

École polytechnique de Louvain

A social network around the elderly in home care scenarios

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Chapter 1

Introduction

As the world's population ages, there is a growing desire from elderly people to stay home instead of going to care homes. However, in doing so, there are many communication barriers that make it difficult for elderly people, caregivers, and relatives to communicate effectively. These challenges may result from a variety of causes, including cognitive problems caused by age, physical restrictions, or technological obstacles. Many seniors find it difficult to use technology, and most communication platforms do not cater to their special needs. As a result of that, having a communication platform that is both safe and simple to use is critical for overcoming these barriers and ensuring smooth communication with elders in home care situations.

Most of today's communication tools, including social media and messaging applications, are generally not created with senior people in mind. These platforms may present difficulties for them, such as small text sizes, confusing interfaces, and unfamiliar features, making them difficult to use.

These communication difficulties might have major effects on elderly people in home care situations. Poor communication between them and their caregivers can lead to missed medical visits, medication mistakes, and other difficulties that might endanger their health and safety. A lack of interactions with family members, friends or neighbours can also cause feelings of loneliness and isolation, which can be detrimental to their mental health.

This issue needs to be resolved. Finding a way to facilitate communication around an elderly person to make them feel less lonely, to coordinate care around them is important. And by "care", we mean it in a broader sense. We mean insuring their general well-being. Using traditional social networks like Facebook Messenger and WhatsApp is not ideal for multiple reasons. They do not focus so much on having a seamless means of communication to coordinate care. Even though these apps provide features like group communication, what they lack is crucial in the context of elderly people who stay at home. When it comes to basic WhatsApp, Messenger and Signal groups:

- They don't provide **good access control** which means that all members of a group have access to all information shared within that group and we want to avoid that.

In the case of an elderly person receiving care, this means that sensitive information about their medical condition and care plan could be shared with people who do not need to know it. This can lead to misunderstandings and breaches of privacy.

- They do not offer sufficient security measures to **protect sensitive personal information**. For example, WhatsApp and Facebook are owned by the same company, and there have been concerns about how they use and share data. Signal, while more privacy-focused, does not have the same level of access control features that elderly people expect. Signal's access control features include features like being able to hide your phone number from users, group privacy settings like disabling group invitations altogether to prevent unwanted group inclusions. But that is not enough.
- Elderly individuals do not need to be included in every group chat that concerns them. In certain cases, there may be conversations specifically focused on coordinating care for an elderly person. Traditional messaging platforms like WhatsApp would require the elderly individual to create and be part of a group, even when their active participation is not necessary. And for an elderly person, or anyone, receiving all those messages can lead to an overload of information that may not be relevant to their immediate needs.

Given the increasing demand for home assistance and the communication challenges that come with it, there is a clear need for a communication platform that is tailored to the needs of elderly people and their caregivers. The platform must be simple to use, secure, and specifically developed to handle the unique communication issues that emerge in home care situations. This is the challenge that we are addressing in our research.

As we strive to address the challenges faced by elderly individuals in home care situations, it is essential to understand an elderly person's network and explore alternative social network paradigms that cater to their specific needs. Recognizing the limitations of traditional social networks, our research delves into using another social network paradigm. Existing social networks are frequently either fully flat (an online platform where all users have equal status and visibility, without hierarchical structures or centralized control) or use basic group structures with no interactions between them. This might be restrictive for senior people and their relatives who need a more personalized and customised approach when interacting with their close social network. Take, for example, a senior who has family members, friends or neighbours who assist them regularly with the help of other services like health care and food delivery or who simply interact with them. The idea would be to have a platform where these people can interact with each other without having to necessarily put everyone in a single group. This will make coordination easier and help with not getting everything mixed up in a single group conversation with everybody.

1.1 Differences between horizontal social networks and vertical social networks

The concepts of horizontal and vertical social networks are important to understand. A horizontal social network is a general-purpose social network. They are built for anyone and everyone, which allows them to attract people with diverse interests. Examples of these types of social networks are Facebook, Twitter, Instagram and TikTok. These apps are considered horizontal social network platforms because they are designed to encourage substantial social engagement and content sharing among a wide range of users, with no constraints based on age, interests, or other characteristics. This is the biggest advantage of a horizontal social network. They allow the linking of people from various backgrounds and interests on a big scale. However, they may lack a level of intimacy and personalization, making it difficult for users to form genuine connections.

A vertical social network aligns with a more specific and focused purpose, where the network is designed to cater to a particular community or shared interest. In a vertical social network, the connections and interactions are often rooted in real-life social links and relationships, creating a more targeted and niche experience. These networks may prioritize stronger ties and deeper engagement within specific communities. They are often centred on a primary entity or community, making them appropriate for professional or interest-based settings that demand more precise communication. These networks generate a sense of belonging and community among members who have a shared interest or goal. Nonetheless, they may have a small user base and may be less effective at facilitating communication across diverse groups or reaching a large audience. For example, on LinkedIn, users interact with individuals who share their professional interests and expertise. Other examples of vertical social networks are Goodreads (specifically for book lovers) or Nextdoor (designed for local communities). These apps are considered vertical social network platforms because they are designed for specific communities/niches. These platforms usually have more focused and specific functionalities for these communities. Users may have smaller and more specialized networks, and interactions between users are often more private and focused on specific interests or needs.

In conclusion, horizontal social networks have a broad reach and promote mass communication, but vertical social networks provide more focused communication with features tailored to the needs of their members.

1.2 Illustration of the need for a new solution

Examining many life scenarios that demonstrate the need for a more personalized communication platform will provide a full grasp of the communication and coordination issues that older people encounter. We came up with a use case that shows how a communication platform should be created to help older people communicate with their caregivers and family members. We want to highlight the necessity for a safe and user-friendly communication platform suited precisely to the needs of older people and caregivers in home care situations.

Imagine an 80-year-old man named John who lives alone and has few friends, neighbours and caregivers to assist him with domestic work and personal care. Since John's children live in different parts of the country, they want to be updated about his health and well-being and work with his caretakers to provide the best care possible. To achieve this, John's entourage would want a solution that is designed specifically to address this situation of having different circles of people involved in John's general well-being, seamlessly communicate between themselves and coordinate tasks. In this way, John will not have the problem of information silos, where different individuals involved in John's care have different information and are unable to communicate with each other effectively. They will have access to that information on a need-to-know basis.

To sum up, the real aim of this body of work is to build such a solution to address the communication challenges faced by an elderly individual in a home care scenario based on our findings in our research. This body of work seeks to shed light on the potential of such a solution by examining its design and implementation from a technical and user-centred perspective. This thesis will assess the usability and functionality of the app, considering its potential impact on the well-being and quality of life of elderly individuals and their caregivers. We will first delve into a comprehensive literature review, examining the existing research on the willingness of elders to age in place, the specific challenges faced as they age, elderly communication by means of a mobile app and the existing technologies to solve similar issues. Then we will present our solution, a mobile app called *Circles* and explore the high-level view of the necessary components to build it by giving a detailed description of the app. We will also talk about how we decided to build this solution. Furthermore, the thesis will explore the app in a more technical way, showcasing the design aspects, mock-ups, and the unique features and benefits offered by *Circles*, such as the formation of specific social circles, the integration of diverse roles, and the provision of secure and user-friendly communication channels and present our proof of concept for this app while highlighting the different technological challenges we encountered while developing this proof of concept. Finally, we will conclude with a discussion of the result, its implications, and recommendations for the future development and improvement of vertical social networks catering to the needs of elderly people in a home care scenario.

Chapter 2

Review of the state of the art

In recent years, the field of elderly care has witnessed a rapid and explosive boom in technology solutions. This is mainly to address the multiple new challenges encountered by the elderly. One of the driving forces behind this surge is the fast advances in healthcare and medical sciences, which has led to a growth in life expectancy and consequently, a surge in the number of aged individuals requiring long-term care. The United Nations project that by 2050, the global population of individuals aged 65 years and above is expected to rise dramatically with one in six people in the world being elder [1]. In Belgium, the senior population is projected to reach 2 660 685 seniors from 65 and above, which compared to the 1 860 159 seniors in 2010, boasts an impressive 43% increase in 20 years [2], indicating an important need for innovative technological solutions to better the quality of life of these people.

2.1 Current state of technology in the field of elderly care

The current state of technology in the field of elderly care has been well-documented over the years. A report by the National Institute on Aging highlights the need for technological solutions in elderly care, particularly those that support **ageing in place**. Ageing in place [3] refers to the capability to live in one's own home and community safely, comfortably and independently, regardless of age, income, or capability position, rather than relocating to a care facility or nursing home. According to an AARP poll (American Association of Retired Persons)[4], 76% of adults aged 50 and above prefer to stay in their present houses as they age, and 77% want to live in their communities even if their own homes won't satisfy their needs. While the Belgian numbers regarding this aren't available, we can assume that it is the case in Belgium due to the fact that a fifth of the adults aged 65 and more in 2018 requested some sort of home healthcare service, implying that they are ageing in place as well. In France, only a tenth of seniors (75+) is in care homes for the elderly [5]. We can conclude that people tend to have an increased urge to be close to their familiar environment as they age. Many elders are emotionally attached to the houses where they had their children and entertained their grandkids, and they

frequently do not want to leave.

That being said, living alone might not be for everyone. There are things one has to consider when thinking about whether or not to age in your own residence. Ageing in your own residence may be right for someone who:

- Environment
 - Has a strong connection to their current residence and neighbourhood
 - Has a house with features and tools to increase safety and accessibility
 - Has a home that is close to hospitals and medical providers
- Personal
 - Has a strong support system including family, neighbours and friends that live nearby
 - Has the resources to hire home care aides if needed
 - Does not have any medical conditions that require daily assistance or support

To accommodate this overwhelming willingness of ageing in place, the importance of technology-based tools is highlighted because these solutions can help address the challenges and support ageing in place. These technological solutions include wearable devices, connected homes, remote monitoring systems, and mobile applications.

2.1.1 Challenges that the elderly face as they age

When people get older, they, unfortunately, encounter several challenges that can seriously lower their quality of life. Physical limits, cognitive decline, social isolation, and financial uncertainty are some of the most frequent problems that the elderly encounter.

- **Physical limits**

Chronic medical problems that can limit movement and have an impact on their everyday life, such as diabetes, heart disease, and arthritis, can cause physical limits. Also, one in four adults over 65 experiences a fall each year, making falls a serious health concern for older adults (CDC, 2022 [6]). Serious injuries from these falls may include fractures, brain damage, and other traumatic events.
- **Cognitive decline**

Another issue many elderly people encounter is cognitive deterioration. Memory, concentration, and other cognitive skills might deteriorate as we become older. It is important to know that cognitive deterioration exists on a spectrum, and its impact varies among individuals. While some older adults may require specialized care in a care home setting, others may receive support from family members, community resources, or home care services to maintain their independence and manage daily activities. However, cognitive deficits in general may make it more difficult for a

person to carry out daily chores and may necessitate caregiver support.

- **Social Isolation**

Due to moving, losing a loved one, or going through other life events, people may lose touch with their friends and family as they become older. Moreover, difficulties with movement and medical conditions might simply make it difficult for someone to engage in normal social activities, which can cause feelings of loneliness and isolation. In the United States, loneliness and isolation affect 1 in 5 Americans 65 and older according to AARP Foundation [7].

- **Financial Issues**

Seniors may be on limited incomes, making it harder to afford to go to a home for the elderly or simply to cover basic requirements like housing, healthcare, and food. Furthermore, financial frauds and exploitation are an increasing worry for the elderly, with an estimated \$3 billion lost yearly in the United States alone to elder financial abuse (NCOA, 2022[8]).

2.1.2 Mobile apps as a solution

To address these challenges, technological solutions have been created in the hopes of aiding the elderly and a good way is with the use of mobile apps. The Mobile Technology for Adaptive Aging workshop proceedings [9], which were held on December 11 and 12 2019, actually highlight the importance of mobile technology in promoting healthy ageing and providing elderly care services. Mobile apps, like for example health apps, have increasingly been used in furnishing healthcare services to the senior population and perfecting their quality of life. Take the use of medication reminder apps for seniors. These apps can help seniors stay on track with their medication schedules, which is important for managing chronic conditions and preventing hospitalizations.

Communication and social isolation are significant issues faced by seniors. Social isolation and loneliness have been linked to increased risks of mortality and morbidity among older adults [10]. These issues can negatively impact their mental and physical health. Staying connected with family, friends, and loved ones can improve their overall well-being, and mobile apps can play a crucial role in addressing these challenges. The Mobile Technology for Adaptive Aging workshop highlighted the potential of mobile technology in supporting social connectedness. It emphasized that mobile technologies can help older adults stay connected, access information and services, and engage in daily activities, promoting their independence. In fact, 61% of adults in the US aged 65 own a smartphone [11], indicating that mobile technology can be an effective tool for facilitating communication and connectedness among older adults and their families. In Norway, a survey [12] was conducted to study how seniors use their smartphones from the 158 respondents (60+), only 4 didn't use a phone.

While the smartphone adoption rate amongst older people is lower in certain developing countries there is still a considerable amount of seniors who use smartphones and who could benefit from the use of mobile apps. There is reason to believe that the app adoption rate amongst them will keep growing.

However, even though mobile apps can benefit the elderly and even if there are smartphones specifically built for them, there are still some potential barriers that we have to consider and that need to be overcome in order to ensure that these apps are used by as many seniors as possible.

The complexity and usability of applications are key barriers, especially for seniors who may be unfamiliar with technology and find it challenging to use complicated software. Seniors may become frustrated as a result and stop using the apps. Additionally, because there isn't a set standard for app design, it can be difficult for seniors to navigate among many applications, which makes it tough for them to locate the features and functionalities they need and ultimately leads to poor adoption rates.

Seniors' app adoption is also hampered by privacy and security worries. They could be more reluctant to use applications that ask for access to their devices or personal information. Digital illiteracy can also make them more prone to fraud and scams, which might result in a low adoption rate and mistrust of technology. Additionally, some older people might simply not understand the advantages of using applications for their care or may not use them properly, which can lead to a lack of enthusiasm for adopting the technology and low usage rates [13].

Although these barriers are clearly present, they shouldn't be seen as insurmountable obstacles. We just need to make sure they are addressed through innovative and user-friendly designs geared for the elderly, effective training and communication, and partnerships between app developers, healthcare professionals, and caregivers. This will make it possible for seniors to fully utilize the mobile apps' potential in the hopes of bettering their well-being and independence.

2.1.3 The effectiveness of existing elderly care apps

There are many apps that are available that are especially suited to the needs of older people, and the popularity of mobile apps in senior care has substantially increased. These applications may improve interactions with others, physical and mental health, and general quality of life, among other things. Technology-based tools such as video conferencing platforms and social media can help bridge the gap between older adults and their families, especially if they live far away or are unable to visit frequently. To combat this, technology-grounded results that promote communication, socialization and most importantly, aging in place have been developed. In this section, we will focus on 2 apps that have very interesting aspects that we want to use to compare with our ideal solution: "GrandPad" and "Papa".

GrandPad



Figure 2.1: The GrandPad tablet
Source: <https://www.grandpad.net/>

GrandPad is a tablet designed specifically for the elderly, with simple capabilities that let them communicate with their loved ones. This tablet provides multiple features for seniors to stay connected and active with the world they live in, including video conversations, texting, photo sharing, and access to news, games, and other entertainment features. This tablet comes with preinstalled specific custom software that provides one of the biggest pros of this solution which is its ease of use. This is very important for seniors who are not necessarily very comfortable using technology due to a lack of digital literacy. This app has very large icons and very simple navigation so that it is accessible to as many seniors as possible. This app also allows family members and caregivers to remotely monitor the activity and health of their loved ones through the GrandPad Central Admin Website.

GrandPad offers 2 versions: the consumer version and the enterprise edition. The consumer edition is aimed towards seniors and their families whereas the enterprise edition is aimed towards healthcare providers and senior-focused companies including home care agencies, hospitals, and assisted living facilities to connect them easily to the seniors. It has specific features like secure communication, patient monitoring systems through other GrandPad-connected systems etc.

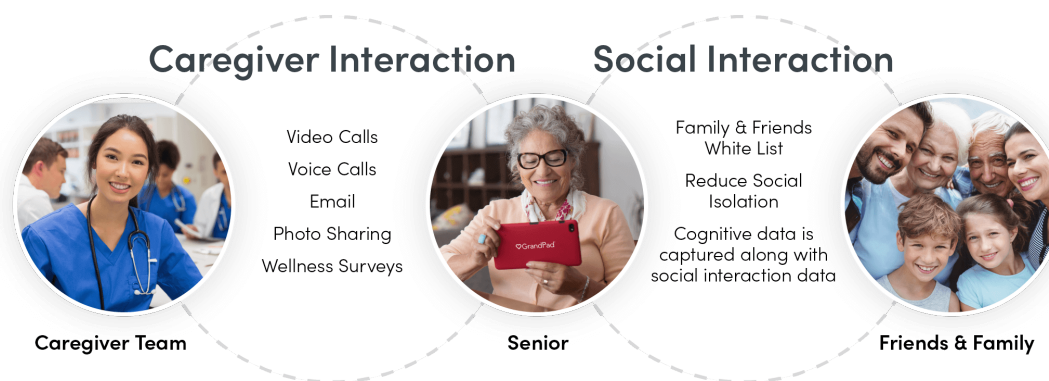


Figure 2.2: The GrandPad Interaction Diagram
 Source: <https://www.grandpad.net/>

Carla Perissinotto, a geriatrician and professor at the University of California, San Francisco conducted a feasibility test using the enterprise edition with 2 aims:

- to evaluate the feasibility of integrating an age-friendly telemedicine (online health care service) platform into the lives of seniors in home care scenarios
- to evaluate the effects of engaging older adults with age-friendly technology to address loneliness.

After giving the GrandPad tablet to 21 patients and giving access to the GrandPad portal app to 14 providers, here were the results after a year of usage:

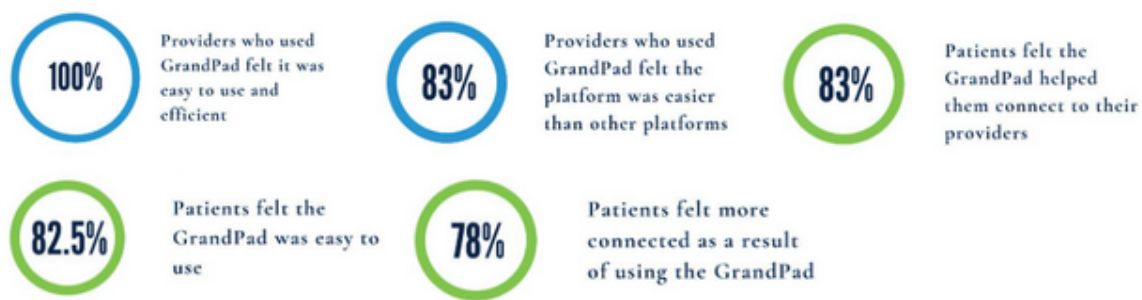


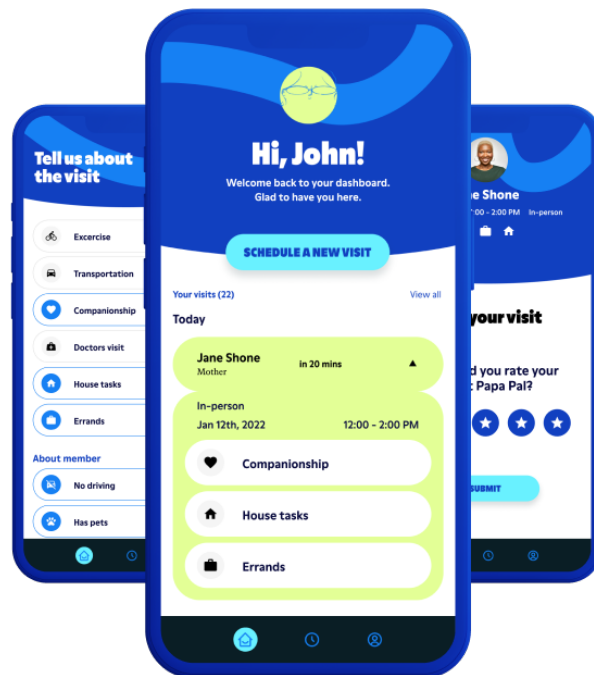
Figure 2.3: The GrandPad study results
 Source: <https://static1.squarespace.com/static/5d30eb93b1af2d00015a4bd0/t/5df3e007b17a726e422452b7/1576263689053/UCSF+poster.pdf>

These positive results conclude the GrandPad solution to aid elders who want to age in place is a good option and is also good for healthcare situations. It also succeeds at making older adults feel less lonely by increasing social connectedness which improves their overall well-being.

Note: The study referenced here was conducted with the help of the people behind Grandpad. While the study highlights the effectiveness of their product, it is important to consider the

potential bias inherent in self-conducted research. It is advisable to interpret the results with a grain of salt and seek additional independent research for a more comprehensive understanding.

Papa



*Figure 2.4: The Papa app
Source: <https://www.papa.com>*

Papa is an online platform that connects seniors with people who assist with daily duties like food shopping, transportation, domestic chores, and companionship. The application's goal is to address the issue of social isolation among the elderly and improve their quality of life.

Older people may join Papa and request a designated companion or caretaker who provides assistance and companionship to seniors, also known as "Papa Pal". The app connects elders with pre-screened people who have been background checked and trained to give companionship and assistance. Seniors may use the app to schedule visits with their Papa Pals and connect with them via message or video chat.

Papa offers a variety of services to help older people stay involved and connected. Papa Pals, for example, can accompany elders on outings, play games, and provide companionship and conversation. The app has a "Papa Health" feature that connects elders with healthcare specialists who may give virtual check-ins and medication management support.

2.1.4 Comparing existing solutions and to our ideal solution

Features/Aspects	GrandPad	Papa	Our ideal solution
Target users	Elderly individuals and families	Elderly individuals and families	Elderly individuals and their social networks
Roles	Not really defined other than the family admin	Seniors and Papa Pals	Admin, senior, primary caregiver, helper, visiting nurse etc
Cost	\$400 base price of the tablet, the full suite of apps also requires a \$65 monthly or \$780 annual subscription	\$20-\$40 per hour Papa Pal companion services	Business model to be determined
Availability	Available in the US and Canada	Limited geographic coverage	Global availability
Social interaction	With family and friends	Between the senior and their companion	Limited to a closed social network
Usability	Tablet + companion app (no messaging)	Smartphone application where companions go through background checks	Users can create specific “circles” and invite anyone to join (They will have to get the app)
Communication	One-on-one	One-on-one	Allows for group communication

This table shows how different and/or similar the GrandPad and Papa are to what we are aiming to build. GrandPad stands out with its user-friendly interface and tailored features specifically designed for elderly users, providing them with a simplified and intuitive experience. It comes with a dedicated tablet but it is quite expensive. And subscribing to a plan to keep using it isn't ideal. Moreover, you cannot engage with more than one person at a time which is problematic in scenarios when a group of people need to be aware of a certain piece of information and it is only available in North America. On the other hand, Papa offers a unique approach by connecting older adults with specific people for companionship and assistance. While Papa comes with an app to coordinate tasks, set up reminders and book a companion, this app doesn't promote connectedness with the senior's existing network as it is more for seniors who are completely socially isolated. Another inconvenience is that companions have to go through the Papa system and get a background check. This service draws similarities to the Uber business model. However, when considering a comprehensive solution that encompasses both communication with a social network, task coordination and caregiving aspects, we believe that our solution emerges as the most promising option as it effectively combines the best aspects of both

apps and offers it at a low cost.

2.2 Examining examples of other vertical networks in other contexts

As we have previously established in the introduction, a vertical social network could utilize a unique approach to address the communication challenges faced by elderly individuals in a home care scenario. Emphasizing the importance of connections and interactions within the elderly individual's community could be a great way to recognize the significance of social relationships for those who may experience limited mobility or feelings of isolation. Having an accessible and user-friendly platform that enables seniors to engage with their caregivers, family members, and friends, facilitates efficient communication and coordination of activities. We also established that thanks to its vertical structure, we can focus on the specific needs and dynamics of the elderly, ensuring a more tailored and meaningful social networking experience. By exploring other examples of vertical social networks in different contexts, we can gain insights into the effectiveness of this model. Here, we will analyze other vertical networks to identify common characteristics, features, and functionalities that make them successful in their respective domains. By doing so, we can learn from what works well in this regard and see how to implement these best practices in our app. To start things off, our first case study is LinkedIn.

2.2.1 LinkedIn

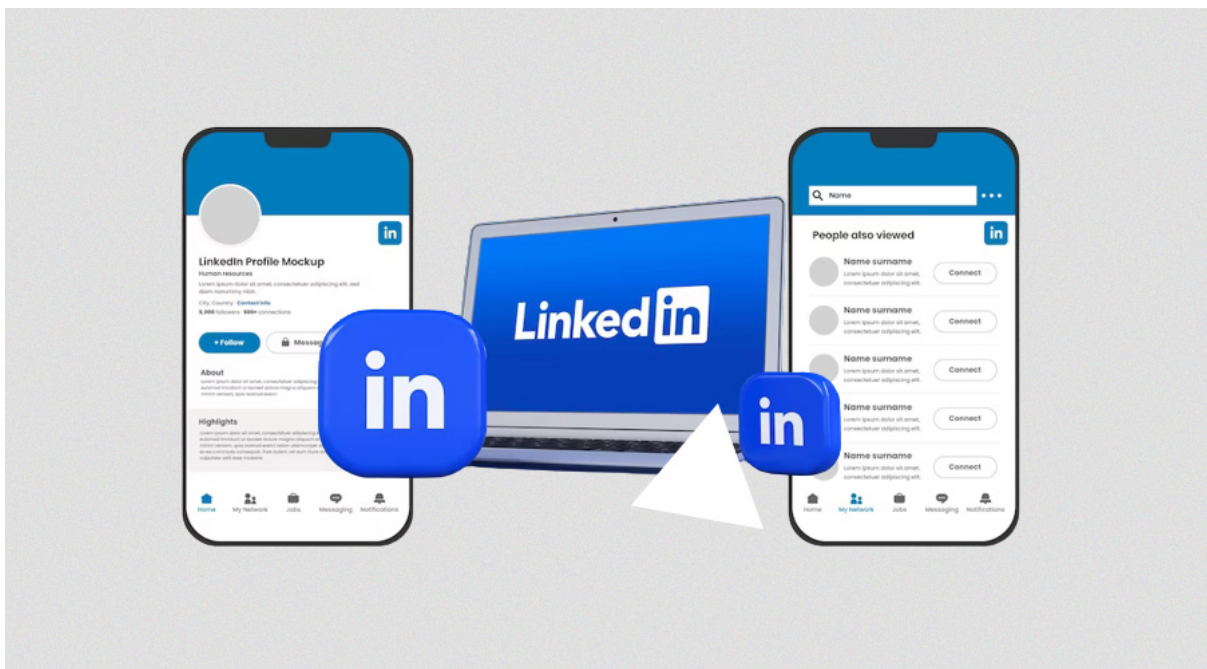


Figure 2.5: LinkedIn

Source: <https://www.analyticsinsight.net/linkedin-launched-ai-powered-features-to-spruce-up-user-profiles/>

[//www.analyticsinsight.net/linkedin-launched-ai-powered-features-to-spruce-up-user-profiles/](https://www.analyticsinsight.net/linkedin-launched-ai-powered-features-to-spruce-up-user-profiles/)

LinkedIn [14] stands as a standout example of a vertical social network as it effectively caters to professionals seeking career advancement and networking opportunities. Its design and features reflect a targeted approach, emphasizing specialized communities and robust user profiles. Drawing insights from LinkedIn's success, our solution can enhance its functionality and user engagement by incorporating similar elements tailored to the needs of the elderly in home care scenarios.

One of the fundamental aspects that make LinkedIn a vertical network is its focus on a specific community: professionals across various industries. Unlike broader social networks, such as Facebook or Twitter, LinkedIn caters to a niche audience, providing a platform where professionals can connect, share insights, and explore career prospects. This specialization creates a sense of belonging and community among users who share similar career interests and aspirations. This can be replicated in our solution since this sense of belonging is exactly the feeling we want to create in our app.

The success of LinkedIn as a vertical network is further reinforced by its features and functionalities that cater explicitly to professionals. The platform offers comprehensive tools for users to showcase their professional achievements, skills, and experiences through detailed profiles. This emphasis on professional identity enables users to establish their credibility and expertise within their field, facilitating targeted connections and engagement opportunities. By incorporating similar profile-building elements, our solution could empower seniors to highlight personal preferences, and specific care needs, fostering a deeper understanding and connection among their social circles.

In addition to specialized user profiles, LinkedIn's user engagement and interface design play significant roles in its success. The platform boasts a clean and intuitive layout, offering clear navigation, easy-to-use search functions, and streamlined communication tools that facilitate efficient networking. By adopting a user-friendly interface, intuitive navigation, and accessible communication features, our solution could enhance its usability for elderly individuals with varying levels of technological familiarity. Ensuring a seamless user experience will encourage active participation, promote meaningful connections, and solidify our solution as an integral part of the elderly's daily lives, making communication and coordination easier for everyone involved in their care.

In summary, LinkedIn's vertical social network model exemplifies the power of targeting a specific community and tailoring features to meet their unique needs. By adopting similar best practices, we can optimize our solution's functionality for the elderly in home care scenarios, creating a platform that fosters meaningful connections, improves communication, and enhances the overall well-being of seniors and their caregivers. The lessons learned from LinkedIn's success can pave the way for our solution to become a vital tool in addressing the challenges of communication and coordination in home care settings, ultimately improving the quality of life for the elderly and their support networks.

2.2.2 Nextdoor

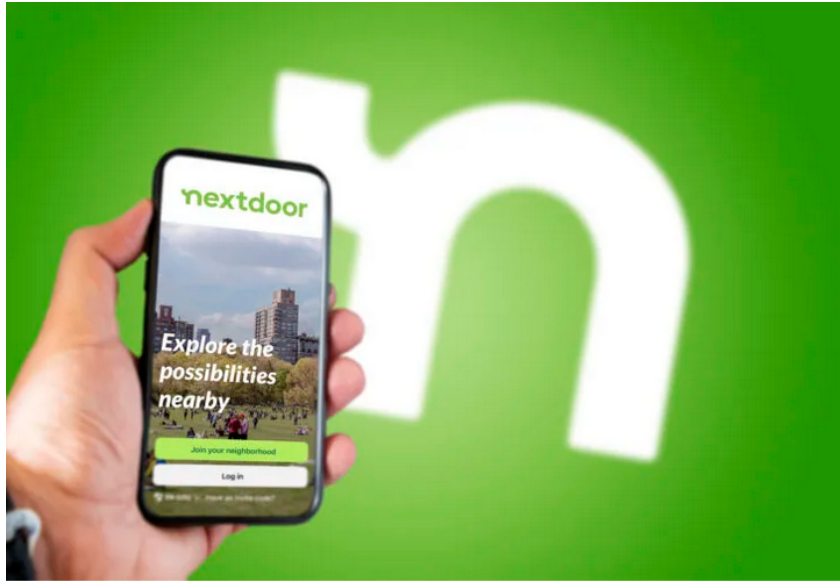


Figure 2.6: Nextdoor app

Source: <https://www.homestratosphere.com/nextdoor-app/>

Nextdoor [15] is another prime example of a vertical network that focuses on building local communities and fostering neighbourhood connections. Unlike broad social media platforms, Nextdoor is designed specifically for neighbours to interact and engage with one another. Users join the platform based on their physical location, allowing them to connect with people who live nearby and share common interests.

Focusing on a specific vertical, in this case, neighbourhoods, Nextdoor enables residents to discuss local events, share recommendations for local services, organize community activities, and address neighbourhood concerns. It serves as a virtual space where neighbours can come together, exchange information, and build stronger, more connected communities.

Nextdoor's vertical network approach offers several advantages. Firstly, it enhances the sense of belonging and community among its users. By connecting with people in their immediate vicinity, individuals can establish meaningful relationships and collaborate on local initiatives. Secondly, it promotes local businesses and services, providing a platform for residents to support and engage with the local economy. Finally, Nextdoor enables the sharing of important neighbourhood information, such as safety alerts or community updates, facilitating a more informed and connected neighbourhood.

2.2.3 Goodreads



Figure 2.7: Goodreads

Source:

<https://computer.howstuffworks.com/internet/social-networking/networks/goodreads.htm>

Goodreads [16] is our last case study of a vertical social network that revolves around a specific community: book lovers and avid readers. Unlike general social media platforms, it serves as a centralized platform where users can discover, discuss, and recommend books, fostering a passionate community of readers. By creating this dedicated space for readers, Goodreads also fosters a sense of belonging and community among users who are passionate about books.

Goodreads's focus on community engagement is very important. The platform encourages users to join book clubs, participate in reading challenges, and connect with fellow readers. These community-oriented features create opportunities for meaningful interactions, discussions, and collaboration. Similarly, our solution could benefit from fostering community engagement. Creating a space within where caregivers, family members, and professionals can come together, exchange ideas, and support one another can enhance the overall sense of community and foster a supportive environment for the elderly.

In conclusion, the examples of LinkedIn, Nextdoor, and Goodreads illustrate the power and effectiveness of vertical social networks in catering to specific communities and fostering meaningful interactions within those niches. These platforms have successfully leveraged their vertical nature to provide specialized functionalities, curated content, and community engagement that cater to the unique needs and interests of their respective user bases.

LinkedIn stands out as a vertical network for professionals, offering a platform dedicated

to career advancement and networking opportunities. Its emphasis on specialized communities, robust user profiles, and targeted features has created a thriving ecosystem for professionals to connect and engage with like-minded individuals.

Nextdoor, on the other hand, focuses on neighbourhoods. With its emphasis on real-world communities, Nextdoor allows users to cultivate a sense of belonging and camaraderie among neighbours, leading to valuable connections, neighbourhood collaborations, and the sharing of important local information.

Goodreads caters specifically to book lovers and readers, offering a centralized platform for content curation, personalized recommendations, and community engagement. By fostering discussions, book clubs, and user-generated content, Goodreads has created a vibrant community where readers can connect, discover new books, and share their passion for literature.

These examples highlight the importance of a vertical approach in social networking, as it allows for tailored experiences, focused communities, and specialized functionalities. By drawing inspiration from the success of these vertical networks, our solution can enhance its functionality and user engagement by incorporating similar elements tailored to the needs of the elderly in home care scenarios. By adopting a vertical model, we can provide a dedicated platform that fosters a sense of community, support, and connection among the elderly and their caregivers, improving their overall quality of life and well-being.

2.3 Concerns in mobile apps for elderly users

As we have previously established in our section exploring the current state of technology in elderly care, mobile apps are becoming increasingly integrated into the daily lives of older individuals. This fact makes it very essential to consider the unique concerns these elderly individuals may have when using these technologies. Understanding and addressing these concerns is pivotal in developing an app that meets their needs and ensures a positive user experience. In this section, we delve into the various concerns that elderly users may have when engaging with mobile apps. By examining relevant studies and statistics, we aim to shed light on these concerns and provide insights into how we can navigate these challenges and build an app that instils confidence and empowers elderly users in their home care journey. We will explore the 2 main concerns: privacy and usability barriers/digital literacy.

2.3.1 Privacy concerns

Research proves that privacy emerges as a paramount concern among elderly users when using mobile apps. Older individuals may express apprehension about sharing personal information and data, fearing potential breaches, misuse, or unauthorized access. In their research paper “Privacy attitudes and concerns in the digital lives of older adults: Westin’s privacy attitude typology revisited,” [17] Elueze and Quan-Haase explore the privacy attitudes and concerns of older adults in the context of their digital lives. The study utilizes Westin’s privacy attitude typology. This typology is a conceptual framework

developed by Alan F. Westin, who was a professor of Public Law & Government Emeritus at Columbia University, to classify individuals' attitudes towards privacy.

The study used a sample comprising 40 participants (21 women and 19 men) between the ages of 65 and 91 years who were willing to answer some digital privacy questions. This is how they were categorized based on the results and their interviews.

- **Fundamentalists (13%)** These seniors consider themselves highly private and exhibit a sense of extreme caution when it comes to disclosing personal information while using digital media. They hold the belief that people tend to share excessive amounts of information, particularly on social media platforms. These individuals are cautious and sceptical about the risks associated with digital media and prioritize maintaining a high level of privacy and control over their personal information.
- **Marginally concerned (25%)** These seniors do not perceive themselves as highly private. They exhibit a lack of awareness or concern about the risks associated with sharing information online. They may not believe that their current online activities make them vulnerable to privacy risks. They do not mind disclosing information about themselves when using digital media, demonstrating a more relaxed approach to privacy and a willingness to share personal details.
- **Intense Pragmatists (15%)** These seniors view themselves as private in certain aspects. They possess an understanding of the risks associated with sharing information while using digital media. Although they are not comfortable with disclosing personal information, they acknowledge the trade-off between protecting privacy and engaging with digital platforms. For example, they recognize the need to provide information when making online purchases but remain cautious about the extent of information shared.
- **Relaxed Pragmatists (42%)** These seniors have a basic understanding of the risks associated with sharing information while using digital media. While they are not fond of disclosing personal data, they may do so depending on the purpose, such as using social media platforms.
- **Cynical Experts (5%)** These seniors possess a well-informed understanding of the privacy risks associated with digital media. Despite their awareness, they do not mind sharing personal information when using digital platforms. However, they hold a belief that their privacy will inevitably be invaded when engaging with digital media, perceiving it as beyond their control.

Various studies have also been made to provide corroborating evidence for these results. The findings from the research highlight the importance of addressing privacy concerns among older adults, which is directly relevant to the development of our app. Just like the older adults in the study, seniors using our app may have similar apprehensions about sharing personal information and engaging in online activities due to fears of scams and privacy breaches. Acknowledging and acting upon those concerns will help our app to instil a sense of trust among the users. This will also guide the design and implementation of privacy traits in the app.

Our first approach to instilling a sense of trust and confidence among our users is to **make our code open-source** and make sure that our users understand what it means as we believe this is a significant step. By making the app's source code publicly accessible, it showcases our transparent and accountable approach to privacy and security.

The open-source nature of our solution allows interested programmers to review the code and assess its security measures. This transparency can help alleviate privacy concerns by demonstrating that the app does not contain hidden or malicious functionalities that compromise user data. In contrast to typical apps that often rely on monetizing personal data for targeted advertising or third-party partnerships like Facebook and Instagram, our app does not engage in such practices. It does not track user behaviour, nor does it sell personal information to advertisers, or utilize intrusive data collection techniques.

Furthermore, the open-source model promotes collaboration and community involvement. It encourages experts and developers to contribute to the app's security and privacy enhancements, creating a sense of collective effort to ensure the app's integrity and protect user information. The participation of a broader community can lead to more rigorous security testing, timely identification of vulnerabilities, and prompt resolutions in the future.

While open source alone may obviously not address all privacy concerns, it serves as a foundational measure to establish trust and transparency. As the development of our app progresses in the future, it is important to continue exploring and implementing additional security measures to provide comprehensive privacy protection for older adults, considering factors such as data encryption, and secure communication channels. But that will come later in the development of the app.

In addition to adopting an open-source approach, our app will **prioritize access control mechanisms**, specifically utilizing Role-Based Access Control standard (RBAC) [18], to enhance privacy for older adults. RBAC is a widely recognized and effective method for managing user permissions and controlling access to sensitive information within an application and in our requirements chapter, we will explain in more detail how we use this standard

2.3.2 Usability barriers and digital literacy

Earlier in this literature review, we showed how age-related problems, specifically cognitive and physical limitations, contribute to the challenges faced by elderly individuals but this is especially the case when they interact with smartphones. The design of smartphone applications does not sufficiently address the specific needs of the elderly. It's important to understand the extent how usability can pose significant challenges to elderly users when engaging with mobile apps if it is not taken into serious consideration. These barriers can hinder the effective use of an app and affect the overall user experience. For example, we know that older people usually take more time to understand how an app works to be able to complete tasks. With that in mind, we cannot just develop a generic app without thinking about these aspects. In this section, we identify and validate various recurring usability barriers faced by older adults and how our app can address these challenges to

ensure accessibility and usability for its target users.

To help understand the usability challenges that older adults face, we refer to a study called “Usability Barriers for Elderly Users in Smartphone App Usage: An Analytical Hierarchical Process-Based Prioritization” [19] (Awan et al, 2021). The researchers conducted a systematic literature review and used the analytic hierarchy process to determine the relative importance of these barriers among older adults. After conducting their own structural literature review, they identified fifteen barriers. Since the findings of this research aim to assist in developing smartphone applications that cater to the specific needs and challenges faced by the elderly community, this study is very valuable to the creation of our app. Here are the barriers that were found:

Small font, screen size, font type, buttons, and colour contrast were identified as contributing to usability problems among the elderly in approximately 76% of the studies used during the literature review. Additional barriers mentioned include difficulties in searching for and identifying icons, font type colour problems, low voice quality, forgetfulness of learned information, rapid technological changes, and the need for software updates.

Menu and navigation issues were the second most frequently cited barrier, accounting for 63% of the selected articles. It was noted that the size of elements in the interface directly affects user preference and usability. Elderly users with low spatial abilities may experience confusion and difficulties navigating smartphone menus. The importance of consistent navigation buttons, visibility and accessibility of core functions, and ease of finding and correcting errors was emphasized. Improving the interface of menus and navigation objects for older adults was deemed crucial due to the functional complexity of smartphones and the potential complexity of their menus.

Lack of experience and knowledge was mentioned as a barrier in approximately 56% of the selected articles for the literature review. The learning difficulties faced by elderly users can be attributed to various factors, such as cognitive challenges, lack of computer usage awareness, and issues related to device interfaces.

Unlabeled and unfamiliar icon size were identified in around 30% of the total articles in the review as a significant barrier to using smartphone applications. This study also reveals that elderly users have limited knowledge about modern smart devices and are often unfamiliar with the icons and their corresponding applications. The researchers highlight that the lack of familiarity with these icons makes it difficult for elderly users to utilize them effectively. They suggest that attaching semantic information to the icons and labelling them with words describing their intended features can enhance their usability for elderly users who face challenges with existing smartphone icons.

Other barriers mentioned in the study include challenges related to the touch screen and QWERTY keyboards, complex interfaces and functions, lack of awareness about technology, visibility and readability issues, text input difficulties, lack of efficacy support and trust, mobile device design problems, drag and drop and multi-tap issues, small keys with narrow gaps, and the cost of devices and internet connection. Older adults often struggle with these barriers due to their limited familiarity and experience with technology, cognitive and physical limitations, and lack of support and motivation. In

conclusion, addressing the barriers to smartphone adoption among older adults requires a multifaceted approach. This includes designing user-friendly interfaces, improving visibility and readability, enhancing text input methods, and offering support and guidance to boost older adults' confidence in utilizing smartphones. By overcoming these barriers, we can empower older adults to fully embrace smartphone technology and leverage apps in their daily lives.

Chapter 3

Design requirements analysis

In the previous chapter, we examined the current state of elderly care technologies, studied what already exists and concluded that building a mobile app would be a good solution to address the challenges regarding communication and care coordination around an elderly person. Now that we have justified the need for an app for the elderly, we will now present you with a detailed explanation of our solution, *Circles*, and present the key elements and functionalities that are essential to its development and design. These core components are key to understanding how *Circles* works.

3.1 Our solution

Circles is a solution to the problems that the elderly confront. It is a user-friendly and intuitive social network platform that places the elderly individual at the centre, surrounded by their social circles of family, friends, and caregivers. This provides for a more comprehensive and connected approach to communication. It allows the elderly to interact with their social network, which includes family, friends, and caregivers. With this app, we try to provide efficient communication and support between the elderly and their carers through its secure and easy-to-use features, while also reducing feelings of loneliness and isolation through social interaction.

Circles is designed with the needs of seniors in mind. This means focusing on accessibility, usability and easy-to-understand interfaces that can, for example, adapt to larger text sizes set by the device's operating system and have familiar features that seniors may be more comfortable with, such as text messaging.

3.2 Vertical social network for the elderly

Circles uses a vertical social network model by setting up its platform around what we call *social circles*, emphasizing the importance of connections and interactions inside these groups. Social circles are the different groups of people that we interact with in our lives. This could be family members, friends, classmates, coworkers, neighbours etc.

In the case of *Circles*, we only want to consider an elderly individual’s close network of people that they would like to interact with on a regular basis to keep them company and for their general well-being. This sort of social networking is different from traditional communications apps like WhatsApp and Messenger and provides the elderly with a more tailored and personalized experience. *Circles* recognizes the importance of social relationships for older people who may have restricted mobility or feel isolated or needs a lot of help due to them staying at home as opposed to going to a care home for the elderly. *Circles* provides an easy-to-use platform for seniors to communicate with their carers and loved ones and help the people in their network to efficiently arrange activities around the seniors’ care and daily life. The app recognizes the significance of ensuring a seamless and supportive network for the elderly, where their caregivers, family members, and friends can come together to provide the necessary assistance and support such as medical appointments, medication reminders, meal preparation, transportation, and other essential tasks. The app’s task management system allows for the creation, assignment, and tracking of tasks, ensuring that everyone involved is aware of their responsibilities and can contribute to providing comprehensive care.

By emphasizing the platform’s exclusivity through social circles, *Circles* contrasts the horizontal frameworks of existing social networks. Seniors or trusted family members can build and manage their own social circles, which include family members, friends, and caregivers. These social circles may be modified to each user’s specific needs, allowing for more concentrated and targeted communication. For example, an elderly user may have one circle of closest family members, another circle of close friends, and a third circle of healthcare professionals.

This vertical structure also enables better communication between caregivers and family members, who can use the platform to coordinate care and share information about the user’s health and well-being. This is especially significant in home care circumstances, where efficient communication is critical for guaranteeing the safety and well-being of older people.

Furthermore, with features such as large text sizes, simplified interfaces, and clear navigation, *Circles* places a strong emphasis on user-friendliness and accessibility while current social networks might be difficult for senior users to navigate and efficiently use.

Overall, *Circles* represents a new social networking paradigm that is particularly tailored to meeting the needs of the elderly and their caregivers. *Circles* has the potential to transform home care scenarios and enhance the quality of life for millions of elderly people worldwide by offering a secure, user-friendly, and flexible platform for communication and coordination.

3.3 Use cases for *Circles*

In the introduction of this thesis, we illustrate the need for *Circles* by using an imaginary situation of an 80-year-old man named John who lives alone and who would benefit from this app. John’s family live in different parts of the country and he has a community of

people around him who would love to interact with him and help him in his daily life if need be. Using this initial situation, we will present 2 scenarios where John makes use of this app, to highlight its relevance and introduce how *Circles* should be used.

The way that *Circles* works is by creating groups of contacts called “circles”. Each circle represents a particular social circle in John’s life. We could have a circle for his immediate family where his family members can chat together, one for his neighbours who help John out if need be, one for his caregivers and medical specialists etc. This will enable those social circles in his network to not only communicate with each other but also communicate with different members in different circles depending on the members’ roles because their role determines the access level that they have on the app. Different roles have different accesses and permissions but we will explore that in more detail later.

For now, let’s set up a few roles for the people involved in John’s care:

- **Primary caregiver:** John’s daughter, Susan, who has the highest level of access to John’s information and can manage his appointments, medications, and overall care.
- **Secondary caregiver:** John’s son, Billy, who has access to some of John’s information and can help coordinate his care.
- **Primary visiting nurse:** A professional nurse who provides regular medical check-ups and has access to John’s medical information.
- **Meal delivery provider:** A service person that delivers meals to John’s home.

Now, let’s say that we want to create social circles that represent the different groups of people involved in John’s care. We might have the following circles:

- **Family Circle:** This circle includes John’s daughter and son, as well as any other family members who want to be involved in his care.
- **Medical Circle:** This circle includes the visiting nurse and any other medical professionals who need to coordinate with John’s care.
- **Caregiver Circle:** Home care professionals who provide services to John, such as meal delivery, house cleaning and minimal personal care.
- **Neighbor Circle:** This includes John’s neighbours who occasionally check on him and are granted limited access to information and updates related to John’s well-being.

Now that we have set the initial situation we can explore different scenarios where John uses this app in his day-to-day life.

Scenario n°1

7:00 am - John wakes up and checks his phone. He sees a notification from *Circles* that reminds him to take his morning medication. He clicks on the notification and the app

takes him directly to his medication reminder space within the app. John sees that his medication schedule for the day is already listed and checks off the medication he just took. By doing so, the person with the “Primary caregiver” role in the app can see that John has taken his medication and can add or remove some pills from the list if need be.

Thinking Process: He thinks to himself that it's nice to have everything in one place, rather than having to remember to check different apps or websites for his medication schedule. In the future, he can give in-app access to his pill lists to other members of his network or to a whole circle like the Family Circle for example.

7:30 am - John's meal delivery provider arrives with breakfast. The provider asks if there are any changes to John's dietary needs or preferences for the coming days. John says that he will check later and notify him if it is the case.

9:00 am - John's daughter sends him a message in the Family Circle, asking how he slept last night. John replies that he slept well, but that he's been feeling a little tired lately. His daughter suggests that she schedules an appointment with the visiting nurse to get checked out. John agrees. John's daughter sends a message to the Medical Circle asking if a nurse can come over to check on John this afternoon. Once a nurse in the circle accepts, John's daughter then navigates to the Appointments/Reminder to add the new appointment with the visiting nurse for later during the day to John's appointments and sends a message to the Family Circle letting them know.

3:00 pm - The visiting nurse arrives for John's appointment. During the appointment, she notices that John is low on iron. After the appointment, the nurse sends a message to John's meal delivery provider to request more foods rich in iron. She then sends a message to the Family Circle letting them know how the appointment went. John sees the message and replies with a thumbs-up emoji, indicating that everything is okay.

6:00 pm - One of John's neighbours arrives to help cook dinner and eat with him since he's been feeling a bit lonely and to do some light cleaning. He notices that John's kitchen sink is leaking, and asks if he knows how to contact a plumber. John opens the app, navigates to the Caregiver Circle, and sends a message asking for recommendations for a good plumber. One of the other caregivers replies with a recommendation, and John thanks them.

Summary/Thinking Process: Throughout this day, John is able to navigate easily through the app to access the different circles he needs. He appreciates the simple interface that helps him keep track of which circle he's in, and the ability to communicate directly with his caregivers, medical professionals, and family members without using multiple apps or platforms. He also appreciates the privacy and control that the app provides, ensuring that only the people with the appropriate roles and access levels can see and interact with his information.

Scenario n°2

7:00 am - John wakes up and checks the app to see if his caregivers have updated his medication schedule for the day since he now has to take 3 zinc tablets a day. He sees

that the new supplements have been added. He also sees that his daughter has posted a message in the Family Circle, asking how he slept and how he's feeling this morning. He responds to her message to let her know he's doing okay.

7:30 am - John's meal delivery provider posts a message in the Caregiver Circle, letting the caregivers know there will be a delay in the delivery of John's breakfast due to traffic because he doesn't have direct access to John. So John's primary caregiver, his daughter, sees the message in the circle and notifies John about the delay.

2:00 pm - John borrowed a couple of special books 2 weeks ago from the library out of town and needs to hand them over before tomorrow. He sends a message in the Neighbour Circle asking if someone can hand over the books for him today. Lucky for him, his neighbour Alice is on her way to her friend who lives next to that library and notifies John on the app that she will pop by to collect his books. She also sees that John asked for someone to help him change his trash bags so she tells him that she will do that as well.

3:00 pm - John's son, who lives in another country, checks the app to see how John is doing. He sees John's updates and posts a message in the Family Circle to let them know that he's thinking of them and hopes everything is going well.

6:00 pm - John's daughter posts a message in the Family Circle, reminding everyone that a family meeting is scheduled for the following day to discuss John's care plan. She provides a link to the meeting details and asks everyone to RSVP.

8:00 pm - John needs to get a couple of baking ingredients from the store as he intends to bake tomorrow with a friend. He adds "Get baking ingredients" as a task on his TO-DO list on the app which will be accessible to everyone in his network who volunteered to help John with tasks he may have. John's neighbour, Steven, who is in the Neighbor Circle and someone with the "Helper" role, receives an alert notifying him that a new task has been added to John's list. He claims the task on the app and buys John his groceries.

Summary/Thinking Process: Throughout the day, John also uses the app to:

- *Check his appointment schedule*
- *Send messages to his family, friends, neighbours, and his other caregivers if he needs help with something*
- *Receive reminders about his medication schedule*
- *View his medical information, including test results and medical history*

At the end of the day, John realizes that the Circles app is the only solution that meets all of his needs in one place and that it's much more effective than using multiple WhatsApp or Signal groups that can quickly become cluttered and confusing.

have to know each other before joining any network. For example, there is no global search functionality where one can find another user on the app and send them an invite. This choice promotes trust, accountability, and a supportive environment where the care network consists of individuals who are genuinely connected and committed to the well-being of the senior.

Another design choice was to allow users to join multiple networks because a user could want to be involved in the care of multiple elderly individuals who want to age in place.

3.4.2 Circle abstraction

The circle abstraction is a key component of *Circles*, providing a framework for organizing social connections and interactions within the platform. It involves the concept of creating circles or groups that users can join or create based on their relationships, interests, or common activities. A “circle” represents a dynamic and versatile construct in our app, that brings together people who are in a way directly involved in the life of the senior at the centre of the network, who is ultimately the owner of the network. It’s a virtual space within the platform where users can connect, communicate and engage with one another in the context of the senior. A circle can be seen as a sort of social group formed by the senior and his admins. Within a circle, users can message, share updates with each other, and plan events or activities. It’s basically a central hub where users can stay connected. These circles are typically created based on the different types of relationships and connections seniors have in their lives and their social networks.

The separation of circles allows users to manage and organize their social connections in a more structured and personalized manner. Here’s a breakdown of some common types of circles a senior could have:

- **Family Circle:** This circle typically includes immediate family members, such as siblings, children and grandchildren. It serves as a space for sharing updates, coordinating family events, and staying connected with loved ones.
- **Friends Circle:** This circle comprises close friends and acquaintances. Users can engage in casual conversations, plan social gatherings, and share experiences within this circle.
- **Neighbour Circle:** This circle contains close neighbours who willingly want to help the senior at the centre of the network out. Given the proximity advantage, they could help with monitoring the elderly individual, helping them out with house chores or tasks etc.
- **Caregiver Circle:** For individuals who require assistance or support from caregivers, this circle enables seamless communication and coordination between the person receiving care and their caregivers. It facilitates sharing important information, scheduling appointments, and providing updates on health or well-being.

We could take this notion even further and have circles based on other habits or needs like a **Hobby/Interest Circle** that could revolve around a shared interest, hobby, or activity.

Users with similar passions in the network can thus connect, exchange ideas, plan group activities, and discuss their common interests within this circle. This circle abstraction is really important to the foundation of the app because this creates our privacy by design but before we talk about that, we have to explore another important aspect of the app which is user roles.

Privacy by design is a fundamental principle integrated into the *Circles* app, ensuring that information sharing and interactions within the care network occur on a need-to-know basis. This approach recognizes the importance of respecting the privacy and autonomy of the elderly person while enabling effective communication and collaboration among caregivers and service providers.

In *Circles*, the role-based permission system plays a crucial role in maintaining privacy and controlling the flow of information. The app allows the senior or the admin to selectively grant access to specific individuals based on their roles. This means that not everyone in the network has access to all the information and activities within *Circles*. Instead, access is granted only to those who have a legitimate need for it, such as primary caregivers, healthcare professionals, or authorized family members.

In *Circles*, the concept of circles goes beyond traditional segregated groups found in platforms like WhatsApp. *Circles* serve as a means to regulate and facilitate inter-group communication while prioritizing privacy and control. Interactions between individuals from different circles are carefully managed, ensuring that privacy boundaries are respected.

Within the app, users have the ability to engage in direct messaging (DMs) with individuals, and temporary communication between two circles is facilitated. However, it is important to note that these interactions can only occur with the explicit permission of the elder or the admin, governed by role-based permissions. This approach allows for seamless communication and collaboration between individuals from different circles when necessary while maintaining a high level of privacy and control over the extent of information shared.

3.4.3 User roles

User roles are another important high-level component within the *Circles* app, providing distinct permissions and responsibilities to different individuals based on their designated roles. These roles help establish clear boundaries and facilitate efficient communication and coordination within the platform.

With role-based access control (RBAC) as the standard we use to manage roles, the *Circles* app can assign specific roles to different user types, such as seniors, caregivers, and healthcare professionals. Each role will have predefined access privileges based on their responsibilities and the information they need to interact with within the app. This ensures that users only have access to the necessary features and data relevant to their role, reducing the risk of unauthorized access to sensitive information.

By implementing RBAC, the *Circles* app demonstrates a commitment to privacy and security. It provides a systematic and structured approach to access control, allowing for the careful management of user permissions. RBAC ensures that only those with the

appropriate roles and responsibilities can access sensitive information, promoting privacy, confidentiality, and data protection for older adults using the app.

In *Circles*, various user roles are defined to cater to the diverse needs and requirements of different participants. Here are some common user roles that are set by default on the platform as they are typically relevant:

- **Elder:** The elder role emphasizes their autonomy, empowerment, and involvement in decision-making regarding their own care and well-being. Within this role, the elder has access to specific features and functionalities in the app that enable them to actively participate in managing their daily lives and maintaining social connections. The elder has total control of the app. This means that they can:
 - View and update their personal information
 - Communicate directly with anyone in their network through direct messages
 - Create and become a member of any circle on the app. This means that they could also create a circle and not be a part of it.
 - Create/modify/delete reminders for events and/or medication
 - Create/modify/delete tasks from their task lists for the helpers
 - Request tasks to helpers or caregivers
- **Administrator:** This role is identical to the elder role and it's only really necessary when the elderly individual is unable to set things up themselves. The person with this role is most likely going to be the main manager of the app for the senior as they will be responsible for managing and overseeing the overall operation of the *Circles* app. Administrators have privileged access and control over the system settings, user management, and the overall functionality of the platform. They ensure that the app operates smoothly. They handle technical aspects and have the authority to do anything in the app.
- **Primary Caregiver:** As the primary caregiver, this role holds significant responsibility for the well-being and care of the senior at the centre of the network. They have comprehensive access to the senior's health information on the app like medication details. The primary caregiver can manage and update medication schedules, set reminders, and track the senior's adherence to their medication regimen. They can also communicate with healthcare professionals, coordinate appointments, and ensure the senior's overall care needs are met.
- **Helper:** The helper role is for individuals who are willing to assist the senior with daily tasks and activities. They can access the task section of the app, where they can view assigned tasks, claim tasks and check off completed tasks. Helpers may include family members, friends or neighbours who offer support in activities such as grocery shopping, transportation, or household chores.

One of the key aspects of the role system in *Circles* is its flexibility and customization, allowing for dynamic management of permissions and the ability to create new roles as needed. This flexibility ensures that the app can adapt to the unique requirements and needs of the members of the network. In the admin panel, the senior or the admin, who has administrative privileges, can have control over the roles and permissions granted to each member. They can grant or revoke access to various features and functionalities of the app based on the level of involvement and responsibility desired by each individual. Additionally, the ability to create new roles with a newly defined set of permissions and access contributes to the flexibility of the app. As the network evolves and new requirements emerge, the senior or the admin can define and assign specific roles with customized permissions. This allows for a scalable and adaptable system that can accommodate changing needs and the inclusion of additional caregivers etc.

3.4.4 Task management

Another key aspect of *Circles* is its task management system, designed to facilitate effective coordination and collaboration within the care network. Task management plays a crucial role in ensuring that caregiving responsibilities are organized, delegated, and tracked efficiently. The task management system is designed to be inclusive and flexible, allowing not only designated caregivers but also the elderly individuals themselves or users with appropriate roles like the Helper role to actively participate in task management.

The helpers can access the task tab, which provides an overview of all the tasks that need to be taken care of. This tab serves as a centralized hub where caregivers, helpers, and the elderly person can easily view and engage with tasks. Upon accessing the task tab, users can browse through the list of tasks, organized by priority or due date. This allows them to assess the urgency and importance of each task and make informed decisions about which tasks they can contribute to.

If an elderly individual or a user with the Helper role identifies a task they would like to handle, they can claim ownership of that task within the app. By claiming a task, they signal their intention to take responsibility for its completion.

Once a task is claimed, the individual can proceed to fulfil it according to the provided instructions and any specific requirements. This could involve activities such as preparing meals, assisting with personal care, running errands, or providing companionship.

Once the task has been successfully completed, the individual can mark it as done within the app. This action updates the task status and notifies the senior that the task has been fulfilled.

3.5 User stories

To ensure a comprehensive understanding of the functionalities and capabilities of the *Circles* app, user stories provide a valuable perspective from various user viewpoints. In Agile software development, user stories are concise and simple descriptions of specific tasks or requirements from the perspective of end-users. They capture the needs, goals,

and motivations of users, focusing on what they want to accomplish with a product or software in our case. User stories typically follow a format of “As a [user role], I want [goal] so that [reason or benefit].” In this section, we present user stories tailored for different user types, including the common user, the elderly individual/admin, the user with the “helper” role and the user with the “primary caregiver role”. To maintain consistency and clarity throughout the user stories, we have adopted the format of starting each user story with the phrase “As a user.” without specifying the role because we decided to add the 4 main types of users to the side of the table to accurately define which user role can access which features. (the “common user” demonstrates a user with no defined role in the network). This approach allows us to clearly identify the user’s perspective and highlight the role they embody within the *Circles* app.

Table 3.1: User stories

User Stories	Description	Elder/ Admin	Primary Caregiver	Helper	Common user
As a user, I want to create my own social network to engage with those around me.	This feature allows users to create their own social network within <i>Circles</i> . Users can invite and connect with individuals they know, forming a dedicated space for interactions, sharing updates, maintaining relationships and asking for help if need be.	X			
As a user, I want to join an existing network so I can connect with people in an elder’s circle.	This feature allows users to join a specific circle by entering a unique invitation code provided by the elder/admin. By joining the network, users can be given access to circles and engage in conversations and activities with members of that circle.	X	X	X	X
As a user, I want to create my own profile so that I can update information about myself and engage with others in the app.	This functionality enables users to create and personalize their own profile within the <i>Circles</i> app. Users can update their personal information, and provide relevant details to facilitate interactions with other users and circles.	X	X	X	X

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Table 3.1: User stories (Continued)

User Stories	Description	Elder/ Admin	Primary Caregiver	Helper	Common user
As a user, I want to log in to the <i>Circles</i> app using my email and password so that I can access my personalized account and interact with the platform.	This functionality allows users to log in to the <i>Circles</i> app using their unique email and password. Users can securely access their personalized account and engage with the app's features and functionalities.	X	X	X	X
As a user, I want to log out of the <i>Circles</i> app securely, ensuring that my account remains protected when I'm not using the application.	This feature enables users to log out of the <i>Circles</i> app securely. Users can ensure the privacy and security of their account by logging out when not actively using the application.	X	X	X	X
As a user, I want to view all the circles/networks I'm a member of so that I can engage within them if need be.	This functionality provides users with an overview of all the circles or networks they are a member of. Users can easily access and navigate between their circles, enabling seamless engagement and interaction.	X	X	X	X
As a user, I want to engage in conversations within the circle that I'm in so that I can interact with other members.	This feature allows users to participate in discussions and conversations within the circle they are a part of through messages. Users can share their thoughts, ask questions, and engage with other members, fostering communication and social interaction.	X	X	X	X
As a user, I want to engage within any circle in my network within <i>Circles</i> so that I can stay connected.	This functionality enables users to actively engage within any circle in their network. Users can interact with circle members, contribute to discussions, foster relationships, and seek support as required.	X			

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Table 3.1: User stories (Continued)

User Stories	Description	Elder/ Admin	Primary Caregiver	Helper	Common user
As a user, I want to receive notifications about circle activities so that I can stay updated.	This functionality ensures that users receive timely notifications about circle activities, such as new messages, upcoming events, and important announcements. Users stay informed and can actively participate in circle interactions.	X	X	X	X
As a user, I want to see all the relevant upcoming events from the circles that I'm in so that I can stay updated on events that I should be aware of	This feature allows users to view a list of upcoming events from the circles they are a part of. Users can stay informed about upcoming activities and plan their participation accordingly.	X	X	X	X
As a user, I want to search through my contacts, circles and related events so that I can find things easily	This feature allows users to search for specific contacts, circles, or events within the app. Users can quickly locate relevant information and streamline their browsing experience.	X	X	X	X
As a user, I want to create a task and add it to my task list in the task centre so that I can keep track of the things I need to do and ensure nothing is overlooked.	This functionality allows users to create and add tasks to their personal task list within the app. Users can enter a title, a description, set deadlines, provide clear instructions or details associated with the task and track their progress, ensuring clarity and ensuring effective task management and organization.	X	X		
As a user, I want to create a new circle and invite members to join so that we can have a dedicated space based on our relationship or shared interests	This feature enables users to create a new circle within <i>Circles</i> and invite specific individuals to join. Users can define the circle's purpose (name), invite relevant members, and establish a dedicated space for communication, collaboration, or shared interests.	X			

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Table 3.1: User stories (Continued)

User Stories	Description	Elder/ Admin	Primary Caregiver	Helper	Common user
As a user, I want to add a contact to my <i>Circles</i> app so that I can easily reach out to them and stay connected with them within the platform.	This functionality allows users to add contacts to their <i>Circles</i> app by generating a unique invitation code. Users can share this code with others, allowing them to join the app, be added to circles, and facilitate seamless communication and connection.	X			
As a user, I want to delete a contact from my <i>Circles</i> app so that I can manage my contacts list and maintain an up-to-date and relevant network of connections.	This feature enables users to remove a contact from their <i>Circles</i> app. Users can delete a contact from their contacts list, ensuring that their network remains organized and consists of relevant and active connections.	X			
As a user, I want to take a contact out of a circle so that I can manage my members' list of a circle and maintain an up-to-date and relevant network of connections.	This functionality allows users to remove a contact from a specific circle within the app. Users can manage their circle's members, ensuring that the circle consists of relevant individuals and facilitating effective communication and collaboration.	X			
As a user, I want to create an event so that I can organize social gatherings, activities or reminders within my network.	This feature enables users to create events within the <i>Circles</i> app. Users can provide event details such as the title, category, date, time, participants, notes and location, facilitating the organization of social gatherings, activities, or meetings within their network.	X	X		
As a user, I want to create event categories to better organize and classify different types of events, making it easier for me or participants to find relevant activities/reminders.	This functionality allows users to create categories for events within the <i>Circles</i> app. Users can classify events based on their type or theme, making it easier to organize and locate specific activities or reminders within their network.	X			

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Table 3.1: User stories (Continued)

User Stories	Description	Elder/ Admin	Primary Caregiver	Helper	Common user
As a user, I want to add participants or circles to an event, ensuring that the right people are invited and can stay informed about the event details and updates.	This feature allows users to add participants or circles to an event within the app. Users can ensure that the right individuals or entire circles are invited to the event, enabling effective communication, coordination, and participation.	X	X		
As a user, I want to set a priority level for a task to indicate its importance and ensure that it receives appropriate attention.	This functionality enables users to assign a priority level to tasks within the <i>Circles</i> app. Users can categorize tasks as high, medium, or low priority, ensuring that they are prioritized and managed accordingly.	X	X		
As a user, I want to set a due date for a task, allowing me to establish deadlines and better manage my responsibilities and tasks.	This feature allows users to assign a due date to tasks within the app. Users can set specific deadlines for tasks, facilitating effective task management, and ensuring timely completion.	X	X		
As a user, I want to give a task a title and description, providing clear instructions or details for the task at hand.	This functionality allows users to provide a title and description for each task within the app. Users can provide clear instructions or details associated with the task, ensuring clarity and proper execution.	X	X		
As a user, I want to assign a task to a helper, delegating specific responsibilities to individuals within my network who can assist me with completing tasks.	This feature enables users to assign tasks to helpers within their network. Users can delegate specific responsibilities and tasks to individuals who can provide assistance, promoting collaboration and effective task completion.	X			

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Table 3.1: User stories (Continued)

User Stories	Description	Elder/ Admin	Primary Caregiver	Helper	Common user
As a user, I want to access the health section on the app to view my medication reminders, ensuring that I stay on track with my medication schedule.	This functionality allows users to access the health section within the app. Users can view their medication reminders, ensuring adherence to their medication schedule and promoting better healthcare management.	X	X		
As a user, I want to assign roles to members of the app to define their responsibilities and level of access within the network.	This feature allows users to assign roles to members within the <i>Circles</i> app. Users can define specific responsibilities and access levels for each role, ensuring clarity and effective collaboration within the network.	X			
As a user, I want to give permissions and access to specific people or roles, granting them the ability to perform certain actions within the app.	This functionality enables users to grant permissions and access to specific individuals or roles within the app. Users can assign specific privileges, allowing designated users to perform certain actions or access specific features.	X			
As a user, I want to revoke permissions and access from individuals or roles, ensuring that I have control over who can perform certain actions or access specific information.	This feature allows users to revoke permissions and access from specific individuals or roles within the app. Users can modify access levels or remove privileges, ensuring control and security over the app's functionalities.	X			
As a user, I want to remove specific messages from a circle's chat so that I can keep the conversation focused and organized.	This functionality enables users to remove specific messages from a circle's chat. Users can delete or hide messages, ensuring that the conversation remains focused, relevant, and organized.	X			

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Table 3.1: User stories (Continued)

User Stories	Description	Elder/ Admin	Primary Caregiver	Helper	Common user
As a user, I want to mute messages from a particular circle's chat temporarily, so that I can reduce distractions when needed.	This feature allows users to mute messages from a specific circle's chat temporarily. Users can silence notifications or hide chat activity, reducing distractions and enabling focus when required.	X			
As a user, I want to easily view the circles I'm a part of to stay updated and engaged within my network.	This functionality allows users to view the circles they are a part of within the app. Users can access an overview of their circles, facilitating easy navigation, and ensuring active engagement within their network.	X	X	X	X
As user, I want to mark that I've taken my medication within the app, providing a record of my medication adherence and helping me stay organized with my healthcare routine.	This feature allows elders to mark the medication they have taken within the app. Elders can keep a record of their medication adherence, stay organized with their healthcare routine, and track their medication history.	X			
As a user, I want to add medications to my health section within the app, allowing me to keep track of my medications, dosages, and schedules.	This functionality enables users to add medications to their health section within the app. Users can enter medication details, including the name, dosage, schedule, and instructions, facilitating effective medication management.	X	X		
As a user, I want to receive a reminder to remind the elder to take their medication if I notice that they haven't done so within a certain timeframe, ensuring their medication adherence and well-being.	This feature provides users with medication reminders within the app. Users receive notifications or alerts, ensuring they stay on track with their medication schedule and don't miss any doses.	X	X		

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Table 3.1: User stories (Continued)

User Stories	Description	Elder/ Admin	Primary Caregiver	Helper	Common user
As a user, I want to edit the medication reminders in the app, enabling me to customize the timing and frequency of medication notifications based on my specific needs.	This functionality allows users to edit the medication reminders in the app. Users can customize the timing, frequency, and other parameters of the medication notifications to align with their specific medication regimen and personal preferences.	X	X		
As a user, I want to claim a task received as a task alert notification from the task centre, indicating my willingness to complete the assigned task.	This feature enables users to claim a task that they received as a task alert notification from the task centre. Users can indicate their willingness to take responsibility for the assigned task, ensuring effective task assignment and management within the app.	X		X	
As a user, I want to dismiss a task alert notification if I am unable to perform the assigned task, allowing for effective task management and communication within the app.	This functionality allows users to dismiss a task alert notification if they are unable to complete the assigned task. Users can communicate their inability to proceed with the task, facilitating efficient task management and ensuring effective communication within the app.	X		X	
As a user, I want to easily access the task centre within the app, providing a centralized location for managing and tracking assigned tasks, ensuring efficient task completion.	This feature provides users with easy access to the task centre within the app. Users can conveniently navigate to the task centre, which serves as a centralized hub for managing and tracking assigned tasks, enhancing task organization and promoting efficient task completion.	X		X	

By capturing the needs, goals, and motivations of different user roles, we have gained valuable insights into how the app can effectively address the unique requirements of each user group. The user stories presented in this section have provided a clear overview of the specific tasks and requirements that users expect from the *Circles* app. With the user stories serving as a foundation, we now shift our focus to the design of the app's interface,

where we will delve into the creation of mock-ups and interaction flows.

3.6 Interface mock-ups and interaction flows

We have put great emphasis on creating a user-friendly interface that enhances the user experience and promotes seamless interactions within the app. To achieve this, we have designed interface mock-ups and a defined interaction flow representing the second use case scenario in John’s life that outline the visual representation and user interactions within *Circles*. These mock-ups serve as visual representations of the app’s various screens, showcasing the layout, design elements, and key features. The interaction flow describes how users navigate through different screens, interact with various features, and accomplish their goals in the app.

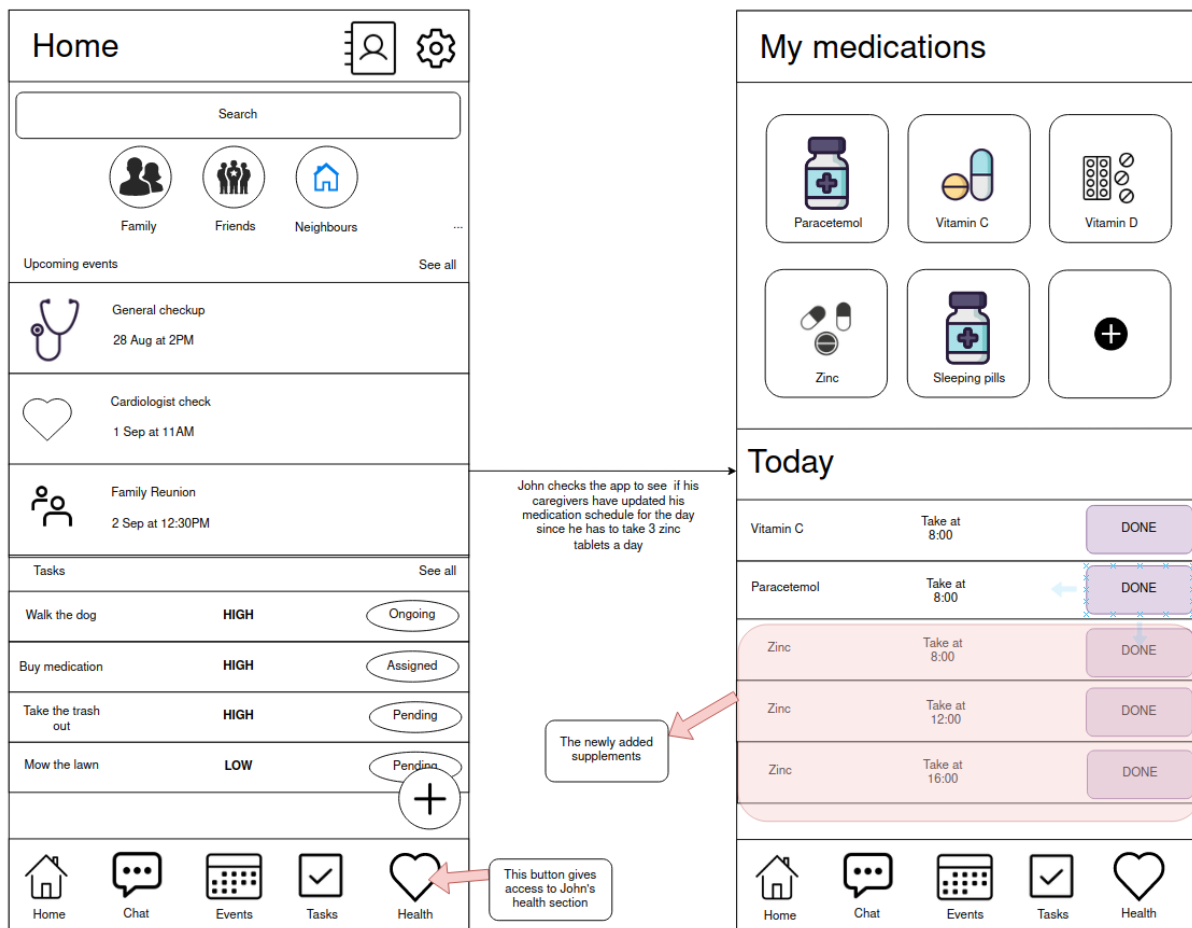


Figure 3.2: Mock-ups for John’s homepage (left) and his health section (right) on *Circles*. John checks the app to see if his caregivers have updated his medication schedule for the day since he has to take 3 zinc tablets a day

On the left, we see John’s homepage when he opens the *Circles* app. At the top of the screen, you can see a search bar where he can search for any contact, circle or event on the application. Under that, we see a visual representation of the circles he’s in. By clicking

on the circle, he will immediately be transported to the circle's chat discussion. Under that, he can find a small recap of his upcoming events that were either created by him or by someone in his network with that permission. By clicking on the event, he can get more details relating to that event. Right under that section is a list of his most pressing tasks, sorted by priority (High, Medium, Low). You can also track the progress of these tasks. "Pending" means that the task needs to be claimed. "Assigned" means that a task has been assigned to someone but has not yet been done. "Ongoing" is when someone has claimed the task and "Done" means that the task has been completed. The plus button on the bottom right side of the screen is a button to create either a new task, a new event, a new contact, a new circle or to join a new circle.

John clicks on the heart icon to access his medication reminders. Here, he can both add or delete medications and click on "DONE" to confirm that he has taken the medication scheduled at that time.

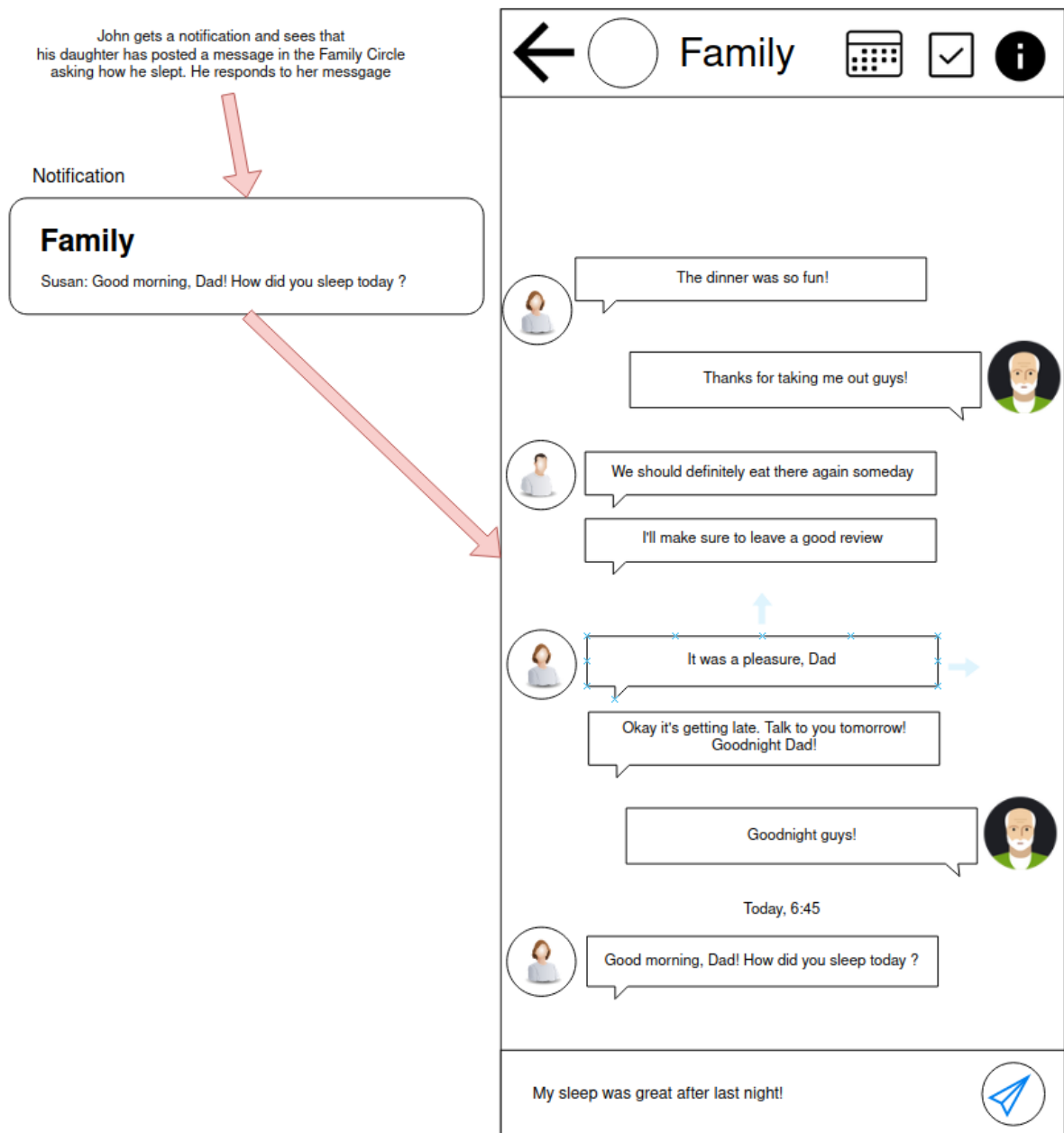


Figure 3.3: Mock-up of John's Family circle. John gets a notification and sees that his daughter Susan has posted a message in the Family Circle asking how he slept. He responds to her message

Here we can see the interactions in John's family circle. On the top right side of the screen, you have shortcuts to the events and tasks related to the circle and a button to get more information on the circle and edit its setting.

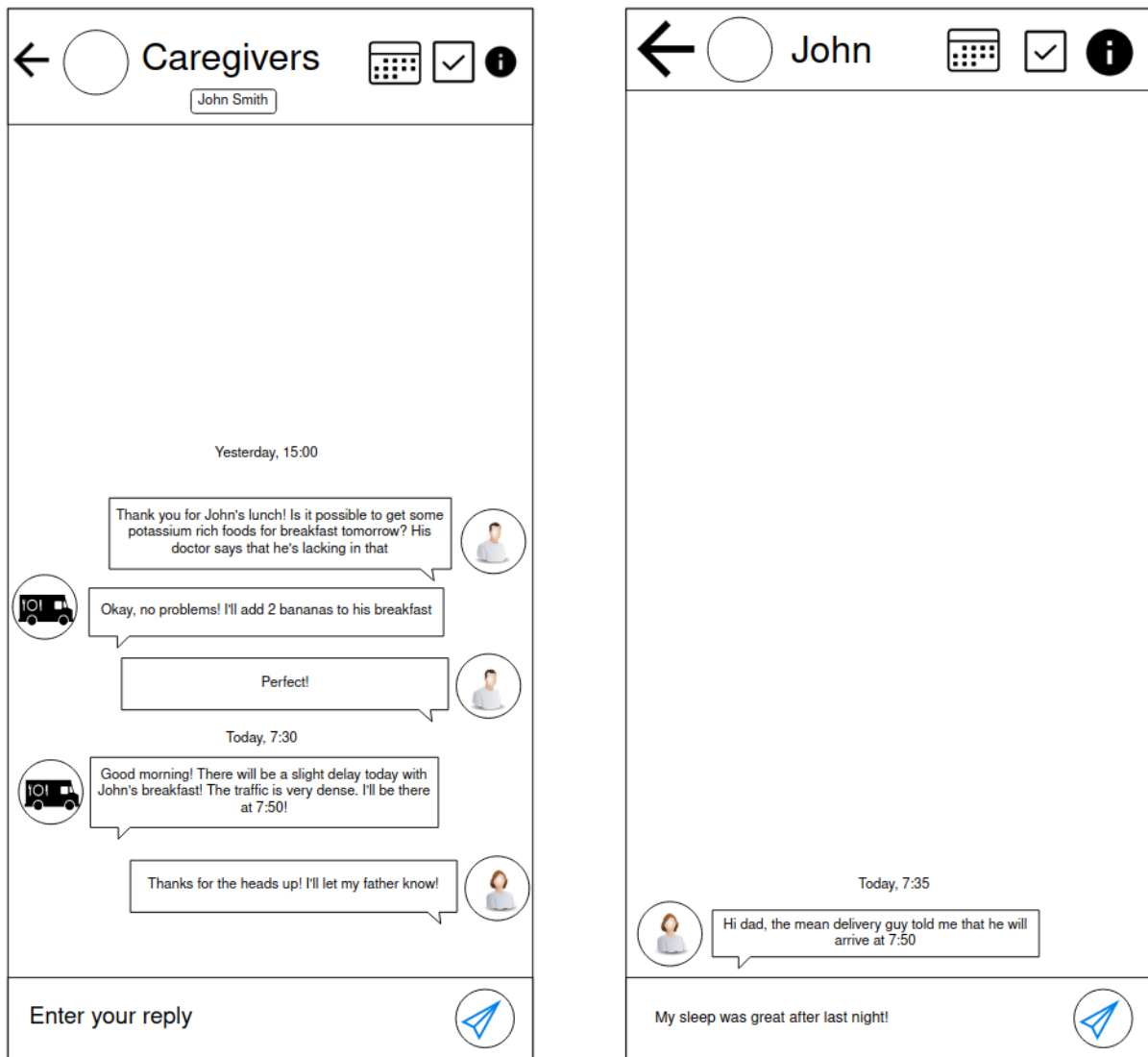


Figure 3.4: Susan's view of the Caregivers circle and her interaction with the food delivery service(left) and with John (right)

Previously, John has temporarily allowed communication between the food delivery provider and the Caregiver circle. We can see their interaction. Since this is Susan's view, we can see that under the Circle name, there is a label with John's name. This is to specify that this Caregiver circle belong to John's network. This label is important because Susan could be in multiple different caregiver circles of other networks. John has decided not to be included in this story so Susan has to relay the information to John via direct messages.

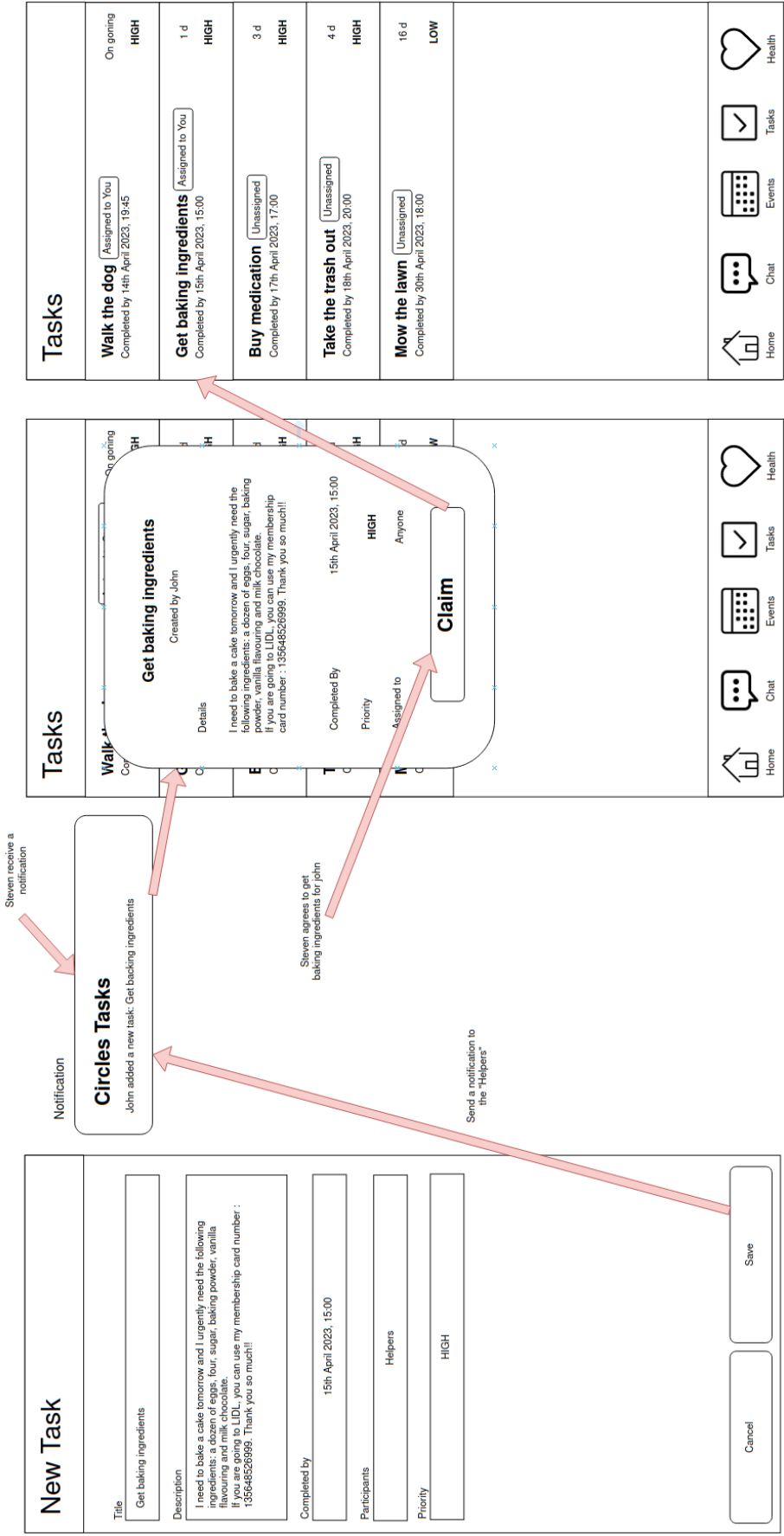


Figure 3.5: Mock-up of John adding a new task (left), Steven receiving the notification of the new task (middle), Steven's view of the task management screen in Circles after he has claimed John's new task

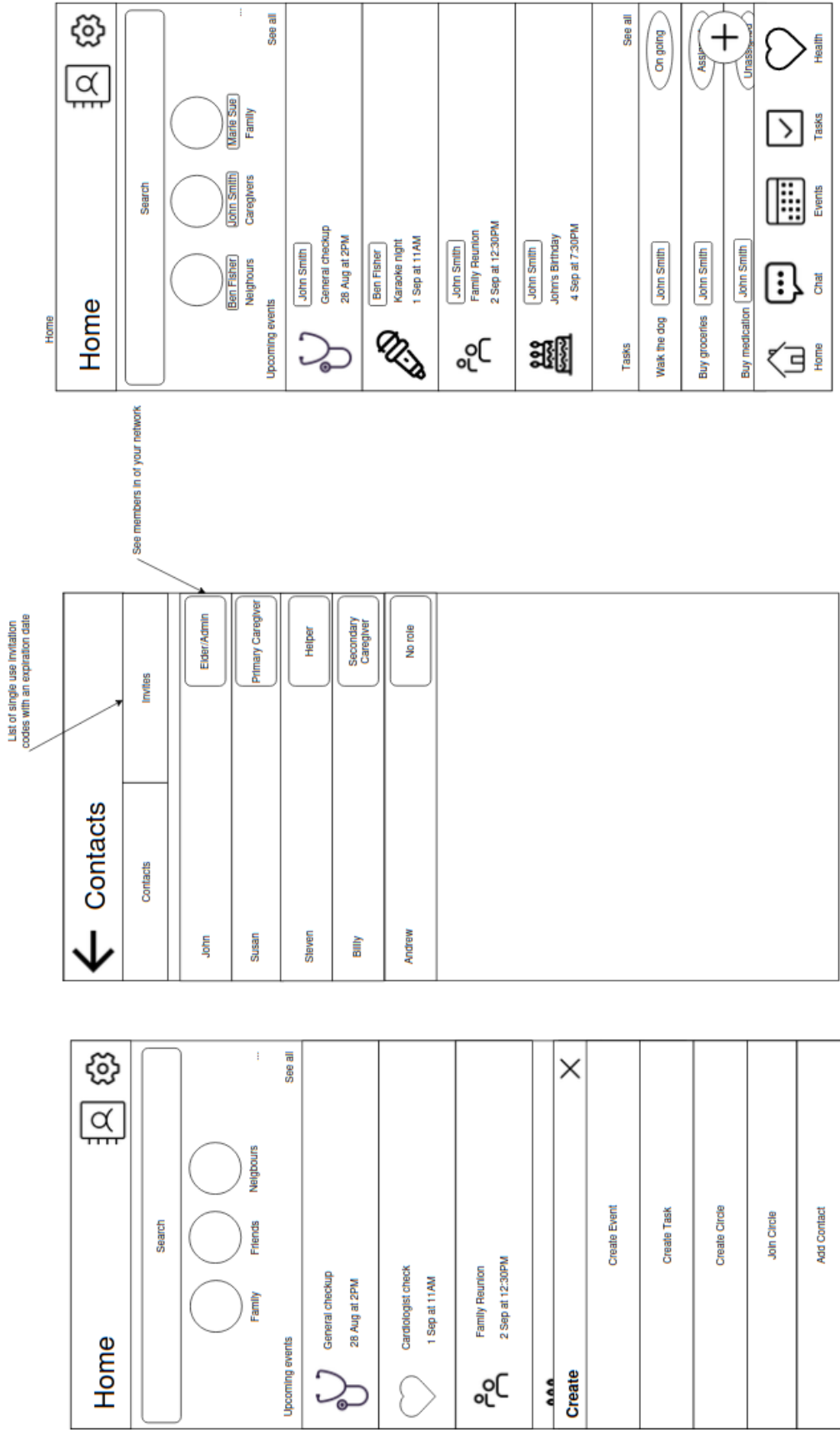


Figure 3.6: Additional mock-ups. John's homepage view when he clicks on the + button(left), John's contact list when he clicks on the contact icon on the top right side of the homepage(middle), Susan's view of her homepage, highlighting the network labels under the circles view at the top, in the event reminder list and in the task management list

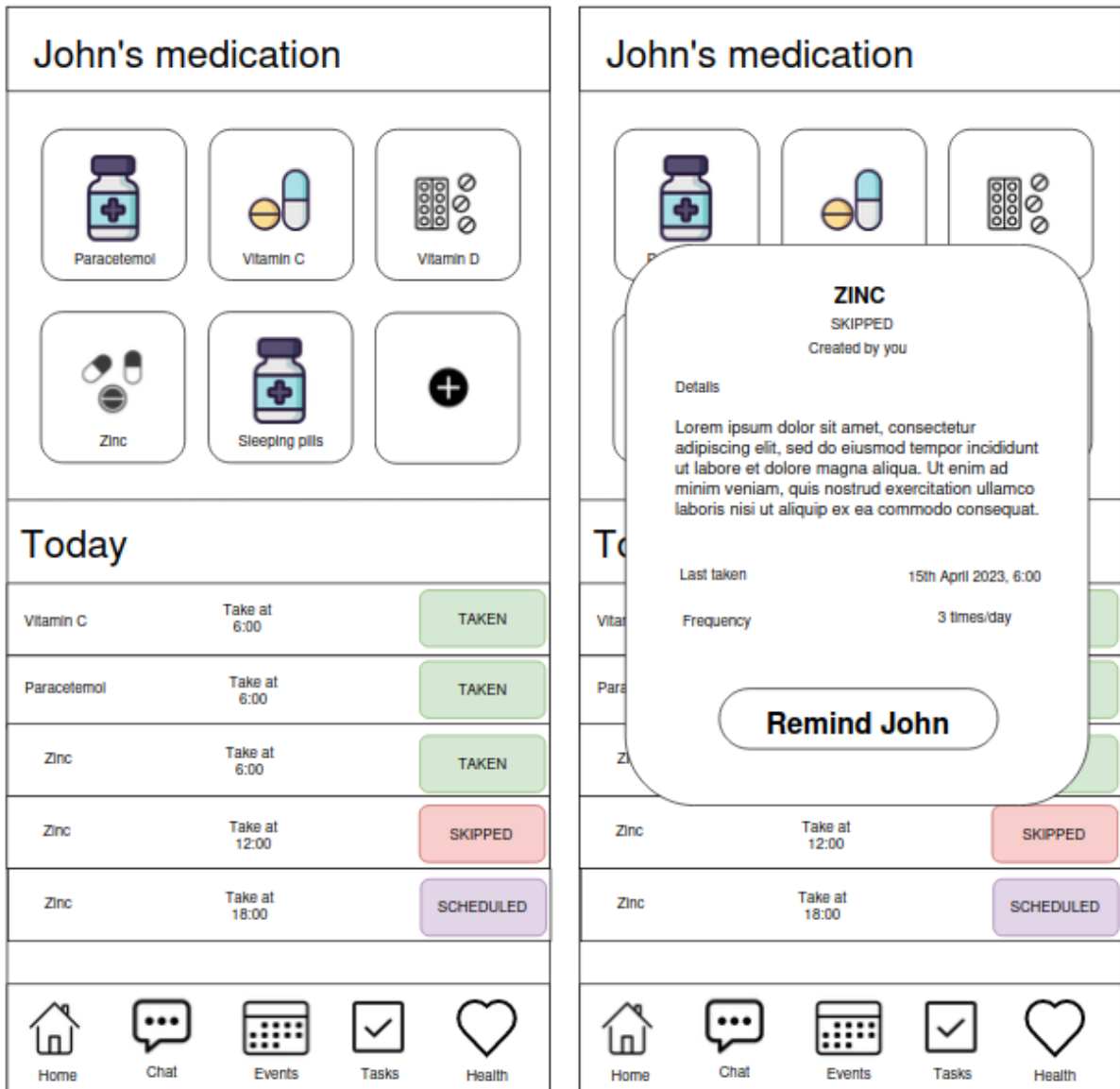


Figure 3.7: Susan's view of John's health section.

Susan's view of John's health section provides her with valuable insights into John's medication adherence. On this screen, Susan can easily access the status of John's medication schedule and track his daily intake. As she navigates through the app, Susan notices that John has missed his zinc tablet at 12:00 PM, which is crucial for his health management. Understanding the importance of medication adherence, Susan takes immediate action by clicking on the reminder associated with the missed dosage. With a simple tap, Susan initiates a reminder for John to take his zinc tablet. This action triggers a notification that is instantly sent to John's phone, ensuring that he receives a timely reminder. The alert serves as a gentle nudge, prompting John to take his medication and maintain consistency in his treatment plan. This real-time interaction between Susan and John exemplifies the app's ability to bridge the gap between caregivers and elderly individuals, fostering a stronger sense of support, trust, and well-being.

Chapter 4

Implementation details

In previous chapters, we explained what *Circles* is and its different features. In this chapter, we will introduce our technical solution and explain how we built the *Circles*' app prototype. In the beginning, we searched among existing open-source projects in the hopes of finding a project that would serve as a base for building *Circles*. A base that we could modify and adapt to include all the functionalities *Circles* needed. One such project was the Matrix [20] protocol and its different implementations. The first section details how we analyzed the Matrix software, and why this analysis led us to decide to go against a Matrix implementation. In the end, we decided not to follow through with the initial Matrix idea and we built our own solution using various modern technologies and frameworks. These technologies and frameworks, as well as the *Circles*' architecture and various screenshots, are presented in the second part of this chapter.

4.1 Matrix experimentation

Matrix is an open-source project that publishes an open standard for secure, decentralised and real-time communication. Since *Circles*' main focus is also communication, Matrix seemed to be a good fit. By using the Matrix open standard, *Circles* users would benefit from end-to-end encryption for all their messages in the app. Those messages could be managed in a decentralised way, meaning that any privacy-conscious person that wishes to take the time to configure and manage their own servers could do so. The Matrix open standard contains specifications for modern text messaging features like group chatting, emoji reactions, replying to specific messages, sending images and files, making polls, and more. Matrix also has voice and video call capabilities.

Another interesting aspect of Matrix was its interoperability. Matrix is open to exchanging data and messages with other platforms using bridges. There are different types of Matrix bridges but they all have the same common goal: allowing Matrix users to send messages to other users via other communication platforms such as SMS, email, social media, and more. Due to the additional complexity involved, we didn't thoroughly delve into this idea.

Due to its potential, we have conducted many experiments on Matrix. Since *Circles* is a mobile application, we tried several Matrix mobile clients, including Element [21] and FluffyChat [22]. These two clients are among the most developed. They contain most of the features that the Matrix standard offers but their interface remains unintuitive in some places which would be difficult for older people. For example, FluffyChat shows unusual status symbols with each message and makes conversation encryption difficult to understand; Element and FluffyChat both make basic features awkward to use or hide these features in sub-menus which makes finding them unintuitive as well. Moreover, the code of these two clients is huge, quite difficult to understand and complex to adapt to our use case. We concluded that Matrix was too complicated and that we would spend a lot of time debugging and fixing complex parts of their Matrix implementation instead of spending the time to work on the actual unique features that *Circles* offer.

In our proof of concept (described below), we present an application built without Matrix. For now, our proof of concept includes a more basic chat functionality that solely features text messages. To enhance *Circles* in the future, we could still use Matrix, however, we recommend taking another approach: include the Matrix protocol step by step using a Matrix SDK [23] instead of building *Circles* on top of an existing app.

4.2 Proof of concept

The proof of concept is an Android app built to showcase a few core features explained in chapter 3. The *Circles* app is built using the state-of-the-art technologies presented in this chapter and is not the result of modifications of an existing open-sourced app.

This proof of concept has a website (<https://circles-ucl.vercel.app>) and the source code is publicly available on Github (<https://github.com/Mathieu-COSYNS-Student/circles>).

4.2.1 Architecture

Circles is composed of two user-facing interfaces and one main server component that calls different databases and external service providers. We used Google Firebase [24] and Clerk [25] to build complex real-time features, send push notifications and manage user authentication.

The architecture image (Figure 4.1) shows an overview of all the software components and services that we used to build circles and how they are linked to each other. *Circles* is built with a series of libraries and frameworks, some of which are shown in the diagram. They are explained in the next section.

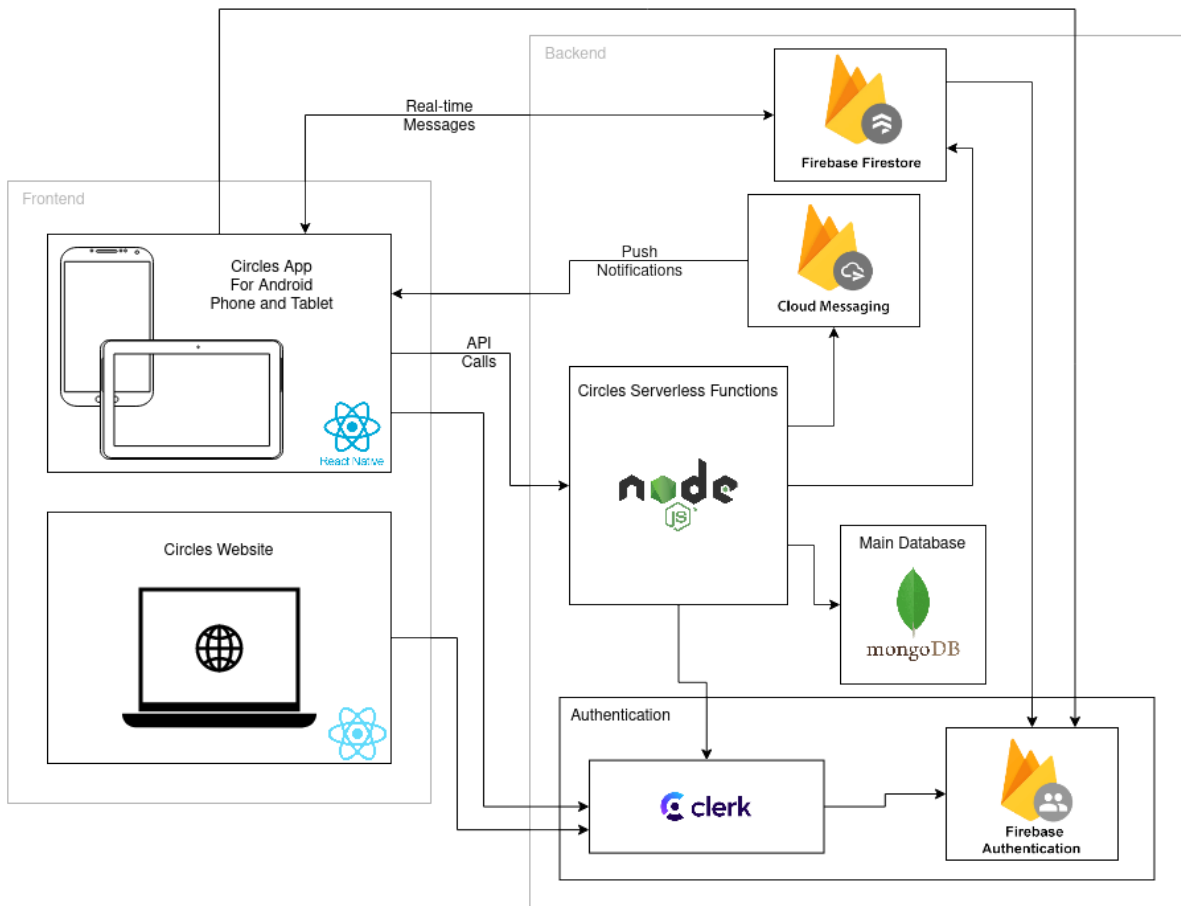


Figure 4.1: Circles Architecture Overview

The main way to interact with *Circles* services is through the *Circles* app. For now, it is only available as an Android [26] APK file but with the technical choices we made, it would be relatively easy to expand the app to Apple IOS [27] devices.

The *Circles* website, is made for marketing purposes. On the website, you can read about *Circles* and its features. On the website, *Circles* users can also log in, access and update their account information. This choice was made because it was really simple to set up and offer account management features provided by Clerk [25] that are not yet available in the application.

4.2.2 Technologies used to build *Circles*

React Native

The main library behind the *Circles* mobile app is React Native [28]. React Native allows its users to create native apps for Android, iOS, and more using React. React Native combines the best parts of native development with React for building user interfaces. Under the hood, React Native renders to native platform UI, meaning our app uses the same native platform APIs other apps do.

Alongside React Native, the *Circles* app uses Expo [29]. The Expo package provides a suite of features (dependencies management, native apps compiler, powerful dev server to connect to any device while developing, comprehensive suite of well-tested React Native modules with bindings to native code, ...) that make it easier to develop and scale complex React Native applications. This greatly simplifies the development process.

For *Circles*, React Native was the best option. Compared to other alternatives, React Native offers an efficient result and ease of development. We could have gone for platform native development or another cross-platform technology instead of using React Native. For users of mobile applications, platform native offers the closest experience to their device but none of the app code base can be shared between Android and IOS devices. This means that in order to extend our support to IOS devices, we would have to write a new app made for IOS only. Other cross-platform technologies such as Flutter, Ionic, Xamarin and PhoneGap all have bigger trade-offs than React Native. They either rely on their own engine to draw the interface or on webviews instead of native platform UI, which greatly affects performances and/or subverts user expectations. Flutter and Xamarin are written in Dart and C# respectively; two programming languages we are not familiar with. It was more straightforward for us to work with React Native since we already knew how to code in React and JavaScript/TypeScript.

Node.js

The *Circles* app communicates with back-end API services written in JavaScript/TypeScript and executed in a Node.js [30] environment. This choice was made mainly because Node.js is already a proven environment to run JavaScript in and we wanted to share the same programming language we used for the mobile application. Since both the app and the server are written in TypeScript, we can share type definition and utility code. This choice was also motivated by the use of the TRPC [31] library. TRPC provides an abstraction and a type-safe way to create web APIs. It helps to validate data and connects the front end to the back end. With TRPC, we can build APIs, without worrying about the underlying HTTP REST API calls and the type of data returned by REST API endpoints.

MongoDB

Since we imagined our app being used by many users, we chose MongoDB [32] as *Circles*' main database. MongoDB is a popular and proven database system to deal with large volumes of data. The database layer on *Circles* is an area that needs more work and performance experimentation. *Circles*' current implementation structures the data in a relational way (see Appendix A.1) and use Prisma [33], an Object Relational Mapper (ORM), as a layer between the Node.js code and the MongoDB database. Our database layer is built like a SQL relational database would be, with highly normalized data. Some queries require a lot of look ups between MongoDB collections. Since we started with MongoDB, we kept it but we think that the data should be denormalized in some places. Denormalizing the data would increase performance and take full advantage of MongoDB. Another solution would be to use a relational database like PostgreSQL [34] as it makes more sense with our current structure. To handle a lot of data in PostgreSQL, there are solutions such as partitioning and sharding [35]. In *Circles*, networks are segregated (a

network does not communicate with another) which means that different networks in *Circles* can be distributed across different SQL servers.

Vercel

Circles' main cloud/infrastructure provider is Vercel [36]. Vercel is a company that built a platform that provides seamless deployments with zero configuration for JavaScript projects. The use of the Vercel platform has many advantages. As a developer, one main advantage is their push to deploy capability. For each commit pushed into our GitHub repository, Vercel creates a deployment with our up-to-date changes. Other alternatives, with the same functionality, exist but the Vercel solution is particularly well-made and easy to use. It allows us to build fast without having to worry about infrastructure.

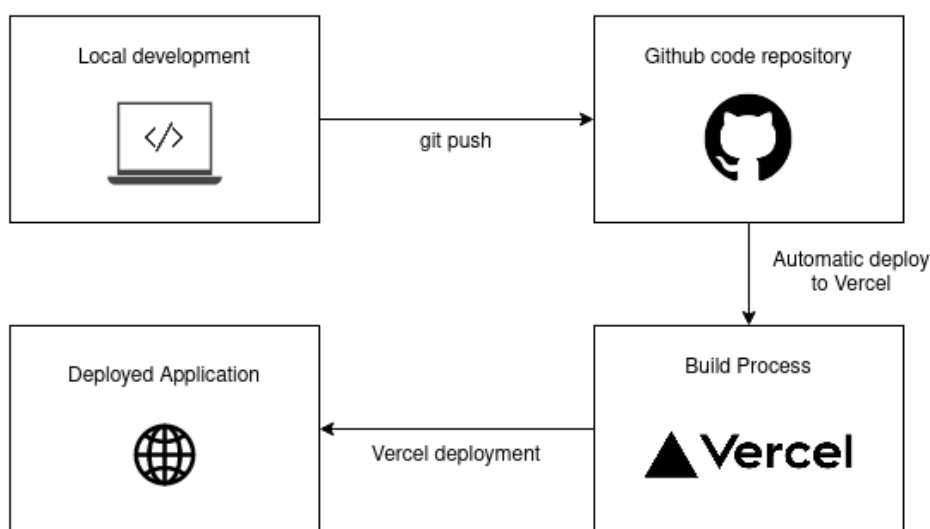


Figure 4.2: Push and Deploy on Vercel

Vercel deploys apps intelligently and creates an optimized configuration for the different parts of our applications. Vercel's static and serverless infrastructure is designed to scale infinitely and then scale back down to zero. It intelligently routes traffic and runs logic as close to the users as possible. Each request is handled in isolation, and content is replicated globally, ensuring stability.

As explained before, *Circles* has a website and a Node.js back-end API. We wrapped both in Next.js, Vercel's framework, allowing Vercel to deploy our application efficiently. In Figure 4.3, we see a summary of how Vercel distributes *Circles*' website and API in different parts of his infrastructure. The Edge Middleware contains the logic to authenticate users and route traffic accordingly. Static Assets contain everything that the website needs. Functions contain our API endpoints.

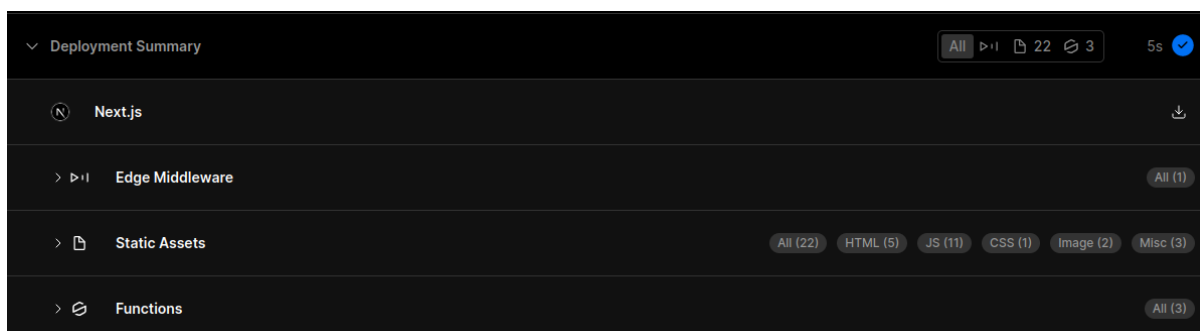


Figure 4.3: Circles Deployment Summary on Vercel

Circles' current implementation does not have a hard dependency on Vercel. Vercel could be swapped with another solution with a minimal amount of work. For this proof of concept, we used Vercel's free tier subscription plan. As the app grows, the cost of running *Circles* could become significant. Behind the scenes, Vercel resells AWS [37] services at a higher price with their added features and simplifications. We think that a self-hosted solution on an IaaS cloud makes sense once *Circles*' deployment costs become more important on Vercel than the cost of hiring a system administrator or spending a developer's time on infrastructure management.

Clerk

Circles' uses Clerk [25] for authentication and user management. Clerk provides us with a simple way to create user authentication. Our current proof of concept only offers password authentication. With Clerk, it was easy to build and it offered extra security compared to something that we would have built from scratch. Clerk automatically sends an email to users who sign in with a verification code. It also sends password reset emails on demand. Clerk checks for weak passwords or passwords that have leaked in past security breaches. Clerk provides other authentication methods such as social login with Google and advanced security measures such as two-factor authentication but those features are not integrated into *Circles*' proof of concept.

Firebase

Firebase [24] is a suite of Google Cloud products. *Circles* uses Firebase for its messaging product and its Firestore real-time database. Firebase Messaging enables *Circles* to send push notifications to *Circles* users (for example to inform a network owner or administrator that someone joined their network using their invite). Firestore is used in the chat part of *Circles*. With Firestore, *Circles* users can send and receive messages instantly.

4.2.3 Current state of the proof of concept

Circles' proof of concept implements core circle features like user accounts, networks, circles, permissions and roles. This section will present, and explain, features available in *Circles* proof of concept.

The proof of concept does not include any functionalities linked to the tasks, events/appointments, medications, or reminders. There are still multiple aspects of the app that needs to be worked on to have a fully featured app with all of the features presented in chapter 3.

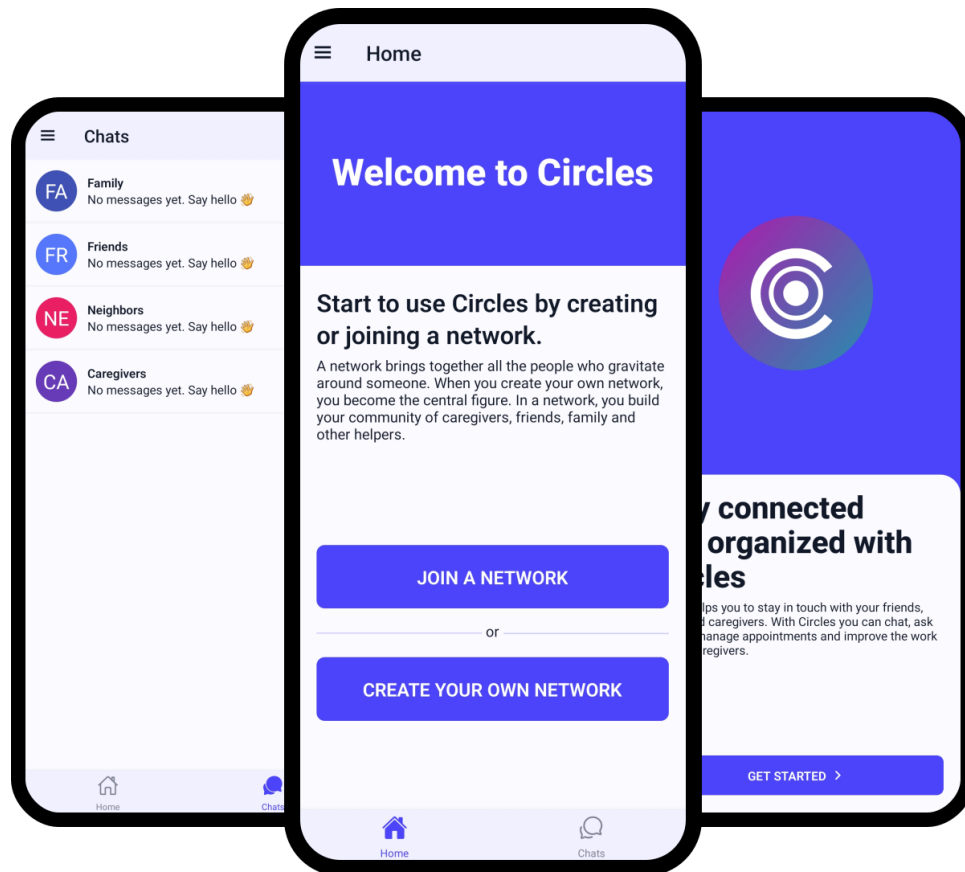


Figure 4.4: Circles app

Onboarding and user authentication

The onboarding (Figure 4.5) is shown to any user when they first open the app after downloading it. When a user clicks on the “Get Started” button, they are redirected to the sign-in screen (Figure 4.6). If they already have an account, they can log into *Circles* with their credentials or they can tap the sign-up button to go to the sign-up screen (Figure 4.7). If a user forgets his password, they can also reset their password by clicking “Forgot your password?”

Figure 4.7 shows the sign up screen. After filling out the form, the user is redirected to a screen where they have to enter the code (Figure 4.8) they received by email. This ensures that everyone signs up with a real email address that they own.

The forgot password functionality (Figure 4.9) works in a similar way to the sign-up email verification. A user who forgot their password will receive an email with a code. Then, they can copy the code in a form to access another form where they can reset their password (Figure 4.10).

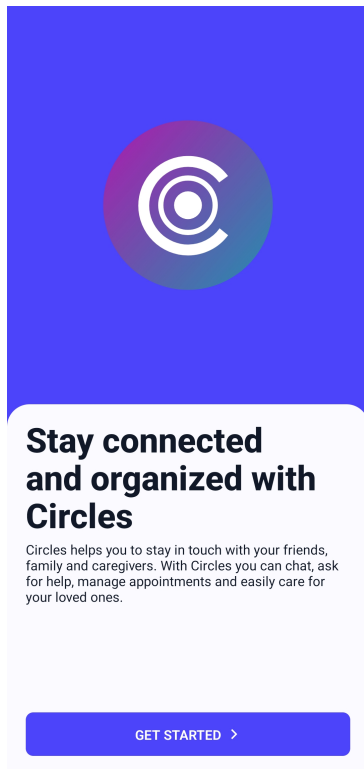


Figure 4.5: Onboarding

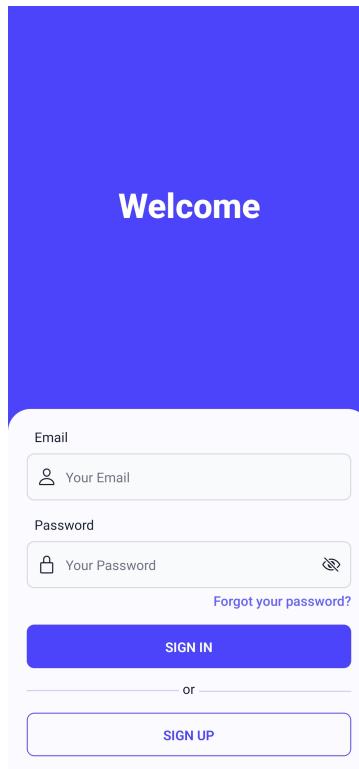


Figure 4.6: Sign in

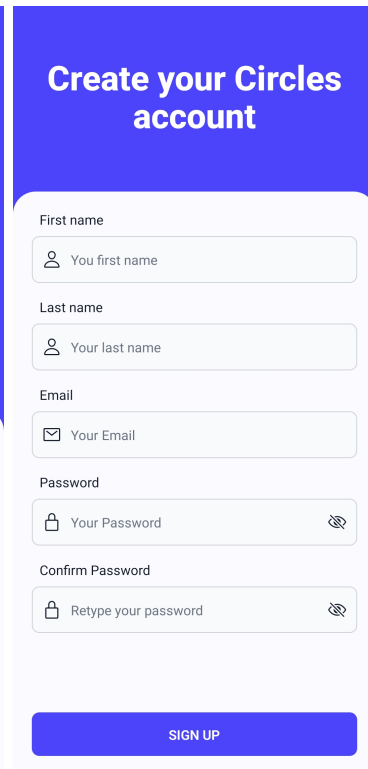


Figure 4.7: Sign up

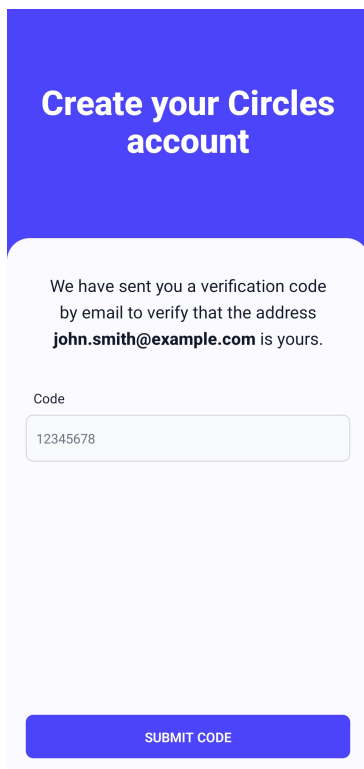


Figure 4.8: Sign Up Email Verification

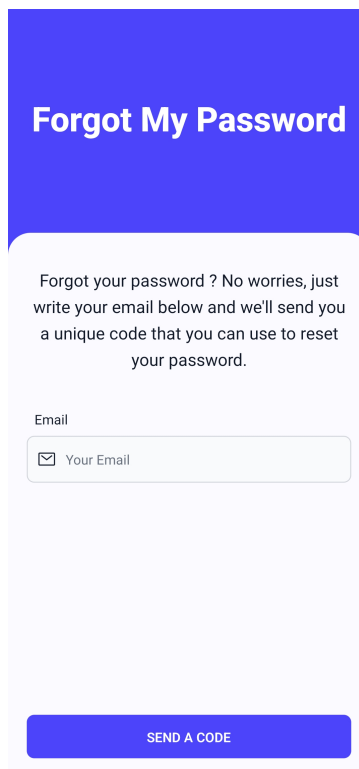


Figure 4.9: Forgot Password

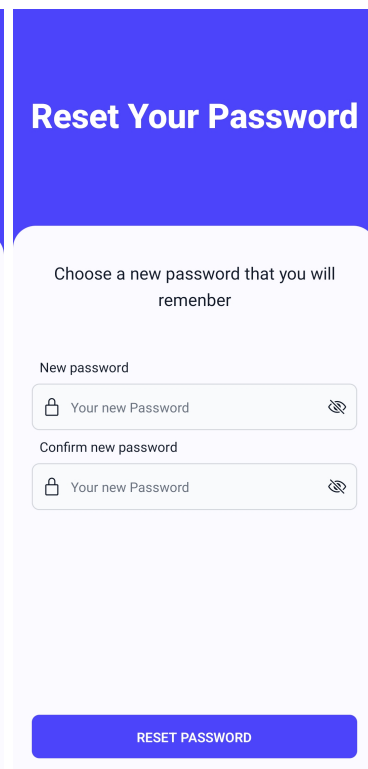


Figure 4.10: Reset Password

Network create, invite and join

Every user can create their own network or join someone else's. Once they first open the app, they do not belong to any network and are presented with a choice: create their own network or join an existing network (Figure 4.11).

Each user can create one and only one network (Figure 4.12). A network's only attribute is its name.

In a network, the elder or the admins can create invitation codes and share them with a person they wish to invite to the network (Figure 4.13). *Circles* generates a code that can be shared within any other app on their device (via email, text message, social media etc). Then, the user who receives the invite can enter the network name and invitation code to join the specified network (Figure 4.14). *Circles* also generates a QR code in the app and offers the functionality to scan QR codes. (Figure 4.15). This last feature is handy for users who are in the same room as it is way easier and safe.

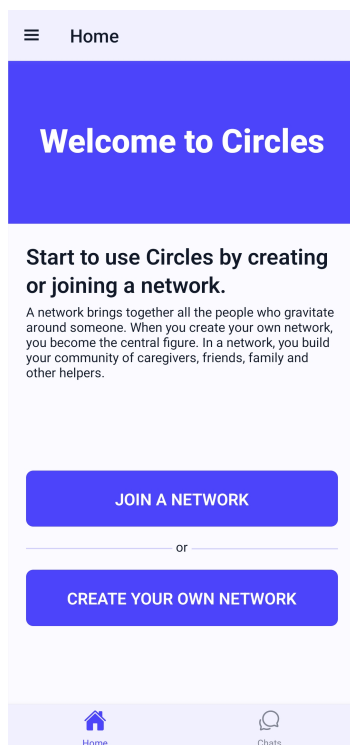


Figure 4.11:
Welcome (shown after signing up)

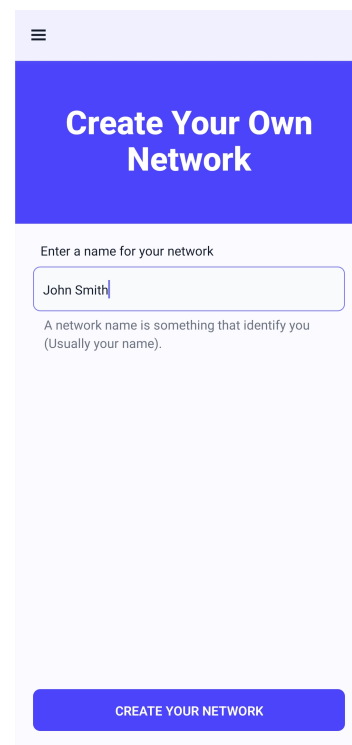


Figure 4.12:
Create a network

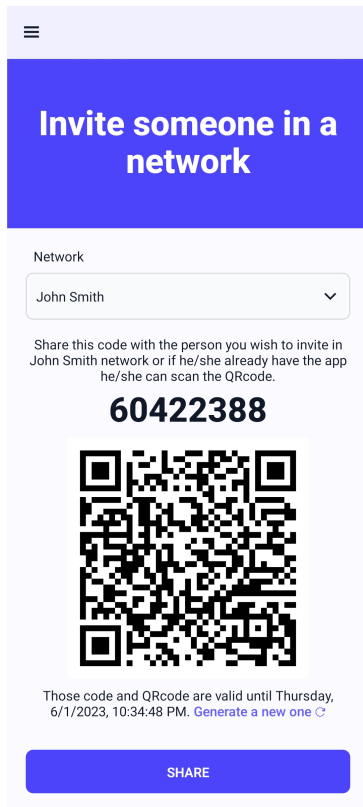


Figure 4.13:
Invite in a network

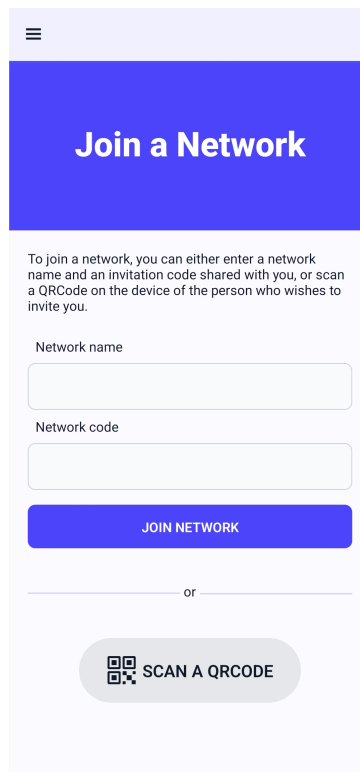


Figure 4.14:
Join a network

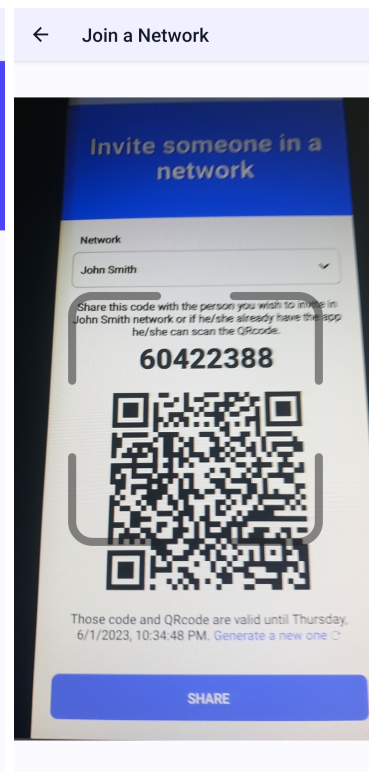


Figure 4.15:
QR code scanner

Network administration

Network owners (users with the “elder” role) or users who have permission can manage the network. *Circles* has a dedicated space where people with the specified access can view every circle in a network, even those they are not members of (Figure 4.16). They also have a page where they can see every member of the entire network (Figure 4.17) and the roles that exist (Figure 4.18). The roles ensure that each network member has access to the information they need and not more. Figure 4.19 shows an example of permission configuration for the “Primary caregiver” role.

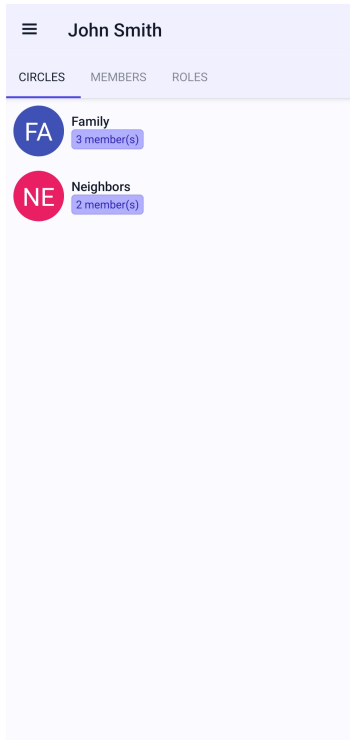


Figure 4.16:
List of circles in a network

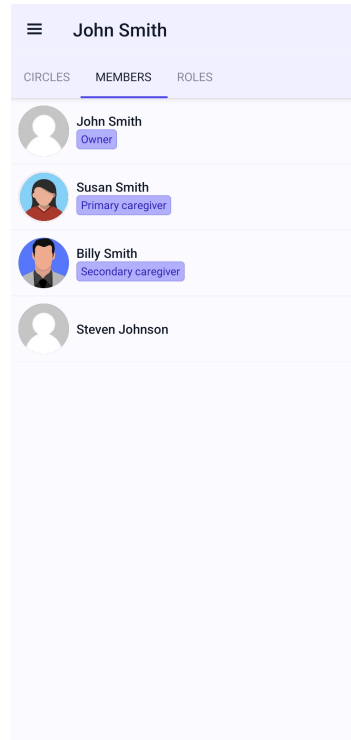


Figure 4.17:
List of network members

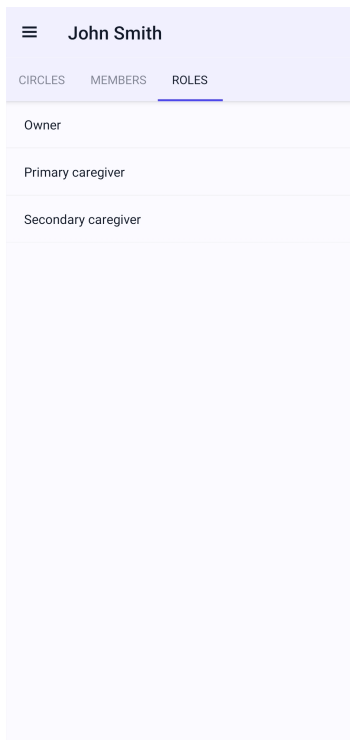


Figure 4.18:
List of roles in a network

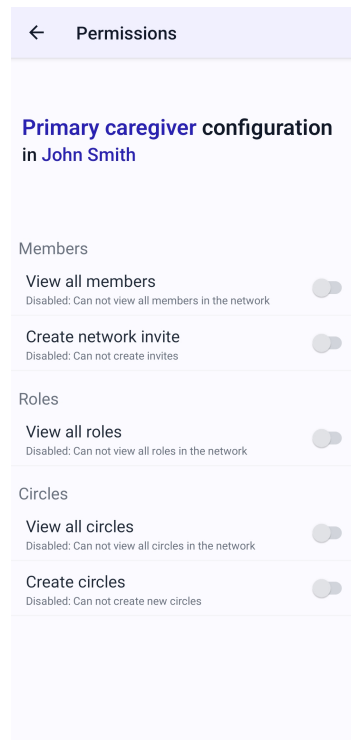


Figure 4.19:
Role configuration for Primary caregiver

Circles

Elders and admins can create new circles (Figure 4.20) inside the network. A network has a name and a list of participants.

Inside a circle, each participant can exchange messages as *Circles* includes a chat functionality (Figure 4.21). In a chat, participants can send and receive text messages in real time. *Circles* chats work well but lack a lot of features that are expected from modern chat apps like sending pictures and videos, voice messages, replying to a specific message, emoji reactions etc...

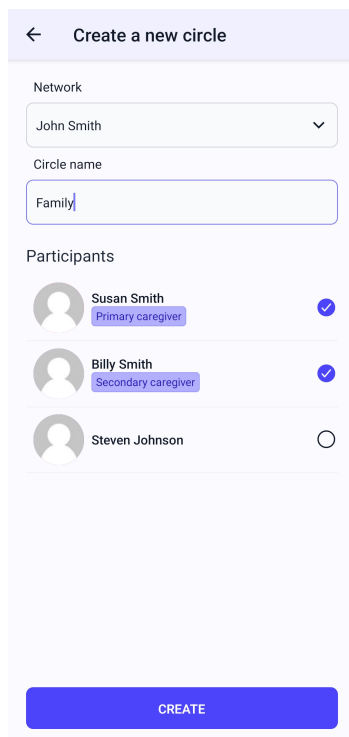


Figure 4.20:
Create circle screen



Figure 4.21:
Chat within the Family circle

Account

The account screen (Figure 4.22) is a page where a user can safely log out or change their password (Figure 4.23).

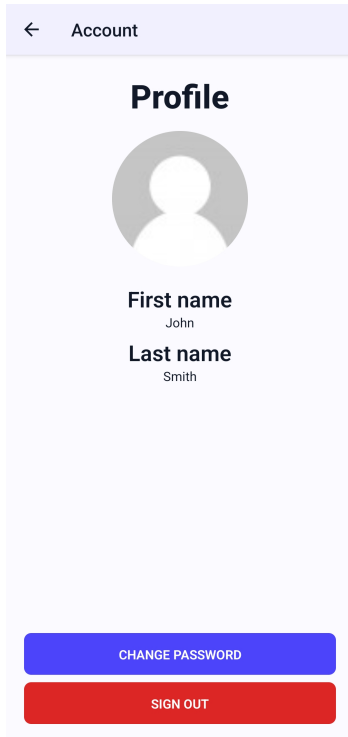


Figure 4.22: Account Screen

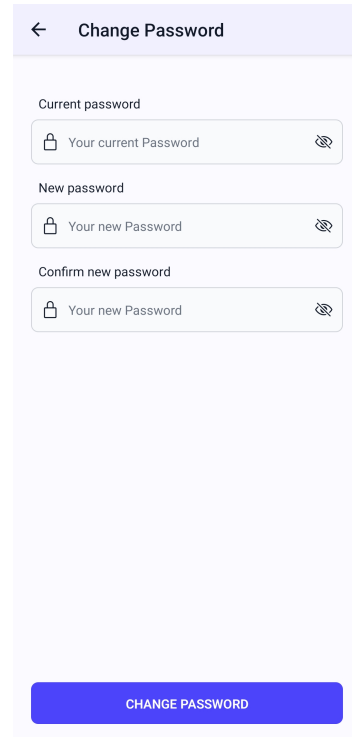
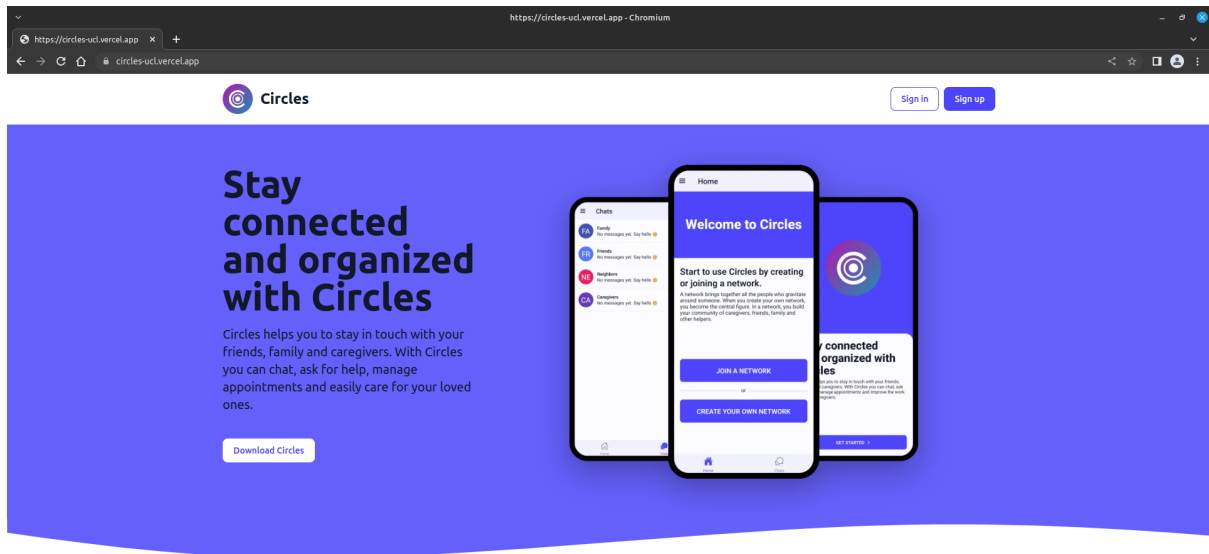


Figure 4.23: Change password

Website

As explained before, *Circles'* website (Figure 4.24) is a website showcasing *Circles*. The website is also the place where users can download *Circles* as it is not available on Google Play Store yet.



Project made by Mathieu Cosyns and Brandon Ngoran Ntam
Source code can be found on [Github](#)

Figure 4.24: Circles website

4.2.4 Accessibility

Accessibility features in *Circles* are as important as other features. It allows people with disabilities to still use the app. In *Circles*' proof of concept, we worked on two visual features to help its users: zoom and dark mode. Those two features are well-tested in every part of the app.

Zoom level

The *Circles* app can perfectly handle a high zoom level set by the Android system. Figure 4.25 and Figure 4.26 show the difference between a normal zoom level and a high zoom level. Zooming in *Circle* makes fonts and buttons appear bigger. We can note that in the right screenshot (Figure 4.26), we also turned the “bolder font” setting on.

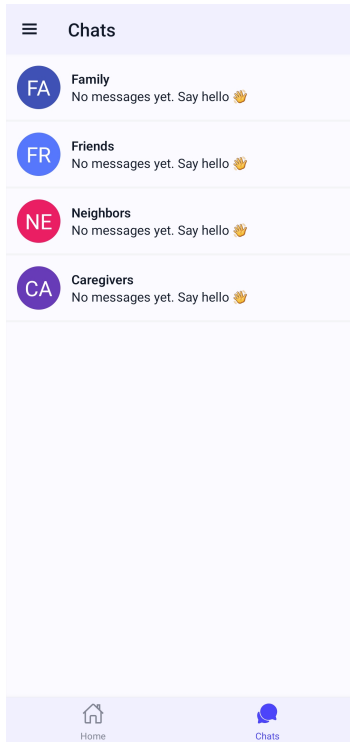


Figure 4.25: Chats Screen (default zoom)

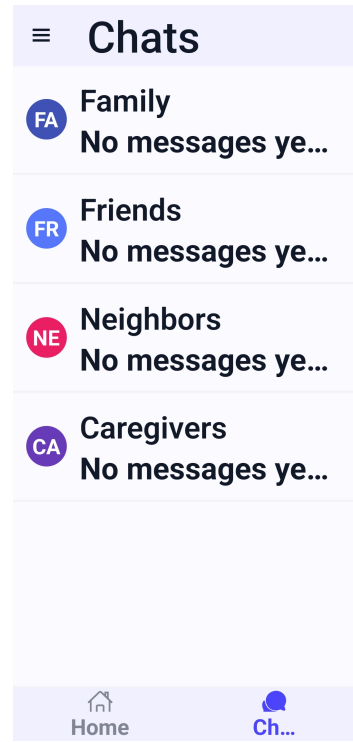


Figure 4.26: Chats Screen (maximum zoom)

Dark mode

The *Circles* app is available in light mode but also in dark mode for users who prefer a darker interface. Dark mode reduces eyestrain by switching to dark backgrounds. Figure 4.27 and Figure 4.28 show the sign-up page with the dark mode turned off (on the left screenshot) and the dark mode turned on (on the right screenshot).

Create your Circles account

First name

Last name

Email

Password

Confirm Password

SIGN UP

Figure 4.27: Sign up (light)

Create your Circles account

First name

Last name

Email

Password

Confirm Password

SIGN UP

Figure 4.28: Sign up (dark)

Conclusion

In this thesis, we recognized the pressing need to address a specific need by the elderly demographic who are in home care scenarios or in other words, ageing in place. The need for better care coordination around them and a better way to communicate and foster relationships with them and how technology can play a crucial role in enhancing their social well-being and overall quality of life. When it came to popular applications like WhatsApp and Messenger, while they have undoubtedly revolutionized communication in the digital age, they are not specifically tailored to address the unique needs and preferences of the elderly.

One of the key limitations of these mainstream messaging apps is the lack of customization and flexibility in managing social connections. In many cases, elderly individuals are part of multiple groups and conversations, which can quickly become overwhelming and confusing. Important messages and updates often get buried within a sea of unrelated information, making it difficult for the elderly to stay organized and focused. Another gripe would be that these apps do not offer sufficient control to elderly individuals over who can access and participate in conversations, forcing them into a situation where all members of a group have access to all information shared within that group. Elderly people don't necessarily need to be in every single group chat that is about them.

Based on this realization, to better understand the scope of this issue and the unique challenges faced by the elderly, we embarked on a comprehensive review of existing studies and research on the current state of technology in the field of elderly care. This led us to discover how many seniors desire to age in place, learn about the challenges they face as they age, research on smartphone adoption rates among them and usage among older adults. We discovered that while smartphones and digital applications have become increasingly prevalent, the specific needs and preferences of the elderly are often overlooked or underserved. We also took a look at existing solutions in the market and examined their features and limitations. Our analysis revealed that while there are various solutions available, such as GrandPad and Papa, they have their own strengths and weaknesses.

Armed with these insights, we set out to develop a comprehensive solution that would empower the elderly, enhance their social connections, and streamline their daily life management. And that solution was the *Circles* app. A platform that empowers the elderly and enhances their social connections. *Circles* tackles the limitations of mainstream messaging apps by providing a more organized and relevant conversation environment, ensuring that important messages and updates are not lost in a sea of unrelated information.

Our proof of concept for the *Circles* app demonstrated its potential and laid the groundwork for future development. We focused on text messaging as the primary communication feature, allowing users to exchange messages within their defined social circles. The app's intuitive design and role-based permissions ensured that conversations remained organized and relevant, preventing information overload. By enabling the formation of specific social circles, the *Circles* app facilitated seamless communication and collaboration among family members, caregivers, and other individuals involved in an elderly person's care network.

During the development process *Circles*, we faced several technological challenges. We had a hard time getting started because we did not know which direction to take and were not sure whether to use a Matrix client or not. This put us on a tight deadline to develop all the features we had envisioned. We then realized that building the app from scratch would enable greater customization and control over the user experience. This decision allowed us to design and implement features that specifically catered to the needs of the elderly population, ensuring a more intuitive interface. However, developing a new fully functional mobile application, no matter what the idea is, takes a lot of time. Therefore, we preferred to spend more time on the design requirements and the development of our ideas than on the development of the proof of concept.

While our proof of concept showcased the core functionality of the *Circles* app, there are several areas for future improvement and expansion. For instance, adding video calls and voice calls would enhance real-time communication and enable more meaningful interactions between users, further strengthening the social connections among the elderly and their care network. We also thought about *Circles*' potential for interoperability, just like what the Matrix protocol offers through its use of bridges. We think it would be beneficial for *Circles* users to have the ability to communicate with individuals outside their daily relationships, even if these individuals do not have the application installed. This would be a valuable feature to consider for future enhancements. Another improvement could be continuously strengthening security measures and data encryption protocols to safeguard user information and ensure privacy. However, user feedback and real-world testing are important parts in studying the effectiveness, refining and optimizing the *Circles* app to better meet the needs of elderly users and their caregivers. And as technology continues to advance and new opportunities arise, we anticipate that future iterations of the *Circles* app can leverage emerging technologies such as artificial intelligence and machine learning to provide even more personalized and proactive support for elderly individuals in home care scenarios. Ultimately, the proof of concept we have presented stands as a testament to our dedication and technical expertise, demonstrating the potential of *Circles* to revolutionize communication in the realm of home care for the elderly.

Finally, through this body of work, we are filled with a sense of optimism and enthusiasm for the future. We are convinced that this holds immense potential for further development and improvement in the realm of vertical social networks catering to the needs of elderly people in home care scenarios. While our work marks an important step forward, it is only the beginning of a journey towards creating innovative solutions in that field. We are proud of the progress made thus far and look forward to the future developments and advancements that will shape the landscape of technology-enabled care for the elderly.

Appendix

A.1 Database model

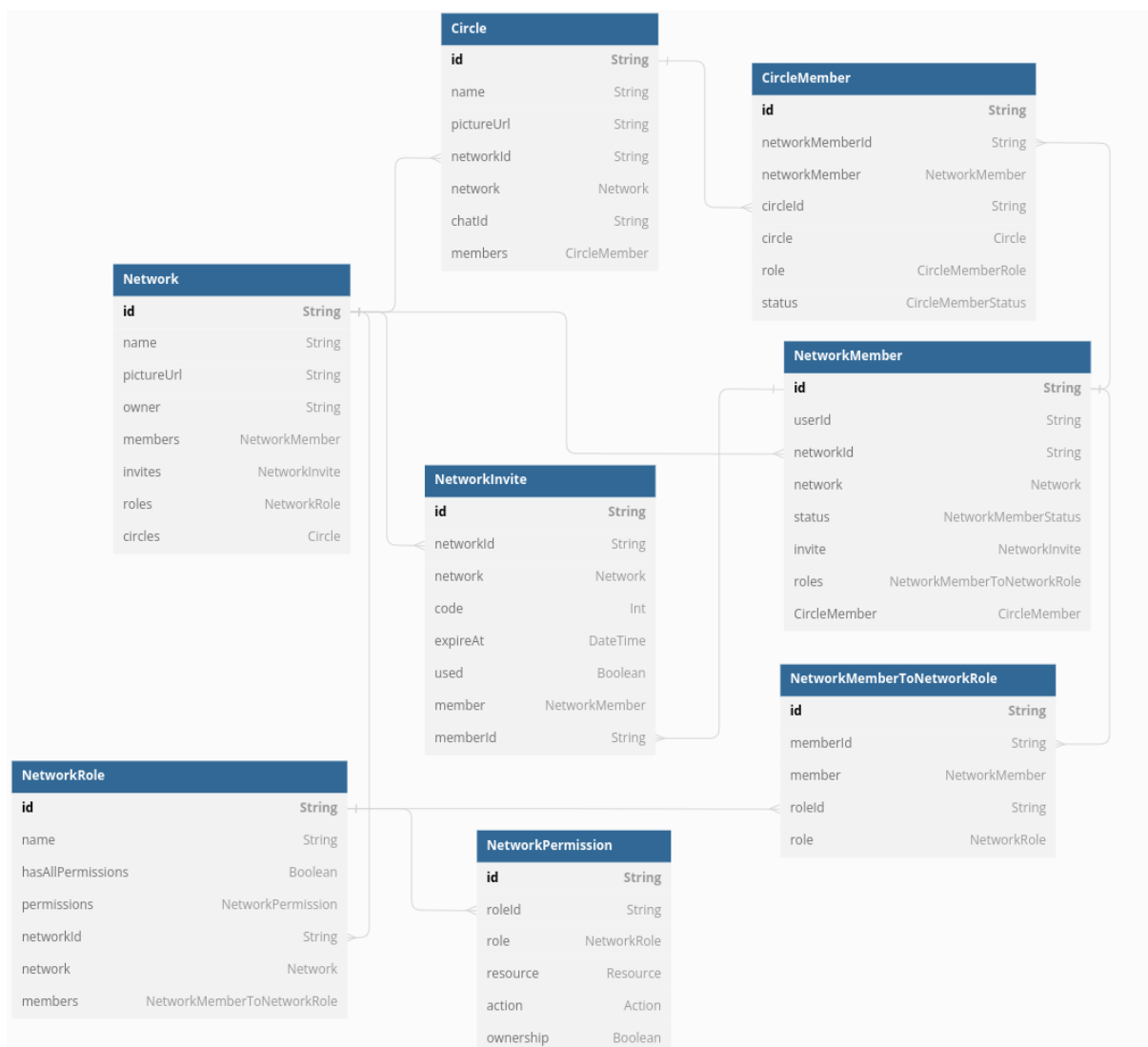


Figure A.29: Circles Relational Database Model

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This research benefited from the use of AI tools, such as ChatGPT and Grammarly and translation tools, such as DeepL, for grammatical/spelling corrections, sentence restructuring, and general language assistance. While these tools were utilized, the content, analysis, and conclusions presented in this thesis are the result of our research in the field of elderly care and technology and our contributions. Those tools served as aids in the writing process, ensuring accuracy and clarity in the language used.

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