Who is visiting is hard to predict due to high staff turnover. It is desirable to give the care recipients better foresight into the visits.

- The care recipient is able to cancel visits up to 15 minutes before arrival and are able to reschedule visits. This is often communicated in connection with an existing visit. It would be desirable if relatives to the care recipients could email the coordinator about cancelling visits to avoid that home care workers show up and the care recipient is not there (bom-besök).

- Most home care visits require the care recipient to be present.

- Scheduled visits when the care recipient is not present occurs about once a week and is often caused by the care recipient being on a stroll or visiting relatives. If the care recipient is not present on a scheduled visit the home care calls their designated contact person (often relatives) to get an understanding of the care recipient's location, hence updated contact information is important. On rare occasions the police had to be contacted in order to track down the care recipient.

- Kävlinge municipality has camera supervision in their home care where a home care worker looks in the camera two times a night during agreed times with the care recipient. About 90% of the nightly supervision via camera is uneventful, the rest is often that the care recipient is visiting the bathroom.

- Some care recipients still need physical nightly supervision such as changing incontinence protection or a care recipient who alarms a lot or needs help when visiting the bathroom.

In summary, the feedback for each scenario was the following:

- **Home care visits**
  - Voice control is not especially realistic for care recipients with impaired hearing or voice, though it could be possible for care recipients who are a bit more alert.
  - Providing different ways of interaction is fundamental since the care recipients differ a lot in cognitive capabilities.
  - The scenario feels unrealistic and very much in the future, however, it would certainly save both time and personnel.
  - It is desirable to inform the care recipient about delays as they often become worried when we are not on time.

- **Nightly supervision**
  - All the use cases felt realistic.
  - Sometimes we have to drive 30 km to turn off a lamp, thus automatic lights are desirable.

- The detection of falls was very valuable. It is good that the caregiver can communicate with the care recipient once the fall has happened to get an understanding of the situation.
- This scenario felt more simple and less demanding than the current camera installment in Kävlinge's home care.
- It is quite common that the care recipient has to visit the bathroom during the night or stays there.
- It is important to be able to communicate with the care recipient if something happens.
- The target group for the system can be care recipients with minor cognitive impairments that are more self-propelled but worried that they would not get help if something acute happened. Some instances of the system could be appropriate for care recipients that suffer from forgetfulness or dementia, though voice control could make them uncomfortable.

3.4 3rd Iteration (Deciding and Specifying)

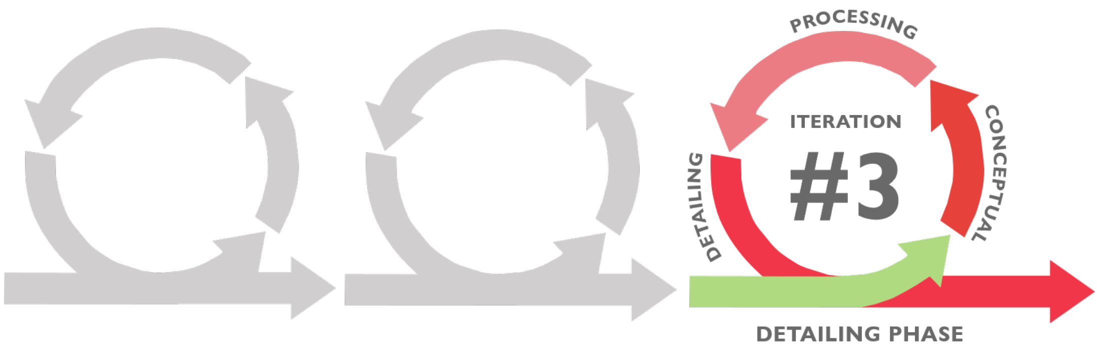

Figure 3.10: Detailing phase and third iteration

3.4.1 Conceptual Phase (Narrowing Down)

Focus on Nightly Supervision

The feedback from the interviews in the second iteration yielded that the scenario for home care visits was a bit more experimentally in its nature in comparison to the nightly supervision scenario. The possibility of giving the care recipient full control and insight regarding their visits from home care was desirable but was permeated by infrastructural challenges within the home care organisation as it is systematized in Sweden today. Furthermore, a technical implementation with several integrated IoT devices that could be easily set up, tested and evaluated in a physical space was estimated to be more difficult to accomplish in the home care scenario in comparison to the nightly supervision. Specifically, two-way voice communication was challenging to implement as well as integrating the user interface in the system (see section 3.5.1 and Adobe XD and User Interface subsection). Both these ways of interaction were a big part of the home care visit scenario and even though voice commands and user interface was present in the nightly supervision scenario, they were not fundamental for the implementation. For instance, the functionality of the Vayyar Home radar, which in turn had a smaller role to play in the home care visits scenario.

Thus, the decision was taken to exclusively focus on the continuous development of the nightly supervision scenario in this third iteration of the design process. Nonetheless, the scenario of giving care recipients more control and insights about their home care visits is still an interesting area. The obstacles, opportunities and potential future developments of this scenario is further analyzed and discussed in section 5.2.

For the nightly supervision scenario, the feedback from the second iteration helped streamlining the interaction flow and highlighted the most important parts of the scenario.

3.4.2 Processing Phase (Defining the Interaction)

Updated Interaction Flow

The interaction flow for the nightly supervision scenario was further developed and outlined from the flow created in the second iteration. The scenario was split up, from three to six use cases to specify the different parts and the interaction between the care recipient, caregiver and the system.

- **Use case 1: Supervision customization**
    1. *The care recipient decides how he wishes to be supervised by the home care during the night by using the the tablet (the customization options for the system was not yet specified in this stage of the process)*
    2. *Once the customization is done, the care recipient turns off the light via the tablet and goes to bed*
- **Use case 2: Alarming the home care**
    1. *The care recipient wakes up during the night and feels sick*
    2. *The care recipient alarms the home care via the tablet*
    3. *The system responds with a confirmation that the home care is on the way*
    4. *The caregiver gets notified by the system about the alarm and visits the care recipient*
- **Use case 3: Deviating movement patterns**
    1. *The care recipient wakes up during the night and goes to the bathroom*
    2. *The system notices that the care recipient leaves the bed and turns on the light automatically in the bedroom*
    3. *The system notices that the care recipient visits the bathroom*
    4. *The system notices that the care recipient goes back to the bed and turns off the light automatically*

5. *The system gives an alert to the home care since this was the forth time the care recipient left for the bedroom during this night, which is deemed as a deviating behaviour for the sake of the use case*

- **Use case 4: Absent from bedroom**
  1. *Same steps 1-3 as Use case 3*
  2. *The system notices that the care recipient has been in the bathroom unusually long*
  3. *The system asks the care recipient if everything is OK via the speaker*
  4. *If the care recipient responds via voice or movement the use case ends and the system gives a confirmation, else, the system gives an alert to the home care*
- **Use case 5: Fall detection part 1**
  1. *Same steps 1 and 2 as Use case 3*
  2. *On the way to the bathroom the care recipient falls*
  3. *The system notices that the care recipient has fallen*
  4. *The care recipient is able to get up again and the system notices this*
  5. *The care recipient alarms the home care via the tablet or the home care automatically gets an notification about the situation*
- **Use case 6: Fall detection part 2**
  1. *Same steps 1 - 3 as Use case 5*
  2. *The care recipient is not able to get up and the system notices this*
  3. *A camera is turned on and a caregiver from home care gets an overview of the situation*
  4. *The caregiver is able to communicate with the care recipient to create an understanding of the situation and whether help needs to be sent*

Fine-tuning the IoT Devices and System

As a final part of the processing phase in the third iteration of the design process, the current IoT devices were further integrated and regulated in order to facilitate the different parts and functionalities of the system. This included mapping out the space in x, y and z variables for the Vayyar Home radar where the bed was, constructing the graphical interface for the tablet, setting up the triggers for the speaker and light bulb and further investigating what data the system should collect and act upon.

3.4.3 Detailing Phase (Third Prototype and Evaluation)

Final Video Prototype

In order to demonstrate the new interaction flow for nightly supervision, a third video prototype was created (see figure 3.11). This video prototype contained all the six use cases for the scenario.

Figure 3.11: Screenshots from the third iteration video prototypes with the scenario for nightly supervision: a) supervision customization b) turn off light via tablet c) alarm home care via tablet d) system notices when the care recipient is present in the bathroom

Interviews with Potential Future Users 60+ Years

To evaluate the third video prototype, interviews with four older people (two women and two men), in the age span of 60-76 years were conducted. The general attitude and knowledge towards technology was positive as all the interviewees were accustomed to tablets and used smartphones daily. However, neither of these individuals was in the present moment in need of any home care assistance and thus they were interviewed as potential future users of the system. The general mindset among these individuals was that they desired to live at home for as long as possible and felt the need of feeling safe and having undisturbed sleep. One of the individuals clearly expressed that they were worried about how she would get help if something happened to her during the night.

In contrast to the previous interviews, this third iteration of interviews focused solely on the third video prototype of the nightly supervision. The video was first shown to the interviewees and then the interview consisted of the following questions with the compiled answers from the interviewees added below:

1. **How would you like to customize this system?**

   It should be possible to turn on and off the camera when needed. A camera in the bathroom is not always desirable. Get the opportunity to be informed if there is someone unauthorized in the home. It is good if you can sound the alarm without having to leave the bed.

2. **How would you like the system to notify you if you are absent from the bedroom unusually long?**

   A phone call, SMS or similar from the home care service. If you happen to fall asleep on the toilet, it could be good with some sort of notification from the system, so you wake up and can go back to bed again.

3. **What advantages do you see with this system?**

   The system feels safe and there is a little risk of being injured without anyone knowing about it. This creates security for relatives as it is often difficult to know how they are. The night is probably the time where you feel the most offended or scared if you get a visit, especially from someone you do not know. Furthermore, it is good that the system keeps track of where you are and how long you have been there. The opportunity to call for help is good. All people who live by themselves should have some form of alarm.

4. **What disadvantages do you see with this system?**

   Cameras in the home are not always desirable since it feels difficult to know what information is being distributed. It seems that there are many devices to be set up in the home, they should not be too visible. Also, what kind of sounds or light does these devices emit? They should not be disturbing. Furthermore, it feels quite unlikely that any old person that falls gets up again, they are often far too clumsy to get up.

5. **In what ways would you like to call for help?**

   It would have been convenient to be able to alert easily via the mobile phone, the possibility to call is always good since it is easy to give a good description during a conversation. Another way would be to have buttons on the toilet so you can reach them when you need help. Also, the possibility to say "HELP" or "OUCH" out loud to get help, however, there are many older people who just moan all night and then this solution could potentially be misused.

6. **What are you missing in this system?**

   The possibility to get some insights into what information is being distributed to the home care. Some form of protection from thieves and guided lighting. Also, some form of radio where you can talk directly to the home service, that you either have with you or that is cleverly placed in the home.

7. **How did you perceive the camera's function in the system? (Would you like to have a camera in the bathroom?)**

   A camera is fine as long as it is possible to turn it off when needed. It is more sensitive to have a camera in the bathroom, a sensor feels less intrusive. Perhaps only a camera at foot level in the bathroom so it can register falls but nothing else.

8. **How do you feel about your privacy being affected by this system?**

   In the case of this particular system, it is the cameras that mostly affect privacy. However, this is very individual and depends on your needs and personal concerns about privacy. If you need help you need help and the privacy concerns could wait.

9. **Is this system something you would like to have in your home?**

   Some parts of the system, like voice and light control seem good. The camera part is complicated in regards to privacy. If you lived alone then maybe it is more desirable. The camera could be placed at foot level to only record falls and nothing else, that would feel less intrusive. Furthermore, the possibility to directly get in touch with home care personnel is good, especially if something has happened.

In summary, the interviews of this third iteration resulted in the following lessons about nightly supervision:

- It should be possible to turn off the camera when needed. If a camera is placed in the bathroom it should only be at foot level to be less intrusive.
- It is good that the system keeps track of where you are and how long you have been there without needing a camera.
- The devices should not emit light or sounds that are disturbing or look overly complex.
- The possibility to get some insights into what information is being shared with the home care is desirable.
- The privacy aspect is very individual. If something acute happens then privacy is less important as you just want help.
- Voice and light control together with the possibility to alarm the home care when needed is very valuable.

These lessons led to the following changes of the scenario:

- The supervision customization for the care recipient was specified to contain settings such as how long you should be absent from the bedroom before the system notifies the home care in order to get some insights into what information is being shared.
- The customization was further developed with the possibility to turn on or off camera supervision and the possibility to put the system in "silent mode". The silent mode would represent the care recipients option to take full control of any privacy concerns as it meant that the home care was not able to see or communicate with the care recipient by initiative. Basically, removing the caregivers insight but still giving the care recipient the possibility to alarm if needed.
- Since voice and light control was desirable they were kept and further specified in the scenario.

3.5 Implementation

This chapter describes the implementation of the system for nightly supervision after the third iteration of the design process was completed, as outlined in section 3.4. Firstly, in section 3.5.1, the architecture of the system is described and illustrated as well as the tools used to create it. Then, in section 3.5.2, the final prototype used for the final user testing (see chapter 4 for more details), is presented.

3.5.1 System Architecture

The basic architecture for the system (figure 3.12) consisted of a *Raspberry Pi* computer connected to a router and PoE switch which could communicate with the various IoT devices via WiFi or Ethernet connection. On the Raspberry Pi, the open source software *Home Assistant* (section 3.5.1) was installed, which in turn had the flow-based development tool for visual programming *Node-RED* (section 3.5.1) integrated. Home Assistant was mainly used for discovering and configuring the IoT devices connected to the router, while Node-RED was used to connect and create the logic of the states and interaction of the IoT devices using the Node.js platform and JavaScript modules.

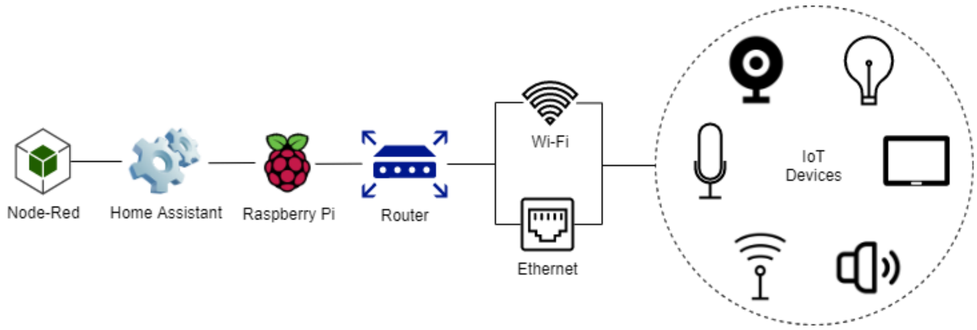

Figure 3.12: System architecture

Home Assistant

Home Assistant is an open source software for home automation. Originally made public in 2013, Home Assistant operates as a central controlling hub for smart homes by connecting IoT devices and integrating them as entities [4]. The connected IoT devices can be automatized and triggered, provided by a rule-based system for creating custom routines. Functionality and automation such as video surveillance, alarm security and household monitoring can hence be enabled. Furthermore, Home Assistant has integration support for a number of devices and services, including IKEA Trådfri and Axis products. The software also provides a library of add-ons that further increases the number of possibilities and capabilities of the connected IoT devices.

Node-RED

Node-RED is a programming tool for connecting hardware devices, APIs and online services using flow-based, event-driven programming built on Node.js [24]. Node-RED provides a browser-based flow editor, with a built-in library used to create logic between different nodes (figure 3.13). JavaScript functions can be created to trigger different events, conditions and actions from the connected devices.

In the Home Assistants dashboard, Node-RED can be installed as an add-on and development tool. In this way, IoT devices discovered and configured by Home Assistant could then be used in Node-REDs editor to create logical events, triggers and actions in its flow-based environment.

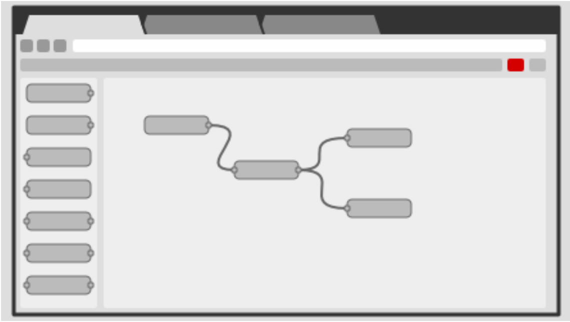

Figure 3.13: Node-REDs browser-based flow editor [24]

Adobe XD and Graphical User Interface

Adobe XD is a vector-based user experience (UX) designing tool for web-based and mobile applications [44]. Particularly effective for designing and sketching wireframes and mock-ups, Adobe XD can be used for creating high fidelity (Hi-Fi) prototypes with custom screen sizes. The software provides a simple way of sharing designs via an URL-link, which in turn could be run and tested on any devices with a screen, Internet connection and web-browser functionality.

Adobe XD was not part of the final implementation and thus was not integrated with any of the IoT devices. The usage was fundamentally for demonstrative purposes in the video prototypes by showcasing different examples of *graphical user interfaces* (GUIs), where the intended user could interact with the IoT devices via the GUI, however, only as a demonstrative solution. In the final implementation, GUIs were constructed in Node-REDs dashboard and thus integrated with the IoT devices connected to the network. The final GUI in Node-RED was created with the feedback from the GUIs created during the design process in Adobe XD, however, Node-REDs GUI options were quite limited and trade-offs on the aesthetics had to be made in order to make it functional and integrated with the system.

3.5.2 Final Prototype

Flow-state Diagram

In order to get an overview of the interaction flow for the nightly supervision, a flow-state diagram was created (see figure 3.14). This diagram shows how the different components and IoT devices were used in each part of the scenario as well as the flow of interaction the care recipient and caregiver is performing within the context of the system.

The solid lines in the diagram represent how a care recipient is interacting and how the state changes, while the dashed lines represent when a caregiver is informed about the care recipient's activities and current state. In addition, the states were given different colors to highlight the different parts of the system. In detail, the green state represented the initial customization the care recipient decided upon. The orange states represented where a care recipient was acting in the context of the system and triggering the different devices. The red states represented the states where a care recipient's actions would trigger some sort of notification to the caregiver. Lastly, the gray states represented where in the interaction flow the caregiver would get information from the system they were able to act upon.

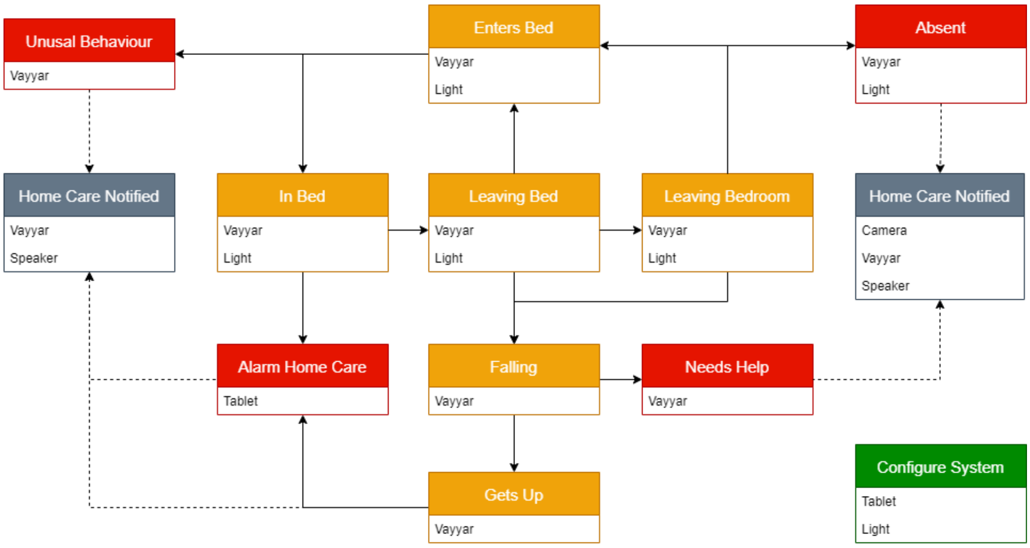

Figure 3.14: Flow-state diagram of the nightly supervision scenario

Clients of the System

The system had one implementation but two different *clients* that could interact with the system in different ways and for different purposes. The first client was represented by the care recipient who was able to interact with the system via the touch screen on the tablet or by voice. This client was interacting *directly* with the system in the sense that they were the ones that triggered the different IoT devices depending on their activities and states, as illustrated in figure 3.14. For instance, the Vayyar Home radar monitored the room presence and fall occurrence of the care recipient, the camera overview was triggered by the states of the Vayyar radar and the light bulb and speaker could either be triggered by the states of the Vayyar radar or by the care recipient interacting with the tablet.

The second client was represented by the caregiver who was able to interact with the system via a monitor and computer mouse. This client was interacting *indirectly* with the system in the sense that they could only act upon feedback from the system the first client (the care recipient) triggered. For instance, the caregiver had no camera overview until this was triggered by the care recipient from either a fall or long bedroom absence. The camera could then be used by the caregiver to take snapshots. The states of the radar were also displayed in text for the caregiver, but with no direct interaction in the sense that the caregiver was not able to alter the states. However, the caregiver was able to contact the care recipient, thus triggering the speaker in that case.

GUI

Each client of the system had their designated GUIs. As described in section 3.5.1, these GUIs were created using the Node-REDs dashboard in order to make them integrated with the IoT devices connected to the system. The GUI for the care recipient was presented on the Portal tablet and can be seen in figure 3.15, 3.16 and 3.17. It contained three tabs to interact with; *Home*, *Settings* and *Your Caregiver*. The *Your Caregiver* tab was based on the persona Per Lennartsson (figure 3.7). The interaction with the GUI was carried out by touching the screen.

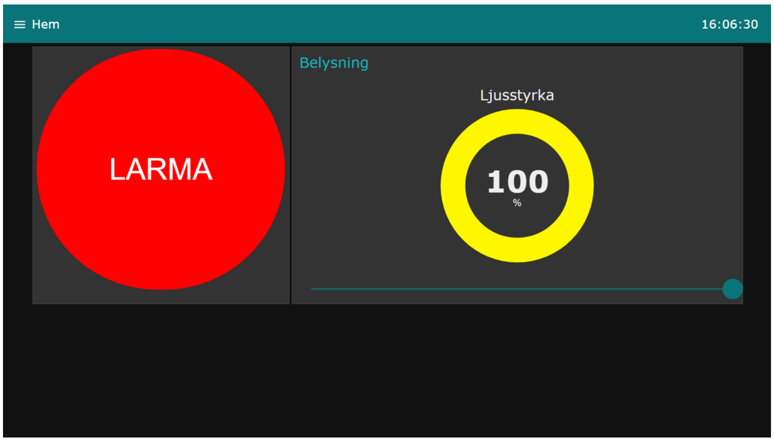

Figure 3.15: The "Home" tab in the GUI for the care recipient were they are able to alarm the home care and control the light bulb

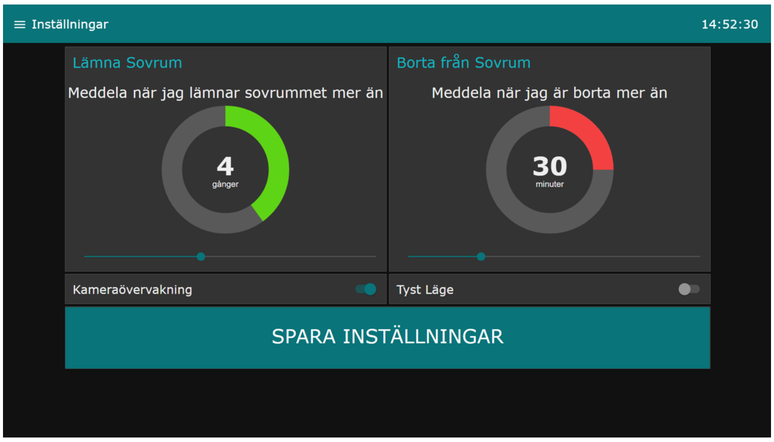

Figure 3.16: The "Settings" tab in the GUI for the care recipient when they are able to configure the system according to their needs

Figure 3.17: The "Your Caregiver" tab in the GUI for the care recipient where they could find information about their caregiver

The GUI for the caregiver was in turn presented on a monitor and can be seen in figure 3.18 and 3.19. This GUI contained two different tabs to interact with; *Overview* and *Your Care Recipient*. The *Your Care Recipient* tab was based on the persona Lennart Persson (figure 3.3). In contrast to the touch screen for the tablet, the interaction with this GUI was instead carried out by using a computer mouse.

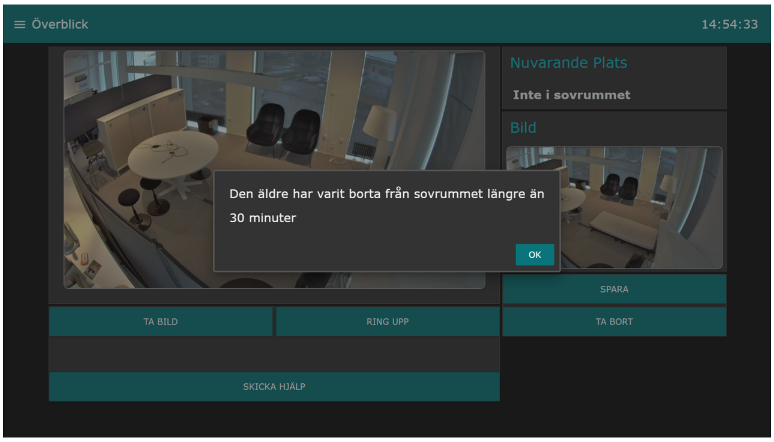

Figure 3.18: The "Overview" tab in the GUI for the caregiver when they got an alert that the care recipient had been absent from the bedroom unusually long

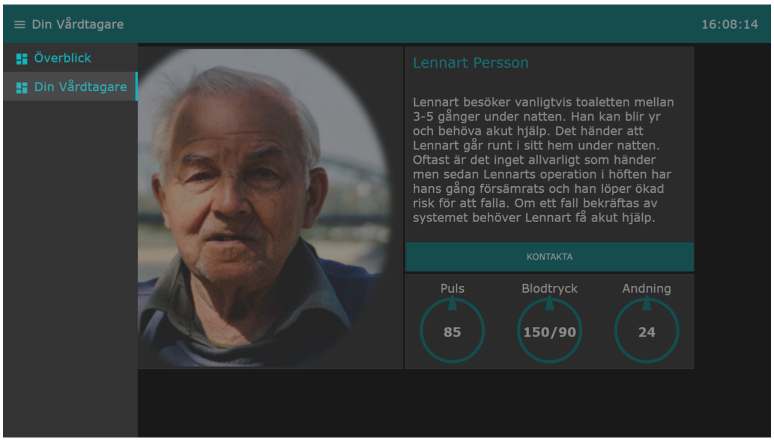

Figure 3.19: The "Your Care Recipient" tab in the GUI for the caregiver where they could find information about their care recipient

Data Variables

In order to enable the different states of the system, specific data variables had to be stated in the Node-RED environment. In detail, the variables were part of the flow context scope in Node-RED, meaning they were visible to all nodes in the same flow [25]. In the case of the system, all the functionality, logical operations and user interface components were part of the same flow, hence the flow data could be reached and updated in all parts of the system, consequently, giving the system constant access to the specified data variables.

The choice of having all the data variables visible in the flow facilitated the usage of the variables in regards to the size of the flow and the number of nodes used. If the system had been larger and required several flows, different levels of visibility had probably been preferred, for instance, setting some of the variables to a global scope [25], allowing them to be accessed by all nodes in comparison to only the nodes within the same flow. However, the implemented system was able to be built inside one flow in Node-RED, therefore this consideration was not necessary.

In summary, the data variables were updated according to the input and output of the different IoT devices integrated in the flow used to implement the system. The final data variables used can be seen in table 4.3 together with their corresponding type, possible values and additional notes of usage and occurrence.

Table 3.1: Data variables used in the system.

Variable	Type	Values	Notes
count	Integer	0...	Number of times the care recipient leaves the bedroom
count_limit	Integer	0-14	Changed by the care recipient via the tablet. If count >= count_limit the caregiver is notified. If set to "0" then no check is done.
timer	Integer	0...	The time in minutes the care recipient is absent from the bedroom
timer_limit	Integer	0-120	Changed by the care recipient via the tablet. If timer >= timer_limit the home care is notified. If set to "0" no check is done.
room_state	String	bedroom, bathroom, fall detected, fall confirmed, fall exit	Depending on the states of the Vayyar Home radar the presence in the bedroom could be monitored. If the radar detected presence the state was set to "bedroom", else, the state was set to "bathroom" as these were the two rooms in the context of the prototype. If the radar detected a fall it would first go into a state of "fall detected". After a timeout the state changed to "fall confirmed". If the care recipient would get up again the state changed to "fall exit" and the radar exited the fall states and went back to presence detection.
in_bed	Boolean	true, false	Depending on specified x, y and z position variables of the radar's presence detection messages, the care recipient was either in or not in the bed.
camera	Boolean	true, false	Changed by the care recipient via the tablet. Depending on the value, the possibility to get a camera overview of the care recipient if something acute happened was either set to "on" or "off" for the caregiver.
silent_mode	Boolean	true, false	Changed by the care recipient via the tablet. Depending on the value, the caregiver was either able or not able to contact the care recipient via the system.

Chapter 4
Final User Test - Nightly Supervision

This chapter describes the final user testing conducted on the final prototype implemented for the nightly supervision scenario. The prototype is described in section 3.5.2. For an in-depth deception of the test, see the test plan presented in Appendix A.

4.1 Set-up

The goal with the final user test was to create a realistic home environment where the functionality of the system could be demonstrated and evaluated. In addition to that, the test environment had to be optimized for observation and analysis without the participants of the test being disturbed. One important aspect of the planning process regarding the user testing was to pick the right test environment. Since the test was conducted in an office environment, on site at the technology company the thesis was conducted on, there were some challenges in regards to the set-up that is further discussed in section 5.3.2.

In order to test both clients of the system, two areas were chosen; one area where the participant acted as a care recipient and one area where the participant acted as a caregiver (see figure 4.1). The area that was selected for the care recipient's part of the test was a partially hidden corner within the open office environment. Shelves and removable walls were utilized to create a sheltered environment. Since a quantity of technical devices had to be mounted in the test environment, railings in the roof were utilized. Some of the technical devices were visible for the participant, and some were hidden. The devices that were facing the participant were either going to play an important role in the system-user interaction or had the role of gathering sensor data. The devices that were hidden were mainly related to the network and the server part of the system, such as the router and Raspberry Pi computer. Furthermore, there was some furniture placed in the test environment. Some furniture played a vital role in the testing, like the bed, as it was part of the test cases. There was also some furniture that was mainly kept in the test environment to create a trustworthy experience, such as a bedside table and armchairs.

The area that was selected for the caregiver's part of the test was a separate office room next to the open office environment. The area consisted of a table for a screen and computer mouse, together with an office chair in which the participant would sit in. It was important that the participant in this part of the test did not have any visual insights into the care recipient's area as to simulate the conditions an actual caregiver would be put in.

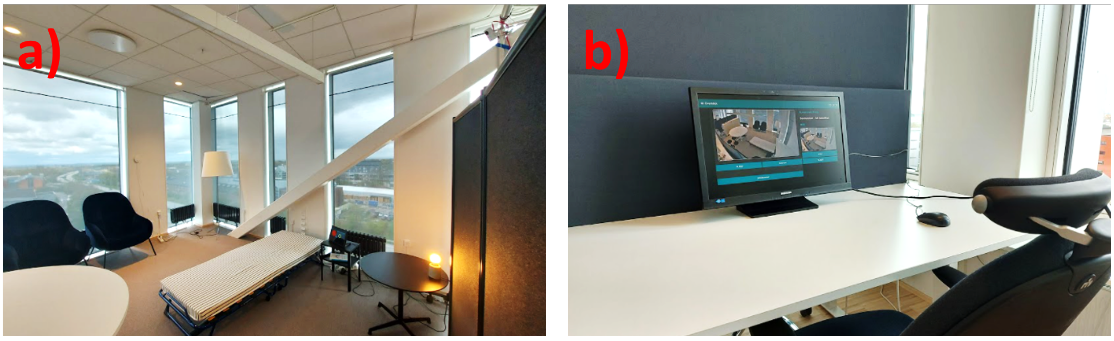

Figure 4.1: The physical set-up of the system for the final user test:
a) the test area for the care recipient b) the test area for the caregiver

4.2 Participants

The group of test participants consisted of employees from the technology company. The participants were chosen as part of a target group with two requirements in mind: individuals from 55 years of age or older, and/or individuals with some sort of direct or indirect home care experience, specifically, experience of working within home care or having close relatives with home care, assisted living or alike. The reason for the interest of individuals from the age of 55 years was to get a better insight into the technical skills of individuals who would be potential users of the system in the future. Participants with some sort of direct or indirect experience of home care would hopefully contribute with some domain knowledge and valuable perspectives for the systems context. In total, the test had 10 participants, including two pilot testers. The participants consisted of 2 women and 8 men, with the majority above the age of 55 years.

Because of the ongoing pandemic of COVID-19, having participants such as currently employed caregivers in home care and individuals that presently got help from home care was not deemed safe and thus excluded as potential participants of the test.

4.3 Procedure

4.3.1 Pilot Testing

Before the real participants were invited to the final test, two pilot tests were conducted. The participants of the pilot test consisted of two other thesis workers from the technology company and were chosen for flexibility. These tests helped streamlining the procedure considering for instance, the wording of the instructions and positioning of the test moderator and observer. The pilot tests were considered successful and only resulted in some minor changes in the procedure of the test. Although the participants of the pilot test did not meet the requirements of the target group, the results of the pilot tests were still combined with the results of the final user test in order to gain more data.

4.3.2 The Final User Testing

This section outlines and describes the content and structure of the final user test as it was conducted in the office environment given the physical setup (figure 4.1).

Introduction

The participants were invited via e-mail by an internal company link to fill out a *target group survey*. The participants that met the requirements of the target group were then invited to book individual time slots for testing. The typical procedure of a test started with the participants being greeted in the office environment of the test and asked to fill out a *consent agreement*. The target group survey is presented in Appendix A.

Test Tasks

The test consisted of in total eight tasks the participants were asked to perform. These were the following (see Appendix A for detailed task list):

- **T.1.1** Caregiver info
- **T.1.2** Configuration
- **T.1.3** Alert home care
- **T.1.4** Bedroom absence
- **T.1.5** Fall detection
- **T.2.1** Care recipient info
- **T.2.2** Notifications
- **T.2.3** Handling a fall

The participant was accompanied by a test leader and an observer. The test leader introduced each task for the participant, while the observer was overlooking the test, acting as a co-actor and controlling some parts of the system. The participants were further encouraged to use the method of thinking aloud (see section 2.1.13).

In detail, the system was partially controlled by the observer in an Wizard of Oz manner (see section 2.1.12). The reason behind this was because the radar had a slight delay in its messages, thus streamlining the testing by controlling and manually triggering some of the parts in a Wizard of Oz manner would keep the participants busy, while still having the functionality intact. Specifically, the triggers of the radar were controlled as well as the speaker by injecting a timestamp node in Node-RED at the desired time and place, depending on where the participant was active.

The first part of the test consisted of care recipient tasks and took place in the furnished office environment as seen in figure 4.1. This first part of the test consisted of five tasks and the participant was, for instance, asked to configure the system, alarm the home care and respond to the system by voice. These were the following tasks:

- **T.1.1** Caregiver info
- **T.1.2** Configuration
- **T.1.3** Alert home care
- **T.1.4** Bedroom absence
- **T.1.5** Fall detection

When this first part of the test was completed, the participant was guided to the separate office room for the second part consisting of caregiver tasks.

The second part of the test consisted of caregiver tasks and took place in the separate office room as seen in figure 4.1. This second part of the test consisted of three tasks and the participant was, for instance, asked to supervise the care recipient via the system, look in the camera and send help if needed. These where the following tasks:

- **T.2.1** Care recipient info
- **T.2.2** Notifications
- **T.2.3** Handling a fall

When this second part of the test was completed, the participant was guided back to the open office environment where the concluding evaluation, consisting of a SUS questionnaire and closing interview, would take place.

Information Gathered

The information gathered consisted of two parts: a SUS questionnaire and an interview. The SUS questionnaire was printed out on a piece of paper and was filled out by the participant using a pen directly after all the test tasks had been completed. After the completion of the SUS questionnaire, a closing interview with the participant was conducted. The interview consisted of three parts. Firstly, questions about the experience of the care recipient's part of the test, secondly, the experience of the caregiver's part of the test, and lastly, some ending questions with a more holistic perspective of the entire system, such as the integrity perspective of the care recipient, the value provided by the system as well as any additional thoughts from the participant of the test.

Once the evaluation was finished the test session was completed and the system and its components were reset to default values and prepared for the coming test (see Appendix A for details).

4.4 Result

In the following section the result data of the user testing is presented. The different parts of the test and methods of the data gathering that were utilized during the test process will have their own subsections with their corresponding results. For further analysis and discussion about the test results see section 5.3.2.

4.4.1 Target Group Survey

The initial data that was gathered before the actual test session was the one from the target group survey. A link to the survey was sent out by mail to a few departments of the technology company that supported the master's thesis. Not all of the answers of the survey was included into the result, only the data related to the individuals who participated in the test. The gathered data of the individuals that did not participate in the test was ignored.

Further, the data collected from the target group survey is both subjective and quantitative in its nature, due to the variety of different types of questions being either scale-based or yes/no questions. The answers of the survey showed that the majority of the participants were in the requested age span, being 55-65 years old or older (see figure 4.2). As some of the participants were not in the requested age group the average age of the participants was 50 years old. A majority of the participants also had some sort of indirect experience of home care (see figure 4.3), however, none of the participants had any direct experience from working in home care. Furthermore, the group of participants consisted of eight males and two females. Every participant in the group had some technical background, either educational or professional. Lastly, most participants also considered themselves to be technically experienced, as the majority of the group rated their own technical knowledge to be 8 or above on the 10-point rating scale (see figure 4.4)

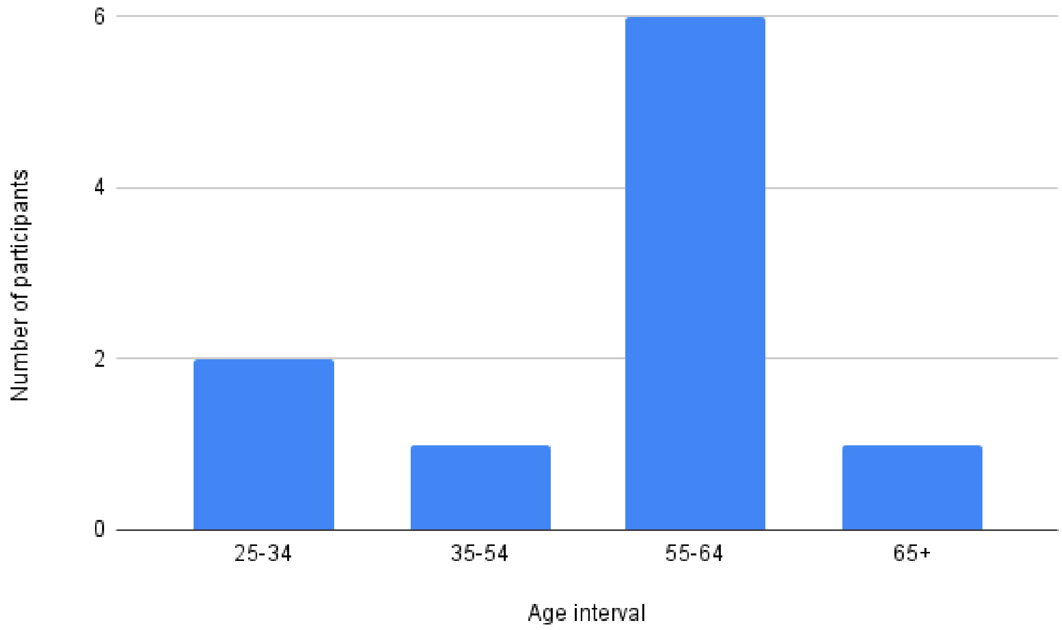

Figure 4.2: Diagram where each column represents the number of test participants in each age interval. The data was gathered from the target group survey.

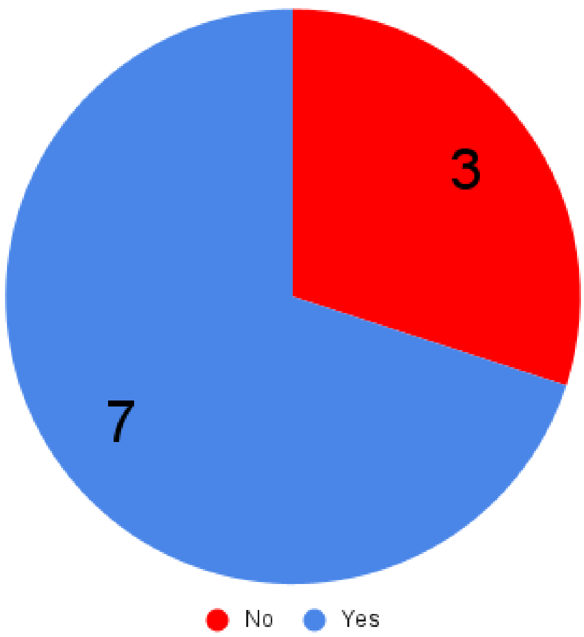

Figure 4.3: Diagram representing the number of test participants with relatives utilizing home care services. The data was gathered from the target group survey.

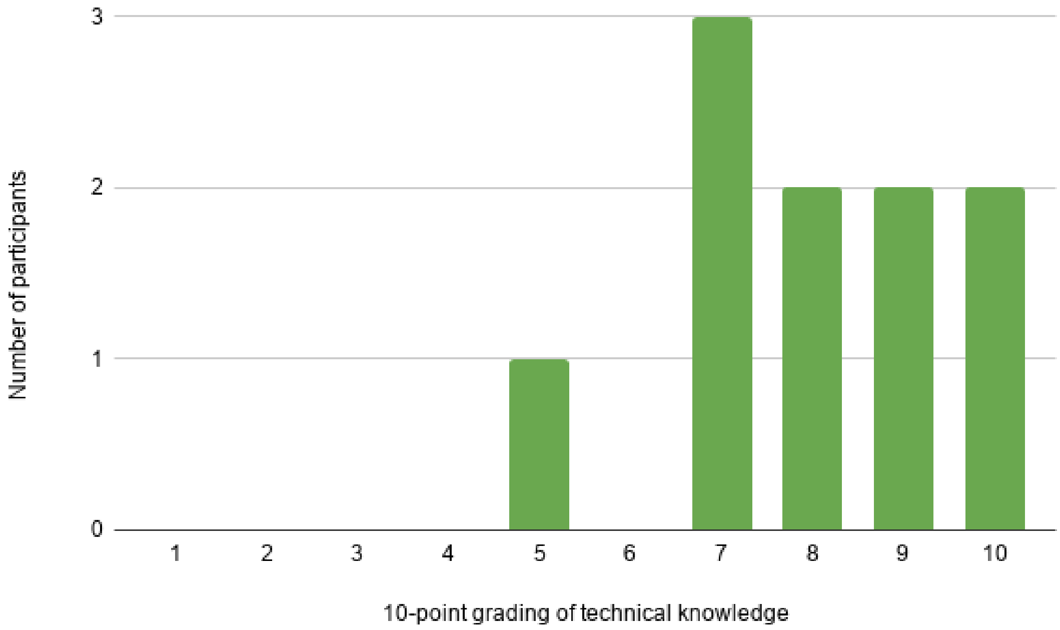

Figure 4.4: Diagram representing the participants self-estimated 10-point rating of their technical knowledge. The data was gathered from the target group survey.

4.4.2 Test Tasks

The data gathered from the test tasks was a combination of subjective/quantitative and objective/qualitative data. The first category consists of the measured time of each test task (see table 4.1) and the second part the gathered observations. The observations are in turn split up into two segments, representing the two parts of the test tasks. The notations in the results uses the form *T.x.y* to identify the specific task, where *T* stands for "Task", *x* for either "1" or "2", representing the first or the second part of the test, and *y* the specific task within each part. Furthermore, a specific participant is labeled as *TP*, as notation for "Test Participant".

Table 4.1: This table contains the measured task time of each participant, minute:second. The left column represents the numeric value of each test participant (TP). The upper row contains the task notations. The format of the task notations is described above.

TP\Task	**T.1.1**	**T.1.2**	**T.1.3**	**T.1.4**	**T.1.5**	**T.2.1**	**T.2.2**	**T.2.3**
1	1:13	2:05	1:32	1:15	0:47	2:26	2:07	1:32
2	0:46	1:48	1:49	0:43	0:35	3:03	1:36	2:17
3	2:04	2:39	2:24	1:46	1:57	4:02	2:35	2:57
4	0:43	2:48	1:33	0:56	0:59	2:52	2:34	2:55
5	1:46	3:03	1:39	1:50	1:46	3:33	1:23	3:12
6	1:07	2:25	1:34	1:25	1:37	4:07	1:58	1:43
7	0:36	2:33	2:20	2:36	1:28	1:34	2:38	2:28
8	2:04	1:39	2:02	1:53	1:06	2:39	2:57	3:02
9	1:37	2:18	1:37	0:48	0:34	2:35	3:23	1:46
10	1:04	2:37	1:14	1:47	1:23	2:07	2:36	1:23

Table 4.2: The columns contain the min, max and average task time, minute:second. By combining all the task time values for each participants these values were generated.

Task	**T.1.1**	**T.1.2**	**T.1.3**	**T.1.4**	**T.1.5**	**T.2.1**	**T.2.2**	**T.2.3**
Min	0:36	1:39	1:14	0:43	0:34	1:34	1:23	1:23
Max	2:04	3:03	2:24	2:36	1:57	4:07	3:23	3:12
Average	**1:18**	**2:30**	**1:46**	**1:30**	**1:13**	**2:54**	**2:23**	**2:20**

Table 4.3: Various task observations. The left column contains observations from the first five tasks of the test, and the right column contains observations from the last three test tasks of the test.

T.1.1 - T.1.5	T.2.1 - T.2.3
Four TPs expressed or displayed some concerns regarding interaction with the touch screen. Three TPs in this group were convinced that their relatives with home care would have difficulties with interacting with the tablet.	Three of the TPs expressed that the information presented about the care recipient was incomplete, which made it hard to make well-founded decisions.
Two of the TPs thought that their caregiver would be able to give them technical support. They tried to contact the caregiver with technical questions through the alert function.	Two of the TPs mentioned that they had difficulties with getting an overview of the care recipient's current state.
Three of the TPs expressed that they thought the given information regarding their caregiver was insufficient. One TP in this group mentioned that they would have liked to be able to take part of the information that the caregiver had access to to be able to feel secure.	One of the TPs thought that it was hard to get to know the caregiver only by the information presented on the screen.
Two of the TPs felt like they would need some additional instructions in the user interface.	Three of the TPs were hesitant in sending help to the care recipient as they did not want to waste resources or disturb the care recipient if not absolutely necessary.
Four of the TPs expressed that they were unsure about what features were controlled by voice.	Two of the TPs expressed frustration related to not being able to call the care recipient when the care recipient had the "silent mode" activated.
Two of the TPs vocally expressed some concerns related to the amount of available configurations and what kind of problems that could result in if the user is lacking cognitive abilities.	One of the TPs expressed that the information regarding breathing and blood pressure was lacking.

4.4.3 System Usability Scale

The data from the SUS questionnaire belongs to the subjective/quantitative data category. Each SUS questionnaire answered represents the holistic experience of the implementation that was tested. Each participant answered one questionnaire after finishing the caregiver tasks and the care recipient tasks. Adding every individual SUS score together and dividing by the number of participants resulted in an average SUS score of *72*. All the questions of the SUS questionnaire can be found in Appendix A.

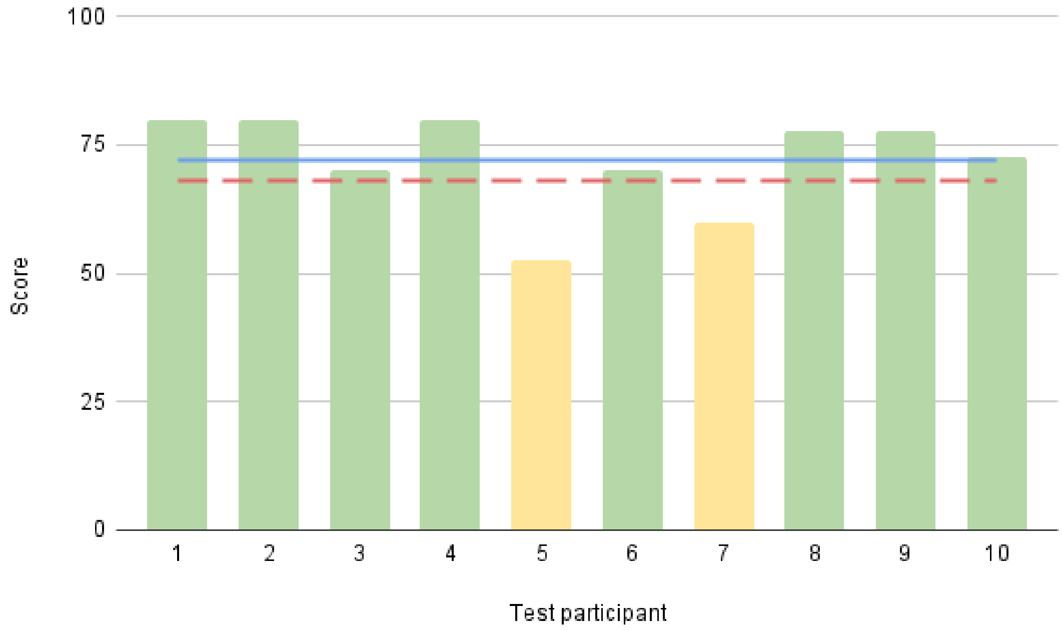

Figure 4.5: Representation of individual SUS score. The upper blue horizontal line represents the compiled SUS score of the final user test, being *72*. The lower red horizontal dotted line represents the SUS score of *68*, which is considered the average value of SUS (see section 2.1.11).

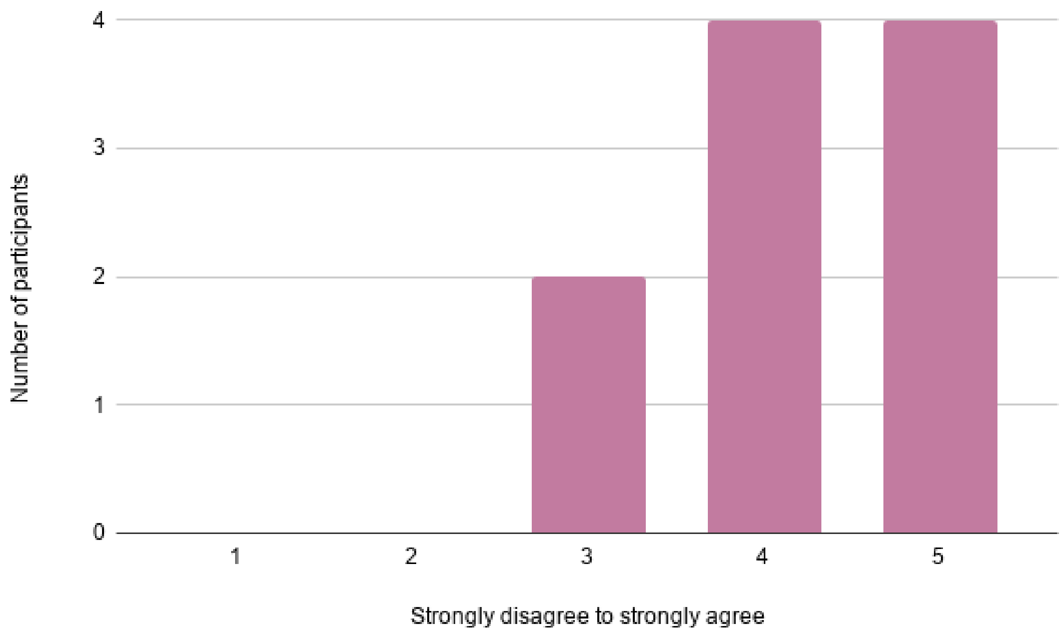

Figure 4.6: 5-point rating. Question four of the SUS questionnaire, *"I would imagine that most people would learn to use this system very quickly"*. The question is seen as particularly relevant due to the intended group of end users having varied prerequisites.

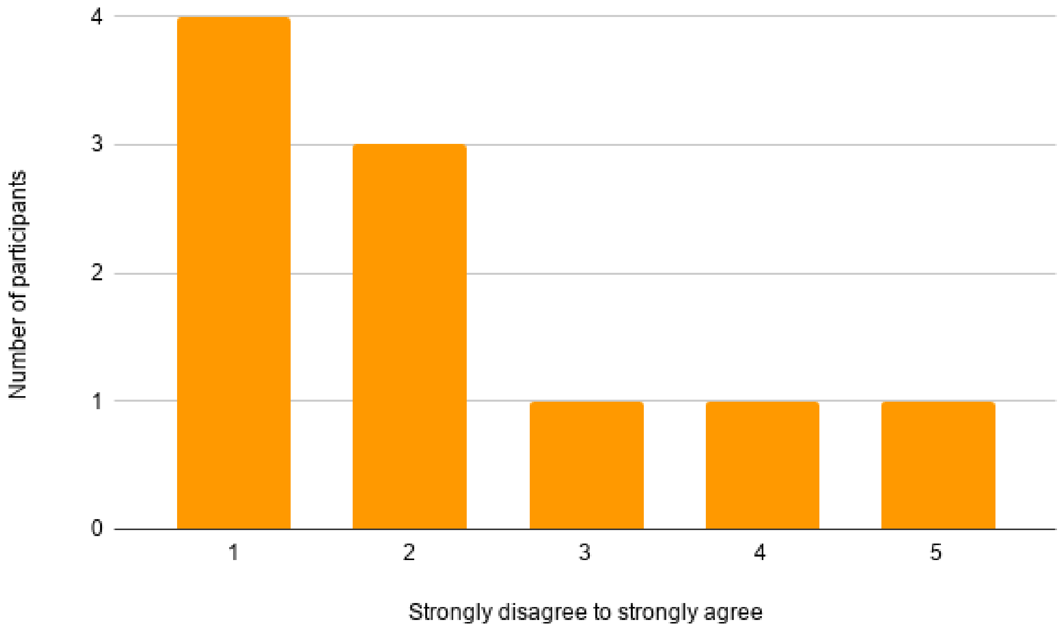

Figure 4.7: Representation of 5-point rating. Answer to question ten of the SUS questionnaire, *"I think that I would need the support of a technical person to be able to use this system"*. Due to the importance of users being able to interact with the system independently this specific question was prioritized.

4.4.4 Interview

The data presented in this section was gathered through the closing interview at the end of each user test. The data category in this case is subjective/qualitative data. In the following section, paraphrases gathered from the interviews three parts will be presented.

The data below is divided into three bullet point lists, as to correspond to the three parts of the interview. The first list summarizes the answers regarding the care recipient perspective of the test. The second list summarizes the answers regarding the caregiver perspective of the test. Lastly, the final list summarizes the answers to the last and more holistic questions of the interview, regarding the integrity perspective of the care recipient, the value provided by the system as well as additional thoughts from the participants of the test. For further details about the specific questions of the interview, see the test plan in Appendix A.

The care recipient perspective

- *To be able to get the full benefit of the solution the system provided, it would be nice with some additional configuration options related to the camera supervision. The care recipient must be able to know if someone is watching them in their home and what data this person watching has access to.*
- *Enabling multiple ways of triggering the alarm functionality would benefit the care recipient*

from a security perspective. A physical button would perhaps be suitable for an older person, to minimize the number of steps in an urgent situation in regards to navigating on the tablet's GUI. In addition to that, it would be nice to be able to call an ambulance directly through the system, instead of having to proceed via the home care.

- *There were some flaws in the user interface. Due to the placement of the alarm button (that being the "Home" tab) it is very likely that someone will alarm the caregiver by mistake, when they for instance simply want to change the light settings. The system should also be configured out of the box as it is too risky to offer this level of configuration to the user, especially if the user is an older person with limited technical experience.*
- *The level of integrity and the level of urgency correlated well in the solution provided by the system. Utilizing the radar technology for detecting room presence and falls is convenient from an integrity perspective compared to a camera.*
- *Older people may have impaired memory. It may be very important for them to be reminded about who is going to visit them or supervise them. This can perhaps be achieved by sharing a video stream of the caregiver during calls, such as when the care recipient alarms the home care. In case of an emergency, the older person must also know that help is on the way and preferably when it will arrive.*

The caregiver perspective

- *The caregiver must know how the care recipient has configured their system in advance. For example, both the caregiver and the care recipient must be able to tell when the cameras are turned on or off. In an urgent situation the caregiver must be sure about how to contact the care recipient. Perhaps there could be a possibility to override the care recipients settings of "silent mode" if it's deemed necessary in order to provide the most sufficient help.*
- *From the caregiver perspective, perhaps it should not be this easy to configure the system as a care recipient. There is a risk that the "silent mode" will be very frustrating for the caregiver. There is also a safety perspective related to this. If the caregiver is not able to contact the care recipient there must be an integrated option to at least contact a relative of the care recipient.*
- *There is a risk that the caregiver will get lost in all the information presented on their screen. The vital information must be easy to access through the system, i.e. blood pressure and heart rate. Also, information about the latest visit from the home care to the care recipient would be beneficial to have easy access to.*

Other thoughts

- *The thought of having cameras in every room of the home is unpleasant. From an integrity perspective it is good that the camera is only used in special cases and acute situations. The radar is not experienced as intrusive as a camera.*
- *It would be better to have radars in the home instead of having caregivers visiting three times a day. Perhaps it would be possible to create the same level of security without home care being involved at all or to a minimum extent.*
- *One major benefit of the system is that the caregivers will be able to help and supervise multiple care recipients at the same time.*

- *It would be nice to chit chat with the caregiver via the system, without calling for an alarm.*
- *Talking to a person while visiting the bathroom is not so pleasant. But in a situation where you need acute assistance and help, integrity is not the top priority.*
- *The system experience needs to be more personalized. Personal questions and reminders would probably increase the care recipient's relation to the system. Only utilizing a big speaker for auditory feedback from the system could possibly be a bit spooky. No one wants to feel like "Big brother is watching you".*
- *A potential user can feel safe as long as instant feedback results in instant decision making. The system provided an increased sense of security without any direct disturbance.*

Chapter 5
Discussion

In this section the different parts of the thesis are discussed. This includes the experiences from having an interaction design process and iterative approach, the obstacles and opportunities of the home care visits scenario and the interpretation of the results from the final user test with the nightly supervision scenario. Lastly, a broader view and ideas for future work are presented and discussed.

5.1 Discussion About the Design Process

5.1.1 The Technical Domain

Although the design process in chapter 3 presents a seemingly straightforward approach and somewhat smooth transition between each of the iterations, in reality, the work in each iteration was marked by both great uncertainty and several sidetracks, specifically within the technical domain of the thesis. Since, there was no prior experience of working in the Node-RED environment, making the last stages of the final implementation a reality, a lot of time and effort had to be put in between and within the iterations in order to facilitate the implementation. This included setting up a desired system architecture with a network for integration (section 3.5.1), getting familiar with the different IoT devices (section 2.2) and how they could be both found and used by the Home Assistant software as well as understanding the logic of the nodes and how to structure the flows most effectively in Node-RED. Furthermore, the different IoT devices had their own pros and cons in regards to integration and implementation. For instance, the Axis devices, such as network camera and speaker, were very straightforward to use and only had to be plugged in via a POE switch to be visible for Home Assistant. These devices also had a lot of entities that could be monitored and changed in Node-RED and the functionality was easily accessed via their designated APIs. In comparison, the Vayyar Home radar was more difficult to integrate as it required an API set-up in Amazon Web Services (AWS). In detail, the messages from the radar were put in a

Simple Queue Service (SQS) queue that first had to be polled with a GET-request in Node-RED, and then deleted in order to make room for the next message. The previous thesis from Amanda Westin and Fiona Hay [38] had also utilized the Vayyar Home radar, however, only conceptually. Thus, the procedure of integrating this device with Node-RED had to be discovered in the thesis. Fortunately, a lot of technical assistance was offered from supervisors and from resources online, specifically from guides that went through the integration in Home Assistant and Node-RED for most of the IoT devices used in the system.

Also, worth adding is that some of the technical devices that were investigated and at times integrated in the system, were not part of the final prototype. Specifically, the network video door station (figure 2.2) was part of the home care visits scenario but not the nightly supervision scenario, as the prototype was based on. Additionally, the PIR sensor (present on both the video door station and the network speaker, figure 2.5) was not used in the final prototype. There were ideas of integrating that functionality as a part of exiting the "absent-notification" the system would give if a care recipient was absent from the bedroom for more than 30 minutes. However, for purposes of streamlining the test, this was not included.

In summary, the work of the thesis contained a lot of technical understanding. If this understanding had been acquired before the thesis was conducted, then of course more time and effort could have been put into the actual implementation. However, the gathering of technical domain knowledge permeated the thesis during all the iterations and made it possible to have a more straightforward approach once the final prototype had to be implemented. In contrast, if all the technical training would have been placed just prior to the implementation, the iterated scenarios would have likely been less anchored in what is technically feasible. This would have probably made the entire implementation stage more difficult and ambiguous and resulted in a weaker prototype with more dummy solutions than real functionalities.

5.1.2 Thoughts About the Iterations

The three phases of the interaction design process were familiar to us from prior courses in education and thus selected as the main methodology in the thesis for developing the selected scenarios. The advantages of iterating through these phases meant that the work could cover both broad and narrow perspectives. By initially having a conceptual approach, less focus was put into not yet defined details as to cover more comprehensive problems and solutions within the context of the scenarios and the thesis. Here the method of bodystorming came well into place as it helped us get a feel for what could be desirable interactions. By further processing the concepts into a step-by-step manual for each of the scenarios, the interaction flow could gradually be outlined. Having personas in this phase of processing the scenarios was extremely valuable as they acted as a form of reference point in order to check that their needs and desires were met, but also that their frustrations and problems were addressed. Lastly, the detailing phase and the realization of the scenarios, were accomplished by creating video prototypes. This was a quick and easy way of prototyping as it allowed the scenarios to take a sort of physical presence, not really possible by merely written step-by-step manuals or sketches. The video prototypes were further useful as they allowed us to get feedback remotely via online interviews, such as home care workers and elderly people, without them having to visit us and evaluate a physical demonstration. In contrast, if each detailing phase instead would have focused on having an implemented scenario and the interviews were replaced by actual user tests, more time would have to be put into prototyping. This would have probably been way too time consuming, especially if implemented parts of the system had to be scrapped. In the case of video prototypes, a new clip of the potential functionality only had to be recorded again and then new feedback could be gathered for the coming scenario, hence, directing more time and effort into solving the problems on a scenario-level than having to combat implementation issues along the way.

As a last part of the third phase and the three iterations, interviews were held with three different stakeholders of the system to evaluate the video prototypes created. These three layers of stakeholders consisted of municipalities and researchers, home care workers and coordinators, and also individuals in the age of 60-76 years, deemed as potential future users of the system. This choice of interviewees was in a way also characterized by the interaction design process, by firstly going conceptual and broad (almost a bit visionary) with the municipalities and researchers in the first iteration. Then, processing the scenarios in more detail, going into the daily challenges and opportunities with the home care workers and coordinators in the second iteration. Then, lastly, detailing further with potential future users of the system gave us hands-on feedback on the solution presented in the third and last iteration.

5.1.3 The Agile Influence

The process of interaction design, with its three phases, was also influenced by the agile methodology in the thesis (see section 2.1.4). Specifically, by having weekly sprint meetings with the supervisors from the technology company. These meetings basically spanned the entire thesis work and were great for a number of reasons. Obviously it helped the supervisors getting a notion of the direction of the thesis and gave them the possibility to aid us with their expertise and domain knowledge. However, more importantly, having weekly sprint meetings forced us to have a goal each week and a well thought out plan, together with a motivation behind it. This definitely helped the process since early hinders could be identified and solved as soon as possible.

Sprint meetings, in their nature, are meant to be quick and hands-on meetings with a solution-oriented perspective [19]. Although the majority of the sprint meeting in the thesis was around 15 minutes and kept around the content of the three questions (see section 3.1.2 for more details), the meetings occasionally drifted towards discussions and more brainstorming-alike sessions that lasted for up to an hour. These discussions were however needed at the point of time to further deep dive into technical issues or scenario-related speculations. In summary, the structure of the weekly sprint meetings was sometimes circumvented for the benefit of the thesis.

5.2 Home Care Visits Scenario

5.2.1 Layers of Interaction

The system that is conceptualized and prototyped in the home care visits scenario had in a certain sense two ways of input and two ways of output to the system. These different inputs and outputs could in turn be grouped in different layers, appropriate for different types of care recipients, depending on their cognitive capability, needs and wants. In detail, the first input to the system was voice commands from the care recipient, the second, GUI interaction with a tablet. Furthermore, the first output was auditory feedback from a speaker, the second, notifications on the tablet's GUI. The most basic layers of interaction, regarding these inputs and outputs of the system, would probably be the auditory feedback from the speaker. The purpose of this feedback was to give the care recipient a notification when, for instance, a visit from the home care was scheduled, delayed or changed. Having auditory feedback mainly puts the requirement of adequate hearing in regards to cognitive capabilities. Further, the output produced by the GUI (with the same purpose as the speaker), has several cognitive requirements, such as sufficient sight and hearing to see and understand the notifications on the tablet. This in turn makes the interaction more complex. However, the inputs to the system puts even more cognitive requirements on the care recipient. Having voice command directly requires a loud and clear voice but also indirectly sufficient hearing, as the system would probably produce some sort of auditory feedback in response to the voice command uttered. Also, the input to the tablet's GUI would demand the care recipient having touch-based precision with their hands and fingers when, for instance, booking and canceling visits.

Apart from the cognitive requirements of these inputs and outputs, different integrity-related aspects could also be taken into account. For instance, how a loudspeaker, giving you notifications, would affect your everyday life, or having a tablet, consistently giving updates and notifications about the caregiver's activities. As a care recipient you would probably not want to be constantly reminded of your home care services, especially not when having relatives visiting you. As investigated in the thesis by Robin Bengtsson [9], creating, designing and placing devices that fits in a home environment, without being intrusive, is key in order to maintain an integrity-based solution. A continuous study of integrity-based solutions, requiring different cognitive abilities of interaction, would be interesting within this area.

In summary, the home care visits scenario could be split up into different layers of interaction depending on the cognitive capabilities of the care recipient. These layers consist of the different inputs and outputs of the system, where the most basic layers of interaction would yield the auditory feedback about scheduled visits from the home care, if they are delayed and alike. Additional layers, demanding more cognitive requirements but also more control, would be GUI-output, voice command input and GUI-input. Also, having the integrity aspects present, when for instance creating, designing and placing the devices, is an interesting area for future study.

5.2.2 Process Obstacles

The home care visits scenario was more or less given equal attention as the nightly supervision up until the end of the second iteration of the design process. The scenario was not abandoned here in regards to being deemed unwanted or invaluable, but was instead paused as to give more time and effort for the technical implementation of the nightly supervision scenario. The initial idea when this was decided was to return to the home care visits scenario after the final user test of the nightly supervision scenario to investigate it further and potentially develop another video prototype. Unfortunately, this was not possible to the extent that was first suggested as the implementation, testing and evaluation of the nightly supervision scenario occupied the majority of the remaining time of the thesis. As a form of redemption for the home care visits scenario, a deeper analysis and discussion of the process and future development was done, as presented in this section.

As briefly described in section 3.4.1, the further development of the home care visits was paused because of two main reasons. Firstly, the infrastructural challenges uncovered after the interviews with municipalities and home care workers in regards to managing the staff and providing care to already full schedules, was something that made the scenario less realistic to use in the Swedish context. Giving the care recipients the possibility to book visits at will would overload the organisation as it is structured today. Even the parts of giving the care recipient more insights into who was visiting from the home care and if they were delayed, were viewed as desirable but unrealistic features of the system. Hypothetically, it is easy to assume that more control and insights for the care recipient is a good thing by default, and it is further comfortable to disregard these functionalities for the organisational challenges connected to them. On the other hand, just having "care recipients" as one lumped group of individuals is by far an inaccurate representation of the reality, although it is comfortable to assume. Consequently, the assumption that all care recipients would want more insights and control of their home care is as true as stating that all caregivers are by default caring and supportive of their respective care recipients. These assumptions may hold true given a small enough sample, however, they are not especially accurate nor helpful when investigating better ways of integrating technology in the home care to save resources, make it more secure and less intrusive. As a response to this, the home care visits scenario was partially investigated from a difficult starting point in the thesis. Starting with the municipalities and home care workers, as feedback generating sources, permeated the scenario with the organisational challenges from the start which was difficult to ignore as the scenario was initially developed. Thus, starting with the care recipient in mind, and all the variants they unfold, would probably have given the scenario a different and perhaps more grounded perspective in regards to solving issues of social needs among the care recipients, in contrast to the efficiency perspective of saving resources the scenario was initially marked by. This could have further been investigated by having interviews with older people about the home care visits scenario. This was not chosen because of the time and effort it required to implement and test the nightly supervision scenario. However, it would have been interesting to have the older people's perspective that was not biased by the infrastructural and organisational challenges that the interviews with the municipalities and home care to a large extent expressed as the main concern.

The second reason for not continuing with an implementation of the home care visits scenario was the technical difficulties regarding voice control and GUI integration, as further described in section 3.4.1. However, another reason was that the scenario posed a more limited IoT integration of different devices as opposed to the nightly supervision. Integrating several IoT devices into a system and demonstration that provided a unique combination of functionalities was an expectation communicated at start from the technology company. This expectation was permeating the home care visits scenario as it was deemed by us as less interesting from a technical viewpoint in comparison to the nightly supervision scenario. Specifically, the scenario had limited camera and radar functionality and leaned more towards solving GUI challenges which was not deemed as interesting as connecting and integrating several IoT devices in a new way.

5.2.3 Opportunities with the Scenario

From a holistic outlook, this thesis on the home care visits was in a way an entirely new perspective of what home care means, for all parties involved. Everything from how older people with home care are labeled, like "users", "patients" or "care recipients" (as the term that is being used in this thesis), to the way home care is distributed, planned and tightly scheduled, speaks of a home care where the older person is passive in the interplay of care recipient och caregiver. The care recipient could almost be seen as being trapped in the designated care they are granted by the home care.

This scenario was in a way flipping the tables by giving the care recipient back control over their visits and care. In the Swedish home care context (given the selection of municipalities that was made), the video prototypes were applauded but more as a theatrical play than a real user case. The organisational challenges are too difficult to ignore. However, this leads to another question: *What about home care contexts that are not as tightly administered and whose idea is to give the care recipient more control?* This is where American examples in Florida of private solutions and centres for assisted and senior living could be interesting. Only the surface of this was scratched but the lessons uncovered that the viewpoint in those cases are quite different in comparison to the Swedish. For instance, in some American assisted living facilities (or senior living facilities as they are also called), the care recipients are seen more as customers and each facility has a motive of attracting customers to their service. Either the customer is made up of relatives to the older person, or the older person is deciding on their own that they want assisted living. A motive behind this could for instance be the social value of not having to live alone. In turn, this puts pressure on the assisted living centres to display and attract the benefits of their particular accommodation. In what sense this compromises the quality of the actual care is unclear, however, attracting customers (care recipients) by showcasing the control they would exercise and insights they would get in their own care would seemingly be attractive arguments, thus this scenario of home care visits could very well fit into that context.

5.3 Nightly Supervision Scenario

5.3.1 Layers of Interaction

The nightly supervision scenario differs from the home care visits scenario in a couple of ways. Firstly, the scenario offers more automation. Less decision-making and interaction is needed from the care recipient's part, which makes it more suitable for older people that do not wish to be more involved in their care, or lack the motivation or capability to do so. Additionally, the parts of detecting falls and deviating movements could very well fit care recipients not covered by the personas, for instance, care recipients with some form of dementia or other severe cognitive impairments. These functionalities do not require decision- or precision-based interaction with the system, unlike the parts of customizing the system via a tablet or responding to voice feedback. Hence, the system implemented for nightly supervision could be specified further in different layers, depending on the older person in mind. The basic layers could be made up of little to non-interaction-demanding functionality, such as a system that detects falls, deviating movements, unusual absence and alarms the home care automatically. Further, additional layers could include voice control and customization options for more control and insights, with respect to the older person's needs and wants when it comes to their nightly supervision.

Secondly, the scenario for nightly supervision was also taking the caregivers part of interaction into account. How and when the home care should be notified about the actions and conditions of the care recipient gave the scenario a whole new dimension. This led to questions about the integrity of the care recipient. For instance, *how much insight and control should be given to a caregiver supervising during the night?* As more information given about a specific nightly situation would probably entail more well-founded decisions from the caregivers part, there is also the perspective of not having to engage with the system if not absolutely necessary, as to decrease the demand of the home care but also the pressure on the older people. Furthermore, time aspects are also relevant. A care recipient just visiting the bathroom during the night is, in a short time frame, probably not as interesting as if this was the fifth time during the same night, especially if repeated over a longer time frame of several days. Consequently, a care recipient might not enjoy having every bathroom visit supervised, though would perhaps approve if the system could notice unusual behaviour given a longer time frame. All this requires the system to make decisions based on the needs of both a care recipient and a caregiver. Moreover, since the scenario was developed with both these needs in mind, an obstacle in the design process was to take both these into account. Therefore, a more comprehensive study of each dimension would be necessary in order to uncover their individual preferences and interplay in the system.

In summary, this scenario has the opportunity to be further specified and adopted to fit a larger user base, made up of older people with varying needs, frustrations, prerequisites and challenges. Also, taking the caregivers perspective and interplay with the care recipient and the system into account, there is room for further investigations into the contexts and interactive situations in the area of nightly supervision.

5.3.2 Test Results

In this section, the results of the final user test of the system implementation for nightly supervision will be discussed. Firstly, the gathered data from each part of the test will be analyzed and discussed. In addition to that, some potential sources of error will be presented.

Interacting with the System

Looking further into the process of testing, there were some key aspects that might have affected the layout of the test. Firstly, the group of potential test participants were limited to a certain group of employees. To be able to get a certain level of experience based evaluation, a few soft requirements were set in the participants booking process. For example, it was desirable that the participants had some previous experience of home care. This could either be working hands on in the field or having a relative with home care support. The idea was that the experience from this service would provide a better foundation to be able to evaluate the system that was tested. At the same time, this requirement did most likely limit the number of individuals that were suitable for participating in the test. The second main attribute that was desired was that the participants should preferably be in the upper age range of adulthood, to get a better understanding of their potential technical proficiency.

Furthermore, two of the participants of the test were pilot testers. Due to successful pilot tests, the results of these were included into the result data. In a case where the process of pilot testing was flawed, the results would not have been included into the result data. In addition to the two pilot tests, there were in total eight individuals that tested the system.

Comparing the desired attributes of the test participants to the outcome there were some noteworthy aspects. For instance, none of the participants had any hands-on experience with home care work. With a set desire of gathering participants with this type of service experience, the outcome was of course not successful in that aspect. Worth mentioning is that 70% of the participants had some kind of experience of having a close relative utilizing home care services. With that in mind, the clear majority of the group of test participants most likely had some basic knowledge within the service field. In a best case scenario, the participants would have had hands-on experience of home care services. This aspect will be further discussed in an upcoming section.

In the act of testing the system, some interesting observations were made. Generally, the test participants were able to interact with the system in a natural manner. Looking at the measured task time, there were no significant outliers, as presented in table 4.1. In the first segment of test tasks, there were some recurrent comments. First off, as four of the test participants expressed some kind of concern regarding the interaction with the touch screen this can be seen as a potential critical flaw of interaction. As a few of the participants mentioned that they had their older relatives in mind during and after going through the test tasks, some of the comments were most likely expressed with the relatives taken into account. Based on the observations, the concerns regarding the touch screen were either related to the fact that some participants took their relatives into account or that some of the older test participants had difficulties interacting with the touch screen. Looking at the older people of today, the technical experience of touch screens may be limited. As touch-based user interfaces are common today, this way of interaction will most likely be more natural for older people in a few decades. At the same time, there can be some physical aspects to take into account when selecting the variations of system interaction. In addition to that, many of the comments that were made during the test phase were related to how and what information was presented for the participant. Both in the role of a caregiver and care recipient, a few test participants expressed that they had difficulties with going through test tasks due to lack of information. In a situation like this, where every participant is a first-time user, there is of course a lot to learn about the system. Ideally, the user interface should be intuitive right out of the box, but to be able to fulfill that goal, the information presented for the user must be well thought through. By testing a product in an iterative manner, there is an opportunity to identify where the solution lacks in presentation of information which opens up an opportunity to potentially improve the product before the next iteration of testing.

In addition to the system that was being tested, it can be valuable to analyze the manner the test was conducted in. The test tasks that the test participants solved were initially defined with the goal of identifying potential flaws. Some tasks were based on situations where the test participant was limited by the system, for instance, not being able to make a call due to the counterparts configurations of "silent mode". One advantage of this approach was that the test participants got an opportunity to experience some potential use cases that perhaps are not so common. Worth mentioning is that some test participants expressed that they would have enjoyed experiencing a few more common scenarios. Focusing on the common scenarios is perhaps a good method if the goal is to give the test participants a holistic everyday perspective of the system. Giving the test participants an opportunity to experience unique scenarios might be better to identify defects that are not obvious at first glance.

The SUS Evaluation

After the test participants were done solving the given test tasks, the process of evaluation began. The first step of evaluation was filling out a SUS questionnaire. The test participants were able to rate their first experience of the system with a 5-point scale. Looking at the result from the SUS questionnaire, the average score was *72* which can be seen as good, since it exceeded the general average SUS score of *68* (See Section 4.4.3). With the concept of the SUS questionnaire taken into account, this average score in this case suggests that the test participants thought that the user experience was good. Even though the average score was good, there were some outliers. Test participant number five and seven both gave the system a score that is below average. Both these individuals ranked their technical knowledge a bit lower than the majority of the group, being a score of five and seven on the 10-point scale presented in the target group survey. With that information taken into account, their perspective of their technical knowledge can affect their attitude to technical solutions. Further, a pair of the test participants gave the system a lower score. This is worth taking into account as it shows that not all test participants enjoyed the user experience, which one can believe only looking at the average score. Of course, these are subjective ratings of the system. Aspects like social norms and lack of experience of similar products can of course affect the score. A good score can be seen as an indication that the experience of the system user is somewhat positive, but most likely it does not imply that the system is fully developed. Another aspect related to the score is that the test participants tested two different client interfaces of the system, but only filled out one SUS questionnaire. Since the selected method was to evaluate the system from an holistic perspective, the single SUS questionnaire per test may not have been such a big problem. In an alternative case where the goal was to evaluate each part of the system separately, one single SUS questionnaire per test session would probably be limiting.

Interviewing the Participants

The final step of evaluation was the interview. The questions that were asked were all open-ended, meaning that they had no predefined answers. The benefit of asking these types of questions is that it opens up for more detailed answers and deeper reflections. One potential drawback that was identified during the test sessions was that open questions tend to make the interviewees drift away from the subject and express sometimes irrelevant feedback.

Furthermore, looking at the answers that were given during the interviews, there were some common parts of home care mentioned. Starting with the configuration of the system, the opinions were divided. Some of the test participants thought that the system should have been ready to use out of the box and that the user should not need to configure it. At the same time, a few thought there should be even more available settings. In addition to this, there were also split opinions about who would be most suited for configuring the system. Some thought that the home care staff should take care of it and a few others thought that relatives should be in charge of that part. Looking at a product market, there will always be users with different desires and requirements. The end goal is to satisfy the intended user to the highest degree, in this case, being the older person in need of such a system. Furthermore, many of the test participants expressed that they enjoyed that the system included multiple alternatives for interaction. The main argument behind this was due to potential physical and cognitive variations of the intended end user. Even though these alternatives were available, a few of the test participants expressed that it would be great to include a few more alternatives for interaction. One desired functionality was a physical button for alarming the home care, as a few expressed that the touch screen can be seen as problematic during an emergency.

Looking into the technical devices that were part of the supervision, a few of the test participants expressed that they believed that the radar was suitable for home environments. Also, it was mentioned that cameras can be seen as intimidating in a home environment and that they should only be utilized in emergency cases. A couple of test participants mentioned that they appreciated the concept of camera supervision not being available at all times. With that in mind, there were also a few of the test participants that expressed that they believe that security is more important than integrity when you are in need of daily support. This aspect is potentially worth taking into account, and may also justify the use of cameras in home environments to a certain extent.

Sources of Error

Usability testing can provide plenty of valuable data and insights. By creating a reliable environment and designing reasonable tasks, there are plenty of opportunities to identify potential flaws. Even though the benefits can be substantial, there will always be some kind of sources of error to consider.

In this specific test scenario, there were plenty of potential sources of error. To start off, the participants did not represent the end users fully. Due to the ongoing pandemic restrictions, there were difficulties in testing with care recipients in present need of home care and caregivers. Instead, the participants of the test consisted of employees from the technology company that the thesis was collaborating with. First off, the age factor is one potential source of error. The participants in the conducted test were on average a lot younger than the intended care recipient users, being the personas. An example of one persona can be found in 3.2.1. Comparing the average age of the test participants with selected persona results in an age difference of about 30 years. The reason why this is a potential flaw is because the participants cognitive and physical proficiency, as well as attitude towards technical devices, might not match the personas. In addition to that, the average level of technical skills of the employees might not be representative of the average person, due to the company being part of the technical product industry. Due to these aspects, the participants might have interacted with the system with ease compared to the intended care recipient users. In addition, the lack experience of home care related work can also have affected the result. In the process of going through the test tasks of the caregiver, some important aspects of the daily work may have been neglected due to the lack of work experience within the field.

Further, the second part of the test result might also contain some potential sources of error. Since none of the participants had experience of working in home care, there might have been a lack of understanding of the current workflow in the field. Due to this factor, the participants' evaluation of the home care controlled features of the system might not have been as representative compared to if the participants had experience of working in home care. From another perspective, the goal of the thesis was to find alternative ways for the home care to work and therefore the experience of the current technical solutions might not have been crucial to be able to evaluate a new type of concept.

Another aspect of the testing that can be seen as a potential source of error, is the environment that the test was conducted in. As the test tasks were performed in an office environment, there might have been some interference compared to if they were conducted in a real home environment. One example of this is the camera that was mounted in the test environment. A camera in an office environment might be more natural than a camera in an actual bedroom. In addition to that, the participants were accompanied by the test leader and observer during the whole process. Having observers present while going through test tasks might interfere with the natural habits, and perhaps some of the participants held back on acting and commenting due to this.

Further, looking at the technical equipment, there might have been some potential result interference. Every test task involved some type of interaction with technical devices. The technical experiences of the participants of these devices were not identical. Due to this, there might have been some inequalities in the process of interacting with the devices.

Another source of error was the SUS questionnaire. The potential error was not related to the questions in the questionnaire, but the manner in which the questionnaire was utilized may not have been optimal. The reason why this aspect could be questioned is that the participants filled out one SUS questionnaire after testing two parts of the system. Even though it was the same system that was being tested, the different parts of the system were designed for different users in mind, namely a care recipient and a caregiver. This holistic approach may have resulted in some confusion as the participants had to combine their experience from both parts into one answer. There is also a possibility that the test participants had less struggle with interaction with the system during the second part of the test, as they already had some knowledge of the system features from the first part.

5.4 Future Work

Looking further into future work within the field or elderly care and interactive technologies, there are some key takeaways from this project that should be taken into consideration. Firstly, looking at home care visits, this scenario possesses many obstacles but also opportunities. For future development of this scenario, it would not be beneficial going forward in the Swedish context. As described earlier in this section, the infrastructural challenges and organisational complexity has to first be investigated and solved in order to facilitate the scenarios potential. American solutions, especially examples of assisted living facilities in Florida, offer a more nuanced context where this scenario could thrive and be developed further. Additionally, it would be interesting to find the use cases for a caregiver in this scenario, as the nightly supervision did. How a caregiver would interact with the system in an interplay with a care recipient, given a home care visits context, would probably be the basis for a master's thesis on its own. In summary, the home care visits, where the care recipient is given more control and insights about their care, are fascinating topics and deserve further investigations in coming theses or projects. This thesis has hopefully laid a foundation and created a starting point for where development of this scenario can continue from.

Furthermore, the nightly supervision scenario, that was physically implemented and tested in this thesis, also offers some potential further work. Looking further into radar technology, and how that kind of technology can contribute to system solutions that offer both security and integrity, is beneficial for use cases involving, for instance, fall detection and room presence. The scenario itself could and should probably be split up in different layers when developed further. Specifically, the different layers of interaction and engagement needed from a care recipient's part, spanning from automatic detection from the system to hands-on interaction with the system. Also, to solely focus on the caregivers part of interaction with the care recipient and the system, deserves a thesis on its own. Another aspect of nightly supervision and alarm solutions is that it can be interesting to look further into how these types of solutions can be independent from home care. Perhaps it is possible to offer the same levels of security and integrity with relatives being involved instead of the home care.

Lastly, the technical aspects of both the scenarios are noted by different ways of interacting with a system in order to assist different needs, cognitive capabilities, but also attitudes and wants of the intended users. For instance, solely relying on voice control would exclude care recipients with impaired hearing or voice and should be supplemented by another way of interacting. As investigated in this thesis, a GUI on a tablet could be an option. However, a more in-depth study of what the requirements such a GUI needs to have, must be explored further. Worth noting is also that a care recipient might desire or not desire to interact and engage with the system and their care, independently of their cognitive capability. Creating and designing GUIs, systems and ways of interaction for older people where the focal point is enhancing the desire to engage and interact, is a dimension that goes away from categorizing older people after their cognitive capability. The problem lies in the system and not the person using it. A system that empowers people to get more integrity, opportunities and freedom should be the main focus when developing technologies for elderly care in the future.

Chapter 6
Conclusions

In regards to the research questions from section 1.2, the conclusion of this master's thesis is as follows:

- **What ways of interaction are possible with current IoT devices?**

The technologies and software investigated and used in the thesis yielded that current IoT devices facilitate interactive GUIs and voice control in order to control and interact with other IoT devices, such as IP cameras, light bulbs and network speakers. Radar technology makes it possible to supervise individuals in a more discrete and accurate manner by monitoring presence and positioning. By using software platforms, such as Home Assistant and Node-RED, these IoT devices could easily be integrated and utilized, creating a system of connected devices that worked together.

- **How can these interactions be designed to fit an older person's needs?**

The needs of older people vary a lot and the interaction with GUIs, voice control and speakers limits the potential users in regards to their cognitive abilities. Cameras are a delicate area and should be used in consideration with the privacy concerns of the older person in mind. Furthermore, radars possess an interesting area of interaction since they offer a less intrusive experience in comparison to cameras.

- **What IoT solutions would decrease the demand of caregivers without compromising the needs of the older person?**

Systems that can provide some sort of remote supervision would arguably decrease the demand for physical visits. However, if an older person is in need of physical care, ways of alarming the home care easily is preferred. Having automatised solutions of, for instance, fall detection, detecting deviating movement patterns and long room absence, without requiring constant supervision (remotely or physical) from home care staff, would decrease the demand of the caregiver and entail less disturbance for the care recipient, especially during the night. Also, giving an older person more control and insights in their potential care is suitable with regards to the older person's needs, given that this is desired by the older person. However, this solution would potentially increase the demand of the caregivers given the current organisational structure of home care in Sweden.

For the specific scenarios chosen and investigated in this thesis, the following in-depth research questions concludes as follows:

- **How can a care recipient be more in control of home care visits?**

By providing a care recipient the possibility to CRUD *(create, read, update, delete)* visits from home care they are given both more control and insights into their provided care. Specifically, this included the possibility for care recipients to be able to book visits (create), get notifications about coming visits and if they were delayed (read), the possibility to reschedule visits (update) and also to cancel visits from home care via the system (delete). The home care visits scenario also touched on the social aspects of older people by giving them access to communicate and schedule visits with other individuals with the same system.

- **How can nightly supervision become more secure for care recipients and less demanding for caregivers?**

Nightly supervision of care recipients can become more secure if the system would be triggered by deviating behaviors and acute situations, such as falls. This leaves the decision-making process in such contexts to the system and would save both resources for the home care and suffering for the care recipients and their relatives. Also, the possibility for care recipients to get instant help and supervision if needed during the night, would further increase the experiences of security and integrity. In addition, having a system that alerts the home care when an action from their part is needed, would decrease their workload. Providing remote supervision is also something that would decrease the overall demand of caregivers, who otherwise would need to physically attend to a care recipient, potentially causing more disturbance than help during a night situation.

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Appendices

Appendix A
Test Plan

TP = Test participant

Purpose, Goals, and Objectives of the Test

The purpose of the testing is to evaluate the system implementation of nightly supervision in a home care context from a usability- and value-creating perspective. The test focuses on two perspectives of the system, both from the perspective of the care recipient and the perspective of the caregiver and the corresponding experiences from these perspectives.

The goal of the testing is to improve the implementation based on analysis of the collected data, as well as getting a better understanding of what desirable functionality a system for nightly supervision in a home care context should have.

Research Questions

- **How is the system experienced from the older person's perspective?**
- **How is the system experienced from the home care staff's perspective?**
- **How is the system perceived from an integrity perspective?**
- **What obstacles arise when interacting with the system?**
- **What are the most valuable functionalities of the system?**

Test Participant's Characteristics

The test will have 6-12 TPs. Due to the ongoing pandemic, TPs are chosen from the technology company the master's thesis is conducted on. A TP is chosen if they fulfilled at least one of the following criteria:

1. **At least 55 years of age**
2. **Experience working in home care and/or nightly supervision of older people**
3. **Having relatives with home care and/or nightly supervision**

Method

To minimize the risk of interfering sources of error the process of testing will consist of predefined steps. In addition to the actual process of collecting data the test will also consist of an introductory stage and concluding evaluation.

Phase	Assignment	Material	Max Time
Preparations	Reset the system to default values.	List of predefined start values	5 min
Before the test	Welcome TP and information about the test. TP fills in target group survey and an consent agreement	target group survey and informed consent	5 min
Tasks	See task table for more information	System implementation and task list	25 min
Evaluation	Scale based survey questions and interview.	System usability scale questionnaire and interview questions	15 min

Target Group Survey

Question	Answer
Email address	*example@mail.com*
Age group	*1. 18-24, 2. 25-34, 3. 35-54, 4.55-64, 5. 65+*
Do you have any experience working in home care?	*1. Yes, 2. No*
If you answered "yes" to the previous question, how long did you work?	*1. < 1 month, 2. 1-5 months, 6-12 months, > 1 year*
Do you have any relatives with home care?	*1. Yes, 2. No*
If you answered "yes" to the previous question, how long have they had home care??	*1. < 1 year, 2. 1-4 years, > 5 years*
How would you rate your own technical knowledge?	*1-10*

Task List

Component	Default value
Timer	*0 minutes*
Counter	*0 times*
Camera supervision	*OFF*
Silent mode	*ON*
Brightness of the lamp (light)	*100%*

The tasks are made up of two parts. In the first part, the TP will act as a *care recipient* and in the second part, the TP will act as a *caregiver*. Thus, each test aims to cover both sides of the interaction with the system, namely the interaction by the care recipient and by the caregiver separately.

Task	Subtasks	Completed state	Time
T.1.1 Caregiver info	1. Take a seat on the bed 2. Activate the tablet 3. Navigate to "Your Caregiver" 4. Read the information	1. TP seated on bed 2. "Your Caregiver" displayed	2 min
T.1.2 Configuration	1. Take a seat on the bed 2. Activate the tablet 3. Navigate to "Settings" 4. Set the counter to 4 6. Set the timer to 30 minutes 7. Turn on camera supervision 8. Turn off silent mode 9. Return to "Home" 10. Turn off the light	1. Light at 0% 2. Counter at 4 3. Timer at 30 minutes 4. "Home" displayed 5. TP seated on bed	5 min
T.1.3 Alert home care	1. Lay down on the bed 2. Await light off 3. Activate the tablet 4. Navigate to "Home" 5. Press the alarm button 6. Wait until answer 7. Say “I need help” 8. Lay down on the bed	1. Lights off 2. TP in bed 3. "Home" displayed	3 min
T.1.4 Bedroom absence	1. Exit the bedroom 2. Wait until the alert goes off 3. Say “Everything is ok” 4. Enter the bedroom	1. Lights on 2. TP standing	3 min
T.1.5 Fall detection	1. Lay down on the floor 2. Wait until the system alert 3. Stay on the floor	1. Lights on 2. TP on the floor	2 min

Task	Subtasks	Completed state	Time
T.2.1 Care recipient info	1. Navigate to "Care Recipient" 2. Read the information	1. "Care Recipient" displayed	2 min
T.2.2 Notifications	1. Navigate to "Overview" 2. Await notifications 3. Hide the notifications 4. Select "Send help"	1. "Overview" displayed	3 min
T.2.3 Handling a fall	1. Navigate to "Overview" 2. Wait until fall detected 3. Minimize the notification 4. Wait until fall confirmed 5. Save capture 6. Start a call 7. Select "Send help"	1. "Overview" displayed	5 min

System Usability Scale Questionnaire

Question	Answer
I think that I would like to use this system frequently	*1-5*
I found the system unnecessarily complex	*1-5*
I thought the system was easy to use	*1-5*
I think that I would need the support of a technical person to be able to use this system	*1-5*
I found the various functions in this system were well integrated	*1-5*
I thought there was too much inconsistency in this system	*1-5*
I would imagine that most people would learn to use this system very quickly	*1-5*
I found the system very cumbersome to use.	*1-5*
I felt very confident using the system	*1-5*
I needed to learn a lot of things before I could get going with this system	*1-5*

Interview

Part 1: Care recipient

- How did you experience the configuration of the system as a care recipient?
- How did you experience alerting the home care service as a care recipient?
- How did you experience your sense of control and safety as a care recipient?

Part 2: Caregiver

- How did you experience the notifications sent by the system as a caregiver?
- How did you experience your sense of overview and control as a caregiver?

Part 3: Other

- What did you think about the system in terms of privacy?
- What value do you see in a solution like this?
- Do you have any additional thoughts?

Test Environment, Equipment, and Logistics

- **The environment** The test will be conducted in an office environment. The two parts of the test will have dedicated areas for creating a bedroom and office scenery with available equipment for mounting the technical devices and interacting with them .
- **The equipment** In addition to the technical devices that are integrated into the system solution there will also be some furniture as part of the scenery. The furniture will consist of a bed and a table. To be able to configure and interact with the system there will also be some additional technical equipment, including a tablet, monitor and computer mouse.
- **Logistics of the test** Since the test takes part in a small sized office environment the selection of TPs is limited. The TPs will be able to book a specific one hour time slot in advance. There will be at least ten minutes in between every test session.

Test Moderator and Other Roles

- **Test Moderator** who welcomes and gives instructions. The role also includes responsibility for answering any questions during the test and interviewing at the end. Responsibility of taking notes and measuring time is also included in this role.
- **Observer, co-actor and wizard** whose task is to observe, take on the role of a care recipient or a caregiver and control some parts of the system. All interactions between the co-actor and the TP will take place via the system. The co-actor will also control parts of the system, in a Wizard of Oz manner.

Collected Data and Evaluation Measures

Method	**Type of data**
Target Group Survey	*Subjective/quantitative data from survey*
Observations of test tasks	*Objective/qualitative data from think-aloud and time measurements*
System usability scale questionnaire	*Subjective/quantitative data from the questionnaire, focusing on the user experience*
Interview	*Subjective/qualitative data from interview questions*

Pilot Test

To minimize the risk of running into unexpected errors during the actual test sessions a pilot test will be conducted in advance. The purpose of the pilot test is to identify potential flaws related to the test plan. If any flaws are identified the test plan will be modified before the real test sessions. The pilot test will be treated as a real test session.