Investigating Nanoservers and their Viability by Improving Usability

- AAU Computer Science Master Thesis -

Project Report

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Abstract:

In recent years, there have been growing concerns over privacy and security in digital communication and over the handling of sensitive information by IT industry giants. Alternatives to mainstream messaging solutions with a primary focus on privacy and the customer's full control and ownership of their own data already exist, but their installation and usage is rather opaque for the average user. This thesis proposes a solution to democratize access to these alternatives, through an installer tool for a private home server that can access the Internet and communicate with others. The thesis begins with an exploration of the landscape of existing systems, research, and the motivation for developing an alternative. It recounts the preliminary work undertaken in the previous semester, going over the technical challenges and resulting solution in exposing a private home server to the Internet. Then, the thesis delves into the research methodology used in the current semester, including a survey and usability study meant to inform the development of the installer tool and its user-friendly and accessible interface. An in-depth description of the tool is provided, focusing on the incremental design approach, and leveraging the results of the studies. In the discussion section, the new solution is compared to previous ones, its limitations are addressed, while also reflecting on the design decisions. Finally, the thesis concludes with a summary of contributions, potential applications and recommendations for future work, highlighting the broader significance of democratizing access to private communication tools in today's digital landscape.

Summary

The thesis "Investigating Nanoservers and their Viability by Improving Usability" was written by Ciprian Prohozescu, Lasse Rehder Sørensen, and Steven Jack Teglman, and supervised by Florian Echtler. The goal of this paper is to better understand and address the current issues we see in regards to data privacy caused by centralized applications such as Facebook Messenger or Instagram, which dominate the instant messaging space. The authors proposed a solution to encourage decentralized messaging by developing and designing a user-friendly solution which would reduce the technological barrier for setting up a private home server. This solution, called NanoPOG (Nano Privately Owned Gateway), would be comprised of a Raspberry Pi running Matrix Synapse, as well as an installation wizard to help users set up their very own private messaging server. The authors released a survey to the general public to better understand the current instant messaging landscape as well as the public opinion and concerns regarding data-privacy. After the development and design of the NanoPOG solution was completed, a usability test was conducted to help assess the product.

This project begins by building upon the team's preliminary work from the previous semester [1], which finalized the technical aspects of creating a NanoPOG server. The work done on the NanoPOG solution for this thesis focuses on design and usability, with a goal of creating a straightforward and user-friendly solution for the layperson. The NanoPOG solution involves a Raspberry Pi preinstalled with a Matrix Synapse server as well as a setup wizard created by the authors. After users plug the Raspberry Pi into power and connect it to a router or modem with an Ethernet cable, they will be able to access the setup wizard via a web browser on their home network. The setup wizard is designed using established design principles, with the goal of effortlessly guiding users through the setup process. Once completed, the user will have set up a Matrix Synapse server with a domain of their choosing, which they can then interact with from anywhere in the world so long as there is an internet connect, and even allow other users to join their server.

During the development and design of the NanoPOG solution, a survey was sent out to the general public. The goal of the survey was to gain insight into the habits, thoughts, and concerns people had about instant messaging. The results showcased how the instant messaging space is dominated by a handful of 5 different messaging platforms: Facebook Messenger, Instagram, Whatsapp, Discord, and Snapchat. The results of this survey also showed that respondents had a moderate to high concern about data privacy when using instant messaging, stating that data collection, third-party access, and device permissions were the aspects they were most concerned about. Despite these concerns, the majority of respondents still use these platforms several times a day, if not several times an hour, thus reinforcing the privacy paradox. Respondents, however, were seemingly interested in a messaging alternative that was privacy-focused, as long as this alternative still contained many of the messaging features commonplace today (sharing media, voice messages, video calls, etc.) and if their social circles were also using this new alternative.

After the initial design and development of the NanoPOG solution was completed, a usability test was conducted which consisted of three sections. Five participants were asked to conduct a think-aloud test while setting up the NanoPOG solution, having them start with the product in a physical box, and ending with the participants having set up a Matrix server and sending a message using Element (which is a messaging client). After the think-aloud test, the participants were asked to fill out a subjective satisfaction questionnaire. The final step of the usability test was an interview with the participant. The usability tests provided the team with valuable information and identified several areas which needed improvement. The answers from the interviews also backed up the themes found in the survey, where 4 out of 5 usability test participants were interested in a solution such as NanoPOG to regain control of their data.

This thesis shows that the creation of a privacy-focused messaging solution such as NanoPOG is possible. We also prove that people are interested in such an alternative, and that there is potential to disrupt the messaging ecosystem by creating a messaging solution which focuses on data privacy and ownership, which is easy to set up and has a low barrier of entry.

Contents

Chapter 1

Introduction

1.1 Problem Overview

The dominance of centralized messaging platforms such as Facebook Messenger and WhatsApp has, in recent years, raised increased concerns over user privacy and the security of the data that is shared, resulting in a tendency towards retaining greater control over personal information [2] [3]. Frequent incidents involving data breaches and leaks [4] have only accelerated this trend, while decreasing people's trust in the industry's current major players. At the same time, alternative solutions have emerged, empowering people to take control of their data by hosting their own communication infrastructure. One of them is the concept of private home servers [5].

To support people wishing to communicate using their privately hosted servers, different software alternatives exist, such as Matrix Synapse. However, adoption of these software solutions is hindered by the technical challenges associated with their installation and configuration. For example, the Matrix documentation fails to explain how keys enable end-to-end encryption in a decentralized network [6]. The advanced technical knowledge required for setting up a Matrix home server (or any of the alternatives) can discourage the average user from exploring this privacy-centric option. This, in turn, fosters dependence on centralized platforms, forcing a compromise on privacy for the sake of convenience.

Our project aims to bridge the gap between the desire to explore the niche environment of private home servers and the technical know-how required to do so by providing a user-friendly solution for installing and configuring a Matrix Synapse home server on a Raspberry Pi, a low-cost and resource-efficient computer.

1.2 Research Questions

We formulate our primary research questions to include three main areas of focus: the technical challenge of building a configuration wizard that can set up and maintain a

home server with minimal user input, designing and testing an interface that is user-friendly and intuitive without compromising on the customization options available for the server, and investigating whether such a solution would increase the average user's interest in privacy-oriented messaging alternatives. Given these areas of focus, we believe our paper will provide two distinct contributions to the field of Human-Computer Interaction: the product itself and the data acquired during the research based on this product. Therefore, we split our primary research question into two distinct inquiries to reflect these contributions.

Primary Research Questions

- How can we design, build, and evaluate an installer tool with a user-friendly interface capable of setting up a home server to be used for decentralized messaging?
- Would such a tool encourage mainstream adoption of secure and decentralized private communication?

1.3 Scope and Limitations

The scope of our project is defined by its two primary goals. We want to make the installation of a private home server accessible to a wide range of users, regardless of technical expertise. The motivation for this undertaking is the desire to expand the adoption of alternative messaging solutions that focus on privacy and data ownership and enable users to store messages on their own servers, thus avoiding the reliance on centralized servers owned by large corporations. We will focus on implementing a piece of software capable of installing a private home server, designing an intuitive and user-friendly interface, testing and refining this interface, and, finally, discovering whether such a product would encourage the adoption of privacy-centric messaging solutions.

While we strive to design the user interface to be accessible to everyone, regardless of technical skill, there will always be a minimum level of knowledge required to install a home server. The evaluation of this interface will be limited by the number of people willing to participate in usability tests and, while we will be able to make some improvements based on the results of these tests, the complete development of this product would require multiple iterations over a time frame that is not available to us.

Chapter 2

Background

2.1 Previous Research

This section presents previous research on related areas of interest. These include the barriers of adoption of a new instant messaging service, as well as the user experience setting up hardware devices by technical novices. In addition the section also explores the importance of having an intuitive user interface in order to reduce these barriers of adoption.

2.1.1 User-Friendly Interfaces

Privacy, as underlined in section 1.1, has been a rising concern amongst internet users throughout the past decade. Ever since the internet became an integral part of people's lives, social media and instant messengers have had a monopoly on user data, despite numerous scandals concerning user privacy [4] [1]. As a result an increased focus on the preservation of privacy have emerged. However, on the topic of home servers, a disconnect happens. Buzzwords like these have long had a connotation of complexity for the non tech-savvy user, and in regards to the setup of home servers, this has often been the case [1]. As highlighted in the preliminary paper, the standard procedure for establishing access to a home server from outside the home network is a tedious task, requiring research, technical know-how, and perhaps even a consultation with an ISP (Internet Service Provider) [1]. This is of course a significant barrier of adoption for a novice user, contemplating a home server's potential in safeguarding their privacy. In order to reduce barriers like these, and provide a user-friendly and efficient experience, it is important to recognize the issues people are facing when introduced to the task of setting up hardware devices in their home by themselves.

The paper "Smart home in a box: usability study for a large scale self-installation of smart home technologies" [7] investigates the task of setting up different types of hardware devices in the home by novice users, which in the circumstance of this paper, revolves

around the elderly population. Their long-term goal is "[...] to design a smart home kit that can be easily self-installed and used to provide valuable activity information" [7].

They argue that "Complex installation procedures and user interfaces, which have long been associated with smart environments, have prevented the adoption of this type of technology to all but specialists or technophiles" [7].

For this reason, their aspiration is similar to ours; to provide a solution which is usable and installable, regardless of technical knowledge. Their findings suggest that the installation of the hardware devices, specifically door sensors and the server box, had a high failure rate. As for the server box, the fail rate is attributed to its appearance, which gave the participants the impression it is hard to deal with, and a worry that it will use too much electricity, as well as a need to improve on the provided installation instructions [7]. The paper concludes by suggesting future work, such as adding more figures to the instructions, and to provide an online tutorial which can help their users with additional context for the installation [7].

Another aspect of a home server setup that must be considered in order to be a viable solution for novice users is the user interface. The physical setup process is typically only part of the experience, as there usually is a need for interacting with devices post installation, for tasks such as configuration, monitoring and maintenance. Therefore, it is important to ensure the usability of the user interface based on the target attributes of the product.

The paper "Prototype, Method, and Experiment for Evaluating Usability of Smart Home User Interfaces" [8] investigated the process of creating a smart home (heating system) and evaluating several on the market user interfaces which could be used to interact with the system. Pertaining to the user satisfaction of the evaluated interfaces, their findings suggest that "graphical user interfaces with visible controls have greater usability for smart home users" [8]. This was in relation/comparison to user interfaces with integrated voice assistants or chat bots, which were determined to be inferior in usability to the aforementioned graphical user interfaces.

2.1.2 Adoption and Usability Evaluation

The ease with which a server can be set up by non-tech-savvy people, and the satisfaction of interactions with the user interface are important aspects in determining the usability of a product. But there can also be external barriers for adopting a new messaging service, and these must be considered. The paper "Understanding individual adoption of mobile instant messaging: a multiple perspectives approach" [9] investigated technical, individual and social factors which people consider important when contemplating switching to, or introducing a new mobile instant messenger into their assortment.

Regarding the technical factors, their results suggest that convenience has the biggest impact on the perceived enjoyment and usefulness of an instant messenger service. In addition, they also showed that the ease of use had a big impact on the perceived enjoy-

ment [9].

In regards to the social attributes, it was shown that "Perceived critical mass had a direct impact on behavioral intention to use mobile IM and identification was shown to have a significant impact on perceived usefulness and perceived enjoyment" [9].

As described by the quote, the amount of people of which a person knows have a significant impact on whether a person intends to use a instant messenger service. In addition, whether or not a person has a perception of themselves being part of the community or groups also has a big impact on their perceived usefulness and enjoyment of the instant messenger service in question.

2.1.3 Research Gaps

As presented in this section, research has already been done on several areas related to the envisioned NanoPOG solution. The highlighted findings are indeed beneficial in guiding the project, and taking inspiration from these, where relevant. However, it is infeasible to draw a 1 to 1 comparison between these papers, and the focus of our master thesis. We believe there is an absence of research specifically concerning the barriers of adoption of a privacy focused messenger service with a physical server setup, by a target audience of novice tech users concerned with privacy. The focus of this master thesis will therefore be, to identify the potential adoption barriers of such a setup, and provide a user friendly implementation, addressing these barriers, within our abilities as well as the scope and time frame of this master thesis.

2.2 NanoPOG

NanoPOG (Nano Privately Owned Gateway) is the name the team has given to the solution we have created for the sake of the usability studies conducted in this report. The goal of NanoPOG is to provide a streamlined and simplified process for setting up a private Matrix Synapse server.

Setting up a Matrix Synapse server by itself can be done with relative ease for someone with basic technological knowledge. The base setup allows a user to use Matrix to its fullest within the confines of their home network. However, if the user wishes to access the server from the outside world, or connect (federate) with other Matrix Synapse servers, there are two main steps that need to be addressed. First, the user must have access to the public IP address of where the server will be set up. This can be difficult or even impossible to obtain depending on the user's Internet Service Provider (ISP). The second step is for the user to possess a web domain which points to the aforementioned public IP address.

The team behind this report spent the previous semester addressing these topics on a technical level. The outcome of those efforts led to a solution in which users did not require their individual public IP addresses or web domains to set up a Matrix Synapse

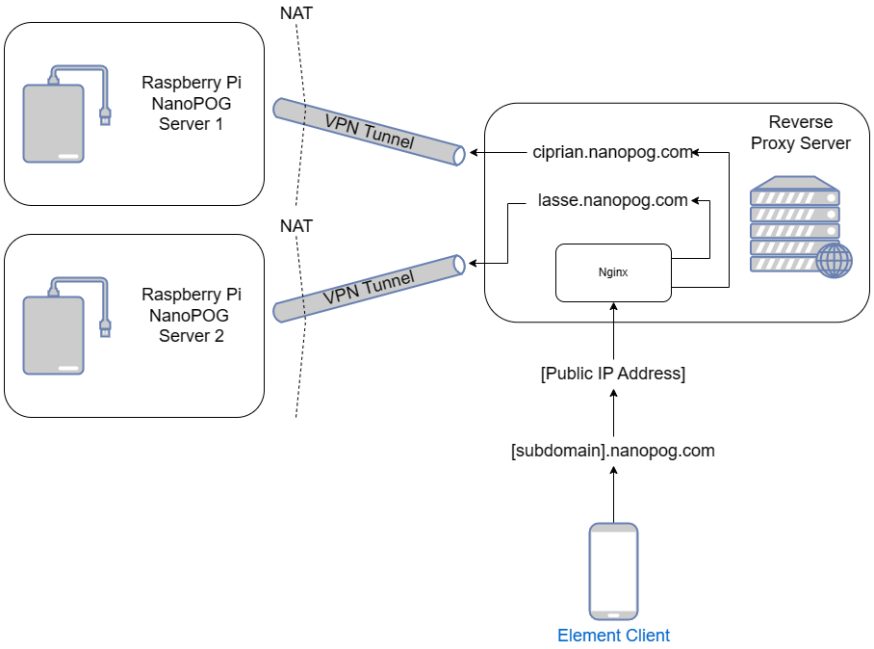

Figure 2.1: NanoPOG Technical Solution Diagram

server. This solution consisted of three main parts; a **reverse proxy server** owned and operated by this team, an instance of Matrix Synapse installed on a Raspberry Pi (which we call the **NanoPOG Server**), and a **WireGuard VPN tunnel** set up between the reverse proxy and each instance of Matrix Synapse.

Figure 2.1 illustrates the technical solution. Each NanoPOG Server has an instance of Matrix Synapse, and on setup establishes a VPN tunnel to the Reverse Proxy Server. Using Nginx, the Reverse Proxy Server routes requests to defined domains (such as ciprian.nanopog.com) to the corresponding NanoPOG Server via the established VPN tunnels. These requests would typically be coming from a Matrix client such as Element.

With this solution in place, users are able to access their NanoPOG servers via their specified domains, as though they were publicly facing servers.

For a deeper look at this solution, see our preliminary research report from the previous semester [1].

Chapter 3

The NanoPOG Solution

3.1 Overview of the NanoPOG Solution Architecture

Building upon our work in the previous semester, we designed a solution that can install and configure a NanoPOG home server accessible from the Internet with minimal user input. We imagine the following scenario: the user purchases the NanoPOG Unit, which includes a Raspberry Pi computer with our software pre-installed; they plug it in and connect an Ethernet cable to it; from their computer, they navigate to the webpage specified in the physical instruction manual they receive in the package and start the installation process from there. This avoids the need to connect the Raspberry Pi to peripherals (a monitor, mouse, and keyboard), which not everyone might have readily available, instead interacting with it via another device connected to the same home network.

To achieve this, the solution must include a web client that can be accessed by other devices capable of reaching the Pi. This client could also handle the logic required for setting up and managing the Matrix server, but for better control over the functionality and improved scalability, we should delegate application logic to a backend component.

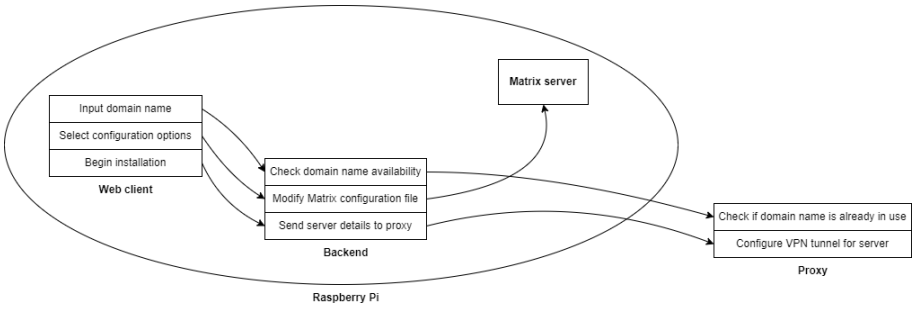

Figure 3.1: The architecture of the NanoPOG solution

Figure 3.1 describes the relationship between the components of our solution (from now on referred to as the NanoPOG Solution). The software installed on the Raspberry Pi

contains the web client, the backend, and the Matrix server. The web client is responsible for capturing user input, such as the desired domain name, and chosen configuration options. These are being sent to the backend, which processes the data and relays it to the proxy server. The server settings are used to modify the configuration file of the Matrix server. The domain name and the request to begin the installation are sent to the proxy server, where a listener script performs the installation logic and sends back a response. For more details on the listener script, see our preliminary research report [1].

In the following sections, we will take an in-depth look into the web client component, walking through the design process and the theoretical background that motivated some of the decisions behind the first iteration of the user interface.

3.2 Usability Attributes

In order to ensure the usability of a system during the design phase, it's important to consider what attributes the system should reflect, and why.

Jacob Nielsen proposes five attributes which describes usability in a system [10]. These are:

1. Learnability: It should be easy to learn [10]
2. Efficiency: It should be efficient to use so it allows for a high level of productivity [10]
3. Memorability: It should be easy to remember, so users can return after a while, and still know how to use it [10]
4. Errors: It should have few to none errors. If an error do occur, users should be able to recover from them [10]
5. Satisfaction: using the system should be a pleasant experience [10]

By clarifying the attributes a system should encompass, it is possible to construct a set of quantitative measurements for them. As described in section 1.2, the desired result is a simple, intuitive and user friendly wizard and dashboard, which allows all privacy-oriented users, regardless of technical abilities, to configure a NanoPOG home server. Based on these requirements, certain usability attributes are more relevant than others. This section will present each attribute with regards to their importance for the system.

Learnability

Learnability is crucial for the wizard, as it is expected most users at most will complete the setup process 1-2 times. It is therefore important, that users are able to recognize the functionality of UI components, and understand the flow of the wizard, without having seen or interacted with it beforehand. The attribute is also beneficial to the dashboard,

however the remaining attributes are of a greater priority.

Errors
The error attribute is important in order to provide a simple and intuitive experience for the user. The reason for this is that, while the wizard might be easy to learn, if an error occurs, it can interrupt the user, diminishing the overall experience and impression of the solution itself. Depending on the user's technical abilities, they might be able to correct certain errors, whilst for those with minimal technical skills, errors could be detrimental. It is important that the wizard possesses high learnability and a low error rate, to create a simple and flowing experience.

Memorability
Memorability is not important in and of itself for the setup wizard. As mentioned in regards to learnability, most users will only go through the setup process once or twice. However, the attribute is essential for the settings page and the dashboard, as users are expected to interact with these throughout their use of the NanoPOG solution. For this reason, users should be able to quickly gain an overview of the functionality based on their recollection of previous interactions.

Efficiency
The inclusion of the efficiency attribute is insignificant for the setup wizard and dashboard. Users are not expected to be able to interact with the system in a way where it would be feasible to measure the efficiency of these interactions. The functionality is limited by design, to keep the system simple and user friendly.

Satisfaction
The satisfaction attribute is important for both the wizard and dashboard. Interactions with both of these should be a pleasant experience for the user, as the level of satisfaction a system has impacts the user's overall impression of the system. Because of this, a high level of subjective satisfaction will benefit the overall opinion of NanoPOG.

The following section will focus on incorporating the aforementioned usability attributes into an initial design for the NanoPOG wizard.

3.3 Initial Design

The initial design of the NanoPOG user interface tries to maximize Jakob Nielsen's usability attributes based on our own experience and preference, as we had no prior tests or user interaction to draw inspiration from. This shortcoming was intended, because we wanted to show our testers a functional system that they can interact with, making their feedback more valuable. The project time frame did not allow for multiple rounds of testing, thus making the possibility of testing on mock-ups and incomplete functionality unlikely.

In addition to these generic attributes, we also tried to follow a number of rules to ensure that the individual elements of our frontend system provide an overall simple and clear picture of the process that must be followed to install a private home server. These rules were chosen from a widely accepted set of various good practices, found in several research papers and other materials dealing with user interface design under different names [11] [12]. After collecting this set of rules, we developed the following structure for our user interface.

3.3.1 Structure of the NanoPOG User Interface

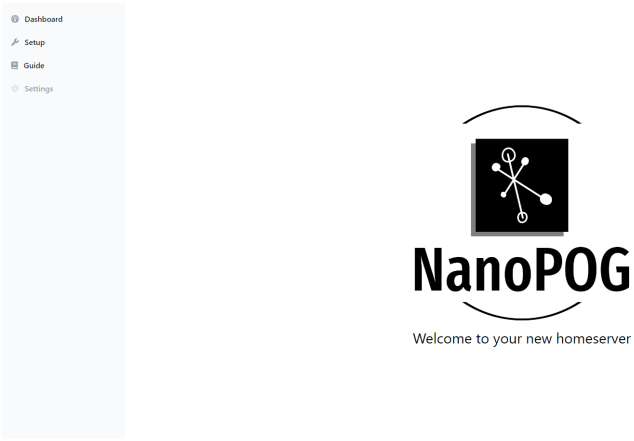

Figure 3.2: Landing page in the initial version of the NanoPOG UI

The landing page simply contains the NanoPOG logo and a welcome message. On the left-hand side, there is a navigation menu containing the other pages that the user can visit: dashboard, setup, guide, and settings. The settings button is disabled at first, because all the options available there require a home server to be set up first (on the setup page). The navigation menu is collapsible on mobile in order to save some of the limited screen space.

Figure 3.3: The dashboard in the initial version of the NanoPOG UI (server not yet set up)

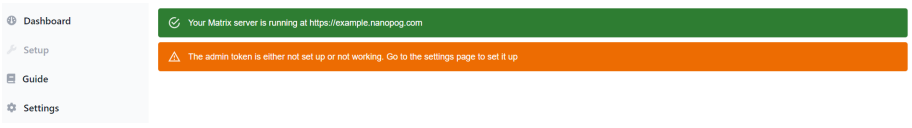

Figure 3.4: The dashboard in the initial version of the NanoPOG UI (admin token not set up or not working)

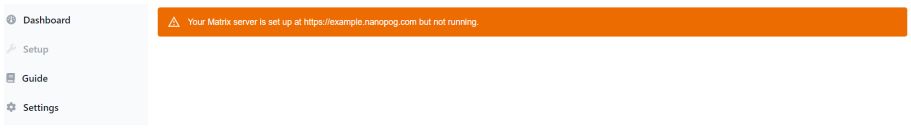

Figure 3.5: The dashboard in the initial version of the NanoPOG UI (server is set up but not running)

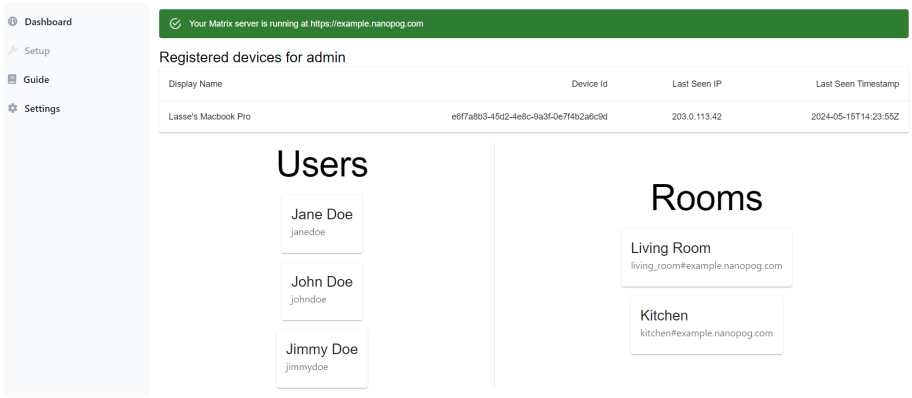

Figure 3.6: The dashboard in the initial version of the NanoPOG UI (everything is set up and working correctly)

The dashboard page has four different "states" depending on the how far the user has gone through the admin configuration. In order for the dashboard to be fully available, the server must be set up and running, an admin user must be created, and a valid admin token must be registered. If any of these conditions are not met, the dashboard page will display a message explaining the issue. Otherwise, the admin user's registered devices, all other users, and rooms currently available on the server will be displayed.

This information is sufficient to give the server owner an overview of their home server and warn them about any potential issues (for example, a user created without their knowledge) without going into too much technical detail.

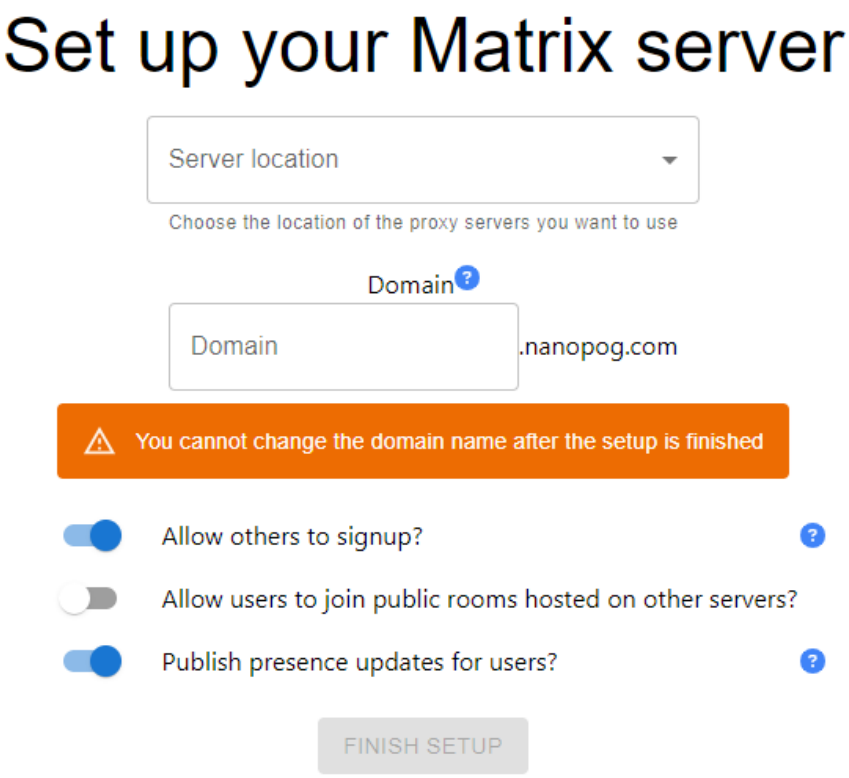

Figure 3.7: The setup page in the initial version of the NanoPOG UI

The setup page allows the user to create their NanoPOG home server while offering a few customization options. The "server location" represents the location of the proxy server that the installer will create a VPN tunnel to in order to expose the private home server to the Internet. This is currently a placeholder for future scaling functionality, once we set up multiple proxy servers on different continents. Once this is implemented, the option closest to the user will always be recommended. The "domain" input field allows the user to choose a domain name for their server and automatically checks for availability, as two home servers with the same domain name cannot be connected to the same proxy. If the name entered in the input field is already in use, an error message will be displayed shortly after the user is done typing. Otherwise, a success message is displayed and the "finish setup" button becomes enabled. The three switches let the server owner determine whether other people are allowed to create accounts on their home server, whether users are allowed to join public rooms hosted on other servers, and if they want to receive status (online, offline, away) notifications of other users. This process can only be done once for each instance of the NanoPOG solution, thus a warning is displayed that the domain name cannot be changed afterwards. This page becomes inaccessible after the server is setup and the navigation menu option is disabled.

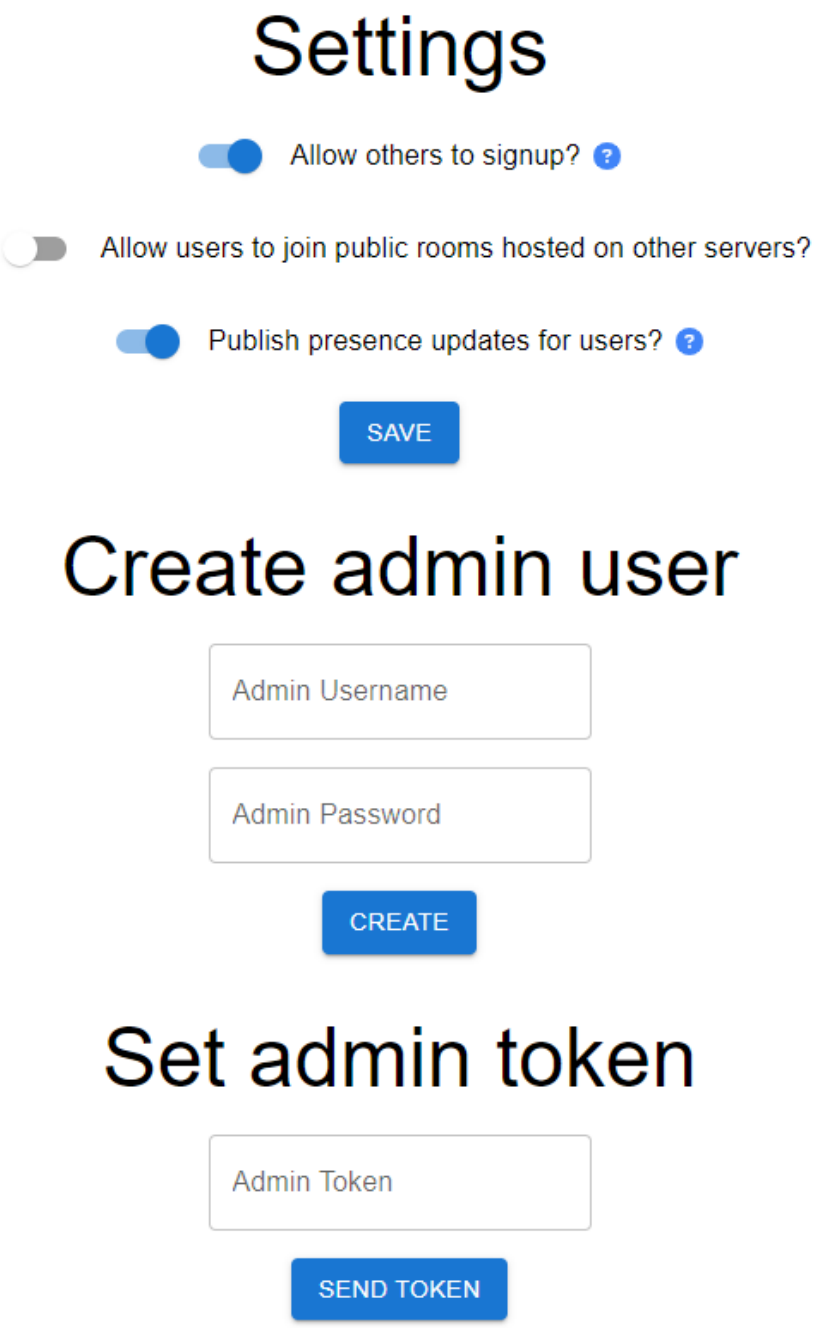

Figure 3.8: The settings page in the initial version of the NanoPOG UI

The settings page becomes available once the server has been set up and it contains three sections: first, it offers the option to change the three switches present during setup (for allowing other users to create accounts, allowing them to join public rooms hosted

on other servers, and receiving notifications about user status); then, it allows the creation of admin users for the purpose of unlocking the dashboard; finally, it lets the user set an admin token also used for enabling the dashboard. The admin token is needed for the API that retrieves information from the Matrix server. Simple admin user credentials (username and password) are sadly not compatible with this API [13].

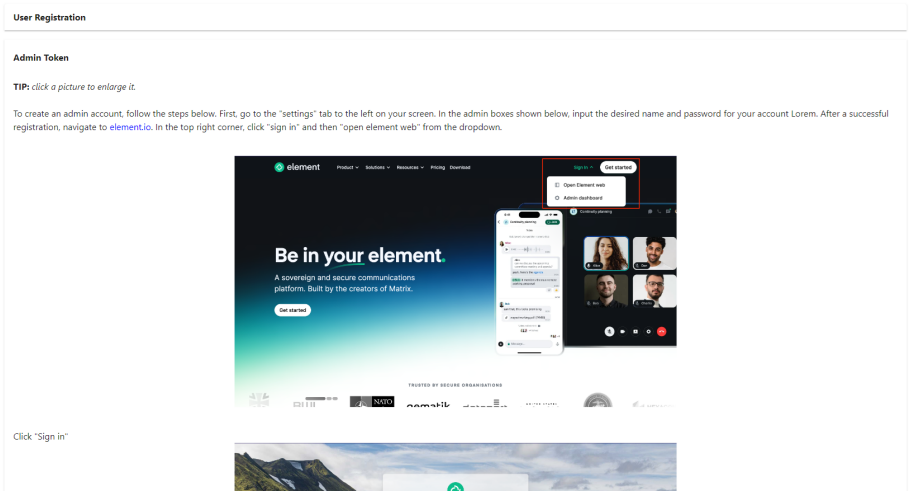

Figure 3.9: The guide page in the initial version of the NanoPOG UI

The final component of the NanoPOG user interface is the guide, containing two sections: creating user accounts and chatting with others using the Element client, and unlocking the dashboard via an admin account, using both the NanoPOG tool and the Element client. The first section must be followed by anyone willing to use their home server to chat with others, while the second section is only for advanced users with more technical know-how.

3.3.2 Design Rules and Guidelines

Simplicity and Clarity

This rule implies a strong focus on the essential features needed for installation and monitoring, while avoiding clutter and unnecessary elements. Labels, instructions, and feedback messages should be clear and concise, only using technical jargon when absolutely necessary. Ali Darejeh and Dalbir Singh argue that applying this rule of simplicity is particularly beneficial to three groups of users with less computer literacy than the average person: elderly users (who lack computer background), children (as novice users), and users with mental or physical disabilities [11]. This means that a design that applies this rule is beneficial for our goal of creating a solution that is accessible to everyone, regardless of their technical literacy.

The application of the rule of simplicity can be observed on all pages of our web client. The landing page contains only the logo of our solution, a welcome message, and the navigation menu (fig. 3.2). The dashboard displays concise information messages and, if everything is set up correctly, simple lists of devices, users, and rooms (fig. 3.6). The setup and settings pages keep technical jargon to a minimum, only providing essential information for the installation and management of the home server. The guide pages go into a bit more technical detail, especially the admin user setup guide, because that process is intended for more advanced users and the NanoPOG server can be used in its entirety without going through it.

Consistency

Consistency ensures that different elements of the user interface follow the same basic visual structure and that similar items perform similar functions. In *Principles and Guidelines in Software User Interface Design*, Deborah J. Mayhew emphasizes the importance of consistency in reducing user errors and increasing the predictability, learnability and efficiency of the application [12]. Consistency can be classified over several of its dimensions:

- **Internal consistency** ensures that the application is consistent with itself. In other words, similar elements within the application behave and look the same. In the NanoPOG user interface, success and error messages all have the same structure, with only a change in color to differentiate them (e.g., fig. 3.3, fig. 3.4, and fig. 3.7). The buttons in the navigation menu are all grey, with an icon on the left and their name on the right (fig. 3.2) and the action buttons are all blue with white text in capital letters (e.g., fig. 3.7 and fig. 3.8).
- **External consistency**, on the other hand, aims to replicate the design of established applications that most users are familiar with, such as the Windows OS, or most webshops. To that end, we have placed the navigation menu on the left and actions buttons at the end of a list of user inputs, as seen in fig. 3.8. Furthermore, fields that accept textual input from the user are encased in rounded boxes, as seen on the setup and settings pages.
- **Visual consistency** implies maintaining uniformity in visual elements such as fonts, layouts, and colors, while **functional consistency** dictates that functions should operate similarly in different parts of the application. On the setup and settings pages (fig. 3.7 and fig. 3.8), all available actions consist of the same sequence of steps: the user fills in the required input, then clicks the action button, then receives a feedback message (either success or error).

Law of Proximity

The law of proximity is a visual design principle born from the Gestalt psychology, which describes how people perceive and process visual information. It states that humans naturally organize visual elements into unified groups, rather than independent parts. Therefore, in UI design, objects that are connected or belong to the same subsystem should be placed closely together, because users will then perceive them as a group [12].

The NanoPOG solution design follows the law of proximity by placing action buttons immediately after the set of user inputs that they make use of (e.g., fig. 3.7 and fig. 3.8), suggesting that the information the user writes in those fields will be processed once the accompanying action button is pressed. Furthermore, navigation buttons are grouped together in the side menu and users, rooms, and devices are placed close to each other in their respective lists on the dashboard page (fig. 3.6).

Law of Continuity

Another guideline resulting from the Gestalt psychology is the law of continuity, stating that the human eye is drawn to continuous lines and patters. It follows that UI elements should be aligned along a certain path to guide the users' attention and create a sense of order [12].

In the NanoPOG solution, the application of this law is evident on the setup page (fig. 3.7). The arrangement of the elements guides the user along the steps needed to set up a NanoPOG server. First, a server location should be chosen, then a domain name (which cannot be changed later and is mandatory). The three switches can be changed or left as they are. Finally, pressing the action button at the bottom of the page creates the server based on the user input above it.

Help and Documentation

Mayhew argues that, even if a designer's goal should be to create a system that can be understood and used efficiently without documentation, some form of help should be present regardless. The information included should be easy to locate, focused on the user's task, comprised of concrete steps, and concise [12].

These are the attributes that we focused on when creating the user guide. It can be accessed from the navigation menu, has its own dedicated page (fig. 3.9) and contains two separate "paths" that a user should follow to achieve two separate goals: registering an account on their server and enabling the dashboard via an admin token. Each set of instructions is written as a series of steps, along with screenshots visualising the elements that the user is supposed to interact with.

3.3.3 Improving upon the User Interface Design

While these guidelines helped create a simple and concise interface that we, as programmers, believe it is easy to use, we still have no real feedback from any users. In the following chapter, we describe the process we employed to gather such feedback, organize it into achievable requirements, and apply them to create an improved version of the user interface. Throughout this process, we kept our ultimate goal in mind, that our tool should make home servers accessible to a wider audience, thus increasing their adoption and popularity.

Chapter 4

Research Methodology

4.1 Overview

This chapter will explain the research methodology which has been employed. Our approach encompasses both quantitative and qualitative methods to gather data on on user preferences and experiences related to messaging apps, how they view privacy in relation to these apps, and finally their thoughts on our NanoPOG solution.

Our research is split into two parts: a survey and a usability study. The goal of the survey was to better understand how people use instant messaging and how they might view privacy protection in relation to the messaging apps they use. The usability test was executed afterwards with a focus on getting feedback on our NanoPOG solution, as well as getting an understanding on how people experience setting up their own private home server.

4.2 Survey Design and Execution

4.2.1 The Survey Design Process and Theoretical Background

Much like our goals for designing the technical solution itself, we wanted our survey to be simple, concise, and capture as much information as possible without causing confusion or disengagement among the respondents. In order to achieve this, we followed a number of guidelines from the established theoretical background for survey design.

Objective of the Survey

The first rule that we followed is having a clear purpose in mind, which should be stated at the beginning of the survey, as well as research questions that the survey should answer [14]. We chose two research questions that the two primary sections of the survey focus on:

- How concerned are users of messaging apps about privacy and the way their data is handled?
- How much of an interest is there for a privacy-centric alternative in which the user has full control over their own data among people who use messaging apps on a regular basis?

At the start of the survey, we state the goal of our project (creating a solution that will enable anyone to set up their own home server and communicate with others), which also motivates the choice of the survey research questions. We aim to find out whether there is an interest for a privacy-oriented alternative to traditional messaging apps, and, if there is, what characteristics and features would determine people to switch.

Structure of the Survey

Based on the research questions formulated above, we split our survey into three sections. The first section contains questions about the respondent's age, gender (optional), and current field of education or work, in order to identify their demographic. The second section aims to find out about the respondent's communication habits. How often they use messaging apps and whether they are aware of the privacy policies of these apps. This section is a preliminary step to the next one, where we ask about their privacy concerns while using messaging apps. Finally, in the last section, we ask whether the respondent would be interested in a privacy-oriented alternative to conventional messaging apps, what missing features would prevent them from switching, and how much time they would be willing to dedicate to the setup process of such an app.

Question Design

The Palgrave Handbook of Survey Research highlights the importance of clarity and simplicity in the language used for questions to avoid confusion and misinterpretation [15]. Furthermore, in chapter 13, Jon A. Krosnick suggests that minor changes in wording can lead to surprisingly different readings of the question and, as a result, vastly different answers [15]. Therefore, we should try to avoid leading questions to prevent bias and use a mix of closed and open-ended questions to cover a wide variety of use cases.

The simplest questions we ask are in the first two sections of the survey, such as "How often do you use messaging apps for communication purposes?" and "Are you aware of the privacy policies of the messaging apps you use?". The other two sections are a bit more technical, but we try to keep the questions as neutral as possible. E.g., "How confident are you in your ability to protect your privacy while using messaging apps? (e.g., avoiding sharing sensitive information)", "Have you ever experienced any privacy breaches or concerns while using messaging apps? If yes, please describe".

Likert Scale

The Likert scale is one of the most widely accepted and utilized methods for phrasing closed questions in surveys, with the goal of measuring attitudes or opinions towards a topic. While such widespread usage has lead to debates regarding the exact use cases and the points on the scale [16], it is still a reliable psychometric tool that can help us extract meaningful information from our respondents while avoiding confusion and misinterpretation.

In our survey, we have used the Likert scale to provide standardized response choices to questions that measured the strength of an emotion, interest, or preference, such as "How important is it for you to have control over where your message data is stored?" (from "1 - Not very important" to "7 - Very important") and "Would you prefer a quick and easy setup process or a more complex and customizable one (that allows you to tweak every aspect of your private messaging app)?" (from "1 - Quick and easy" to "7 - Fully customizable").

Question Order and Logical Flow

The order of questions in a survey matters, as it can generate bias. Specifically, there are two main types of order effects: contrast effects (asking questions in a specific order can result in a greater difference in responses than asking them in reverse order), and assimilation effects (the opposite effect to contrast) [17].

It has been shown that asking a specific question before asking a more general one can result in a contrast effect [17]. To avoid this, we made sure to start with general questions, before narrowing down to a more specific topic. For example, we asked "How concerned are you about privacy in regards to using messaging apps?" before asking "What specific aspects of privacy concern you the most when using messaging apps?". Reversing the order of these questions might have led to a higher reported concern than normal, because the respondent was already prompted to think of specific privacy-related examples.

It is important to maintain a logical flow of questions, moving from simple and engaging to more complex and challenging. Furthermore, the respondent should never be overburdened with several difficult questions in immediate succession [17]. This is the reason why our survey places the section about messaging apps usage (containing simple questions such as "Which messaging apps do you use at least once a week?") before the more complicated sections of privacy concerns and interest in alternatives. The survey also mixes in open-ended questions, which require slightly more creative thinking, with multiple choice ones, to avoid respondents feeling overwhelmed and giving superficial answers.

Incentives

It has been shown that incentives can increase response rates, but can also bias responses (for example, if respondents gloss over questions as fast as possible with the only goal of receiving the reward at the end) [15]. To avoid this, we used a small prize (a JBL Bluetooth speaker) that can only be won by a single, randomly-chosen respondent as an incentive. This alone should not be enough reason for anyone to complete our survey, instead using a genuine desire to contribute as an additional motivator. Furthermore, keeping the time to complete the survey short (10-15 minutes) ensures that the respondents are staying focused while going through the questions.

The full survey can be found in Appendix A.

4.2.2 Gathering Responses

To gather responses, we made the survey available online using Google Forms for three weeks. We shared the URL with friends, relatives, university colleagues, and on Facebook and Discord groups. Furthermore, we designed a poster briefly describing the survey and the available prize, which we then printed out and spread around university campuses alongside smaller fliers. This resulted in a high number of responses, but a slightly uneven demographic distribution. We will explore these results in more detail in chapter 5.

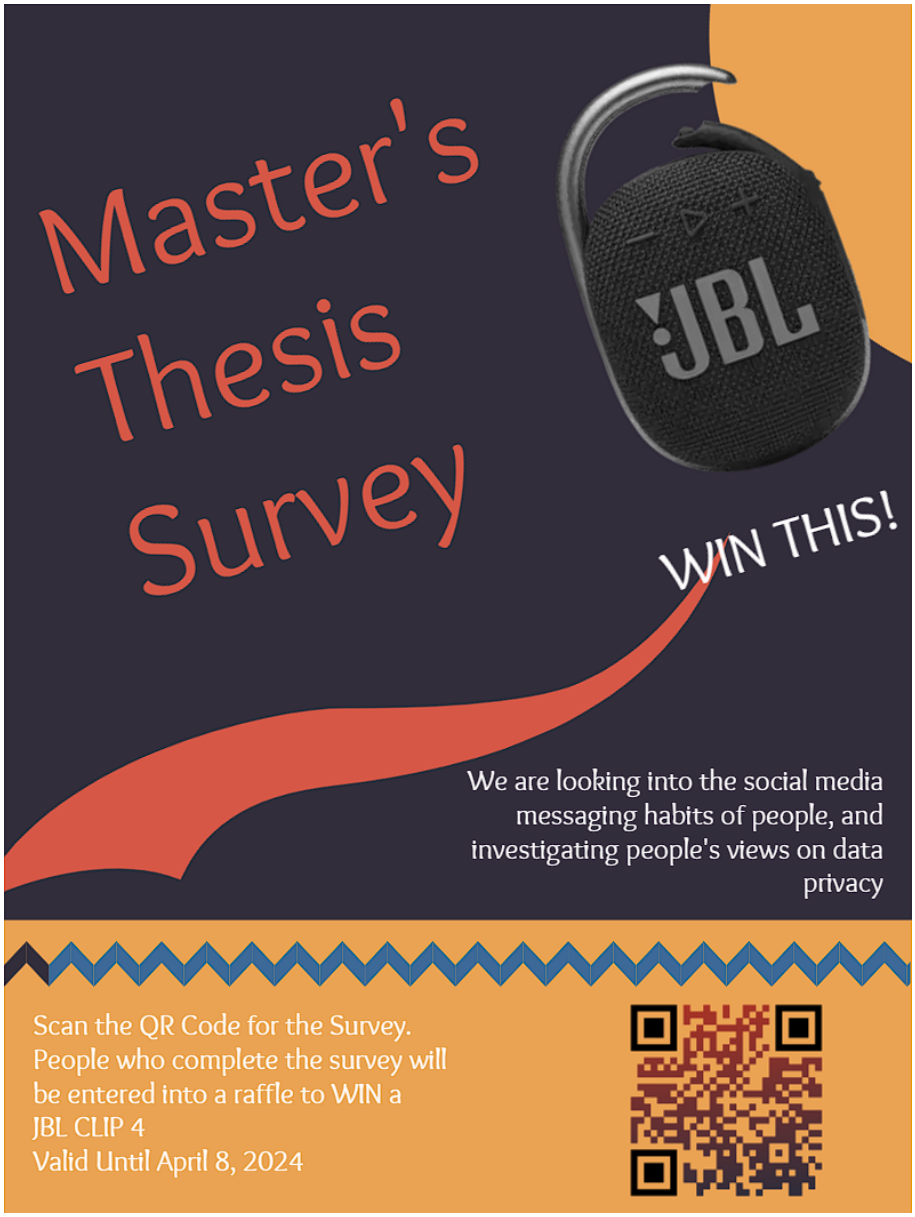

Figure 4.1: The survey poster

4.3 Usability Study Design and Execution

NanoPOG's setup wizard was designed with the intention of being simplistic and user-friendly. These characteristics are motivated by the vision of NanoPOG itself. The primary goal of NanoPOG is to be a viable alternative in the market of instant messaging for individuals concerned about privacy regardless of technical expertise. Setting up and man-

aging a NanoPOG server must therefore be a simple and intuitive experience. After the development of the setup wizard was finalized, the system was subjected to several usability tests, in order to evaluate the extent to which the system has fulfilled the overarching goals of NanoPOG.

The purpose of a usability test is to identify areas prone to errors that end users might interact with. Issues are identified by observing test participants complete a set of tasks simulating real use cases. Usability tests allow for evaluation of the setup wizard, to identify and mitigate pitfalls overlooked in the design phase, and to increase the usability of NanoPOG for end users.

4.3.1 Participants

The complete study consisted of a total of 7 participants. Two of the these were used as part of pilot tests. The number of participants recruited for the usability test are based on the model seen in Figure 4.2

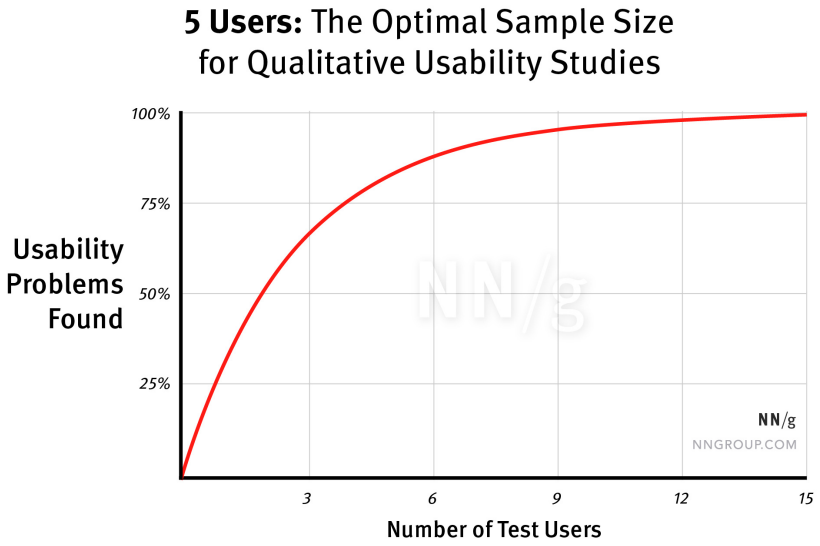

Figure 4.2: Optimal sample size according to NNGROUP

The model depicts the relation between usability problems found and the number of test users. According to NNGROUP, 5 participants are sufficient enough to locate 85% of all usability problems in the system, as shown in the model [18]. The increment in usability problems found with 6+ participants is significantly diminished, and the payoff was deemed negligible considering the scope, time frame and budget of this master thesis.

Initially, the participants were meant to be chosen with the intention of being representative of the target audience, these being members of the general public concerned

with privacy, and interested in alternative solutions. The participants would be recruited through the survey responses and selected by the following criteria:

1. Scored high in privacy concern
2. Interested in alternative instant messaging solutions
3. Interested in participating in a usability test.

The participants would then be sorted firstly by their concern with privacy, as this was deemed to be the most important characteristic. After this, the remaining criteria would be used equally in the sorting process. However, despite nearly 50 percent of survey respondents exhibiting interest in participating in a usability test, the number of replies to the usability test invitation email was critically low. As a result of this, we were constrained to recruit participants amongst the social circle of the group members, disregarding the initial requirements.

4.3.2 Test Setup

The usability test is designed to emulate the experience of receiving a NanoPOG unit, and configuring it for the first time. It was therefore essential to keep the environment as realistic of a representation of the end user experience as possible. Because of this, the usability tests took place in the home of one of the group members, using the setup shown in fig. 4.3.

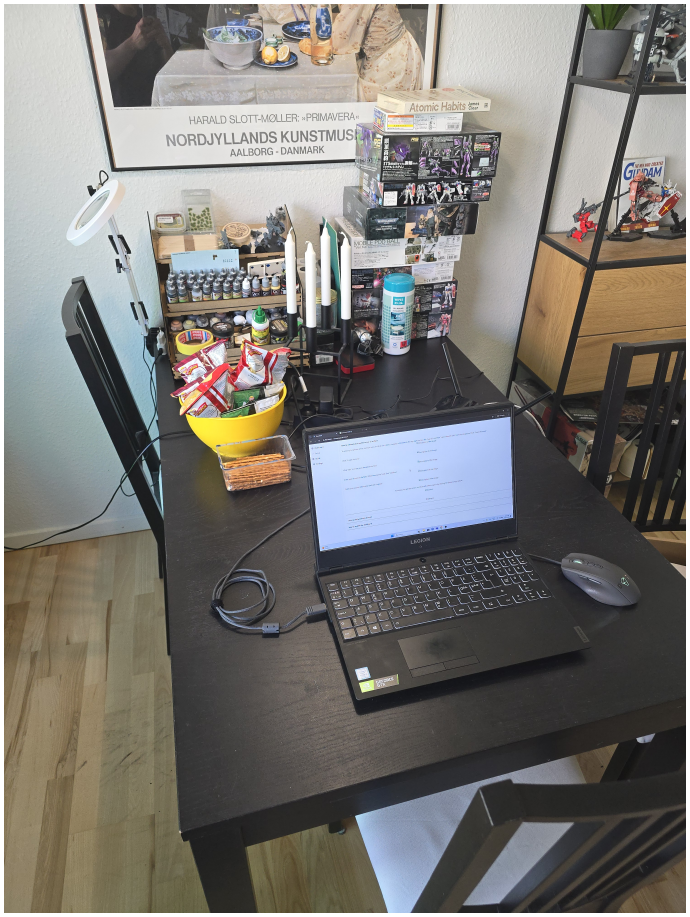

Figure 4.3: Test setup for the usability tests

When planning the usability tests, it was decided not to carry out the tests in the participants' own homes, as this could be considered an intrusion of privacy, adding another level of stress to the participants. In addition, the test environment would then be a variable of change, and would be a point of consideration when analyzing the data.

The equipment available to the participant during the test was a laptop, WiFi router, a set of tasks and the NanoPOG unit. The NanoPOG unit is a package consisting of the NanoPOG server, necessary cables, as well as the info card seen in fig. 4.4.

Figure 4.4: Info card, included in the NanoPOG package

The info card contains an introduction to the product, and a few key points to get the user started in setting up their device. The purpose of the info card is to guide the user towards the setup wizard, which will then take over, and guide the user through the rest of the setup process. Gathering the necessary items for a successful server setup in a "package" is meant to emulate the user experience of receiving the product in the mail.

During each test, only two members of the team were present, one taking on the role as interviewer, the other observer. The interviewers' responsibility was to help the participants with questions, and to prompt the participants to share their experience according to the thinking aloud method described in section 4.3.4. The observers' task was to ensure the proxy server functioned as intended, as well as play a participating role during one of the tasks.

Audio was collected through the built-in microphone of the used laptop, whilst screen recordings were collected through the software "Open Broadcast Software".

Participants were offered free drinks and snacks, as compensation for participating in the test.

4.3.3 Tasks

This section presents a series of tasks the participants were asked to complete during the usability test. As mentioned earlier, the tasks are meant to simulate realistic use cases of the NanoPOG solution.

1. Unbox NanoPOG Solution

Task: Unbox the product

Context: The Raspberry Pi needs to be powered and connected to the internet, such that it is ready for configuration.

Additional info: -

Goal: The task is complete when you see the landing page of the configuration wizard with the NanoPOG logo.

2. Server Setup

Task: Set up a new Matrix server on the Raspberry Pi using the web client

Context: A matrix server needs to be configured in order to chat with others. Please use the settings below.

Additional info: Example domain - happy; Allow others to sign up - YES

Goal: The task is complete, when you see a "success" notification.

3. User Registration

Task: Create a new user.

Context: You need a user on your server to chat with others. Please use the information below.

Additional info: Username: janedoe, Password: Nanopog1234, Domain: happy.nanopog.com

Goal: The task is complete when you are logged in on the Element client.

4. Use Element

Task: Chat with another user on the Element client.

Context: You must find another user and engage in conversation. Please use the information below.

Additional info: Username: @lasse:happy.nanopog.com

Goal: The task is complete, when you receive a hello message from Lasse.

5. The Dashboard

Task: Enable and view the dashboard on the NanoPOG setup wizard.

Context: To see statistics about the server, you must enable the dashboard. Please use the information below.

Additional info: Username: admin, Password: admin

Goal: The task is complete when you can view the dashboard page.

4.3.4 Evaluation

Performance Measurements

In section 3.2, we defined a set of usability attributes, which we determined to be important to include in the design of the UI in order to achieve a simple, intuitive and user friendly system. This section will present a set of performance measurements with the intent of quantifying the usability attributes, based on the performance of the participants during, and after the usability test.

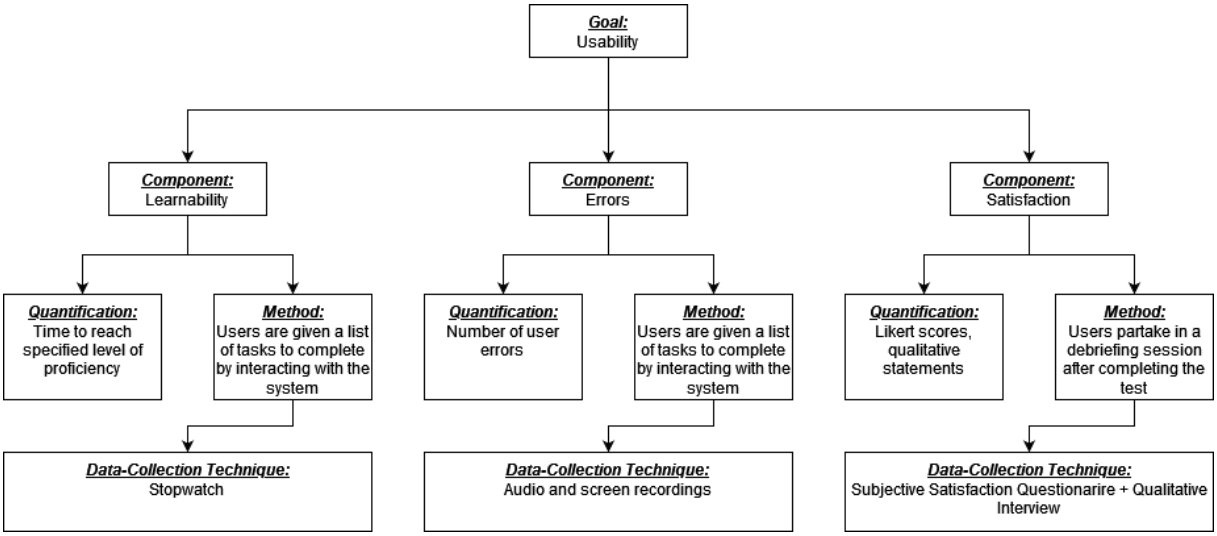

Figure 4.5: Performance measurements for the setup wizard

The model shown in figure 4.5 illustrates the usability attributes incorporated in the design of the setup wizard. The model also describes how the attributes are quantified into measurable components for our usability tests. The learnability of the wizard has been quantified into the amount of time it will take for the participant to reach a specified level of proficiency. For this test, we have defined the participant to be proficient when they are able to complete the set of tasks in a maximum of 15 minutes. This will be measured and tracked throughout the portion of the usability test concerning the wizard, by utilizing a stopwatch to track the participants completion of the tasks. The stopwatch will start at

the beginning of the test, and stop whenever the user have completed the last task. The time to proficiency have been defined based on the results of the survey. As presented in section 5.1.4, 75.3% of respondents prefer a setup time of 15 minutes or less. The error attribute will be quantified as the amount of user errors encountered during the usability test. In addition, the error location will also be logged, in order to gain an overview of possible problematic areas of the wizard. This will be collected during analysis of the audio and screen recordings.

The participants' satisfaction with the wizard will be measured during the debriefing session after the usability test. As part of the debriefing, the participants will fill out the subjective satisfaction questionnaire presented in section 4.3.4, which will provide us with several subjective scores of the system. In addition, we will also gain insight into the participants satisfaction through statements made during the test as well as the qualitative interview.

Thinking Aloud

One of the methods used to evaluate and gather qualitative data is the thinking aloud method [10]. This method is used by having the test participants express their thought process and opinions verbally, in regards to their current actions [10]. This allows us to gain insight into the participants' understanding of the system as well as identify possible misconceptions they might have of the system, which could have resulted in a false impression of a usability error [10]. This is incredibly valuable as it enables us to clarify what the participants experience while using the system. In addition, it can also provide us with the participants' subjective opinions of the system features and design, which might be overlooked in other performance measurements, or forgotten by the participant during the debriefing session. However, it is important for the evaluators to assess the validity of statements given by participants. It is possible to manifest unreliable usability errors if too much significance is given to errors and solutions expressed by the participants, as there can be other causes for these [10]. It is therefore important that the evaluator takes note of the participants' actions whilst they express their frustrations, as it can aid the evaluator in determining the validity of the statements. The absolute main advantage of using thinking aloud is that it allows us to collect and gather a large amount of qualitative data, with a relative small amount of test participants [10]. One downside of the method is that it might feel unnatural for the participants, which can result in them completing their tasks mores slowly or less precisely [10].

Subjective Satisfaction Questionnaire

After completing the usability test, the participants are asked to complete a *subjective satisfaction questionnaire*. Jakob Nielsen explains subjective satisfaction simply as "how pleasant it is to use the system" [10]. By including this questionnaire, we are able to gain insight

into the participants' subjective opinion on certain system attributes, as well as the setup process, and estimate a general consensus on these.

1. How would you rate the ease of setting up the NanoPOG Unit using the provided software?

   Complicated - Easy

2. Please rate the clarity of instructions provided during the setup process.

   Not clear at all - Crystal clear

3. Rate the intuitiveness of the user interface for managing server settings.

   Confusing - Intuitive

4. How satisfied are you with the customization options available for configuring the server?

   Lacking - Fully customizable

5. Please rate the intuitiveness and clarity of the dashboard.

   Confusing - Intuitive

6. How comprehensive do you think the dashboard is?

   Limited - Comprehensive

7. How would you rate the overall performance of the Setup Wizard in responsiveness and speed?

   Slow to use - Fast to use

8. How satisfied are you with the overall process of setting up a home server using our NanoPOG Solution?

   Disappointed - Satisfied

As shown above, the questionnaire contains a number of questions in the style of a Likert scale, which is composed of two opposing statements, and a range of values in between. This gives the participants the opportunity to express their level of agreement or disagreement with each statement.

Interview

We have included a qualitative interview as part of the debriefing stage of the usability study. The questions used during the interview are presented below.

1. Can you walk me through your experience setting up the NanoPOG Solution?

2. Were there any particular steps or tasks that you found challenging or confusing during the setup process?
3. What features or functionalities did you find most useful or valuable?
4. How would you describe your overall satisfaction with the user interface and user experience?
5. Can you suggest any improvements or additional features that you believe would enhance the usability of the software?
6. After having gone through this setup could you see yourself using the NanoPOG solution in the future?

The questions have been designed to gain detailed insights into the users' experience, their thoughts on usability errors and why they occurred, as well as suggestions for improvements to mitigate these errors. In addition the questions have been designed as open-ended questions, meaning they serve as a guideline for the interviewer throughout the interview. This enables the interviewer to ask in situ follow-up questions to participants' answers, to get a deeper understanding of their perspective.

The following chapter will present an analysis of the results gathered from the methods introduced in this chapter.

Chapter 5

Analysis and Results

5.1 Results of the Survey - Quantitative

As explained in section 4.2, the survey which was sent out had both quantitative questions, as well as qualitative questions where participants were able to write open text answers. This section will focus on the quantitative data.

5.1.1 Respondent Demographics

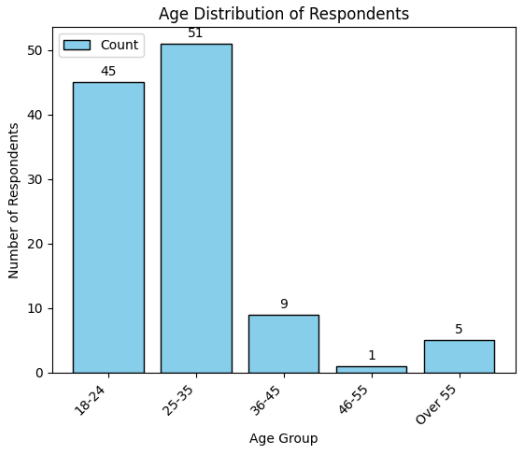

Figure 5.1: Age Distribution of Respondents

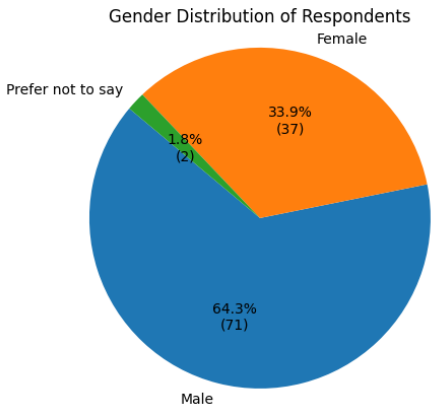

Figure 5.2: Gender Distribution of Respondents

In total there were 113 responses to the survey that was sent out. The majority of respondents were between the ages of 18 and 35, with 64.3% of respondents being male, 33.9% female, and 1.6% preferring not to say.

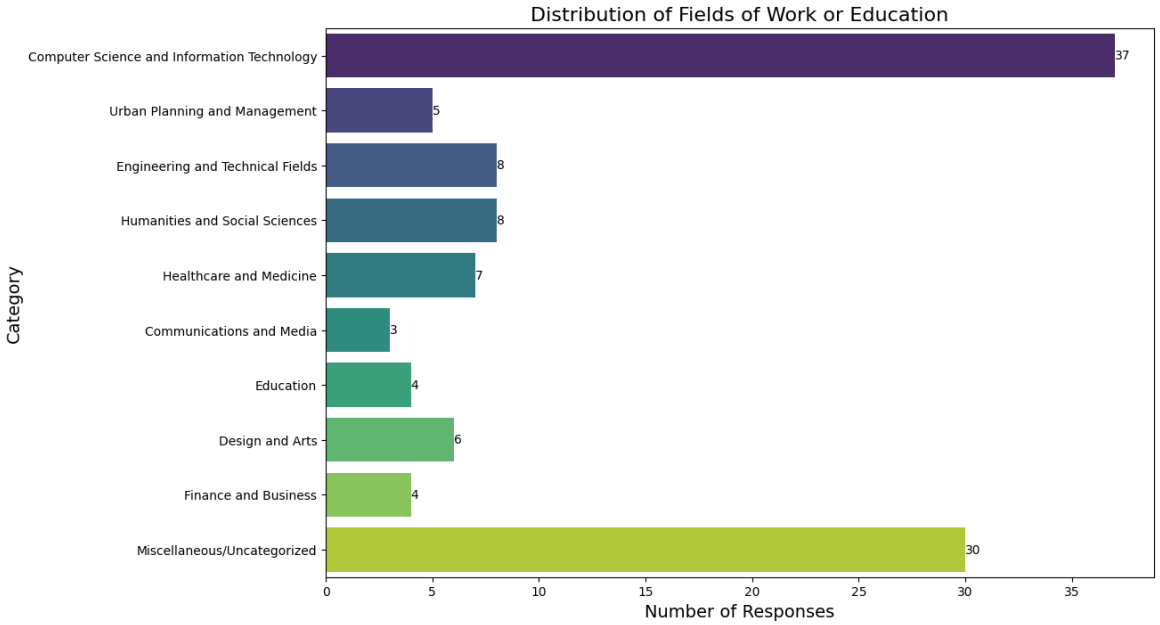

Figure 5.3: Distribution of Fields of Work or Study

Figure 5.3 shows a categorization based off the answers received from the question "What is your current field of education/work". As expected, we observed a plurality of responses categorized as "Computer Science and Information Technology", with 37 out of the 113 responses. The remaining responses were distributed among various other fields.

5.1.2 Quantitative Data - Communication Habits

How often do you use messaging apps for communication purposes?

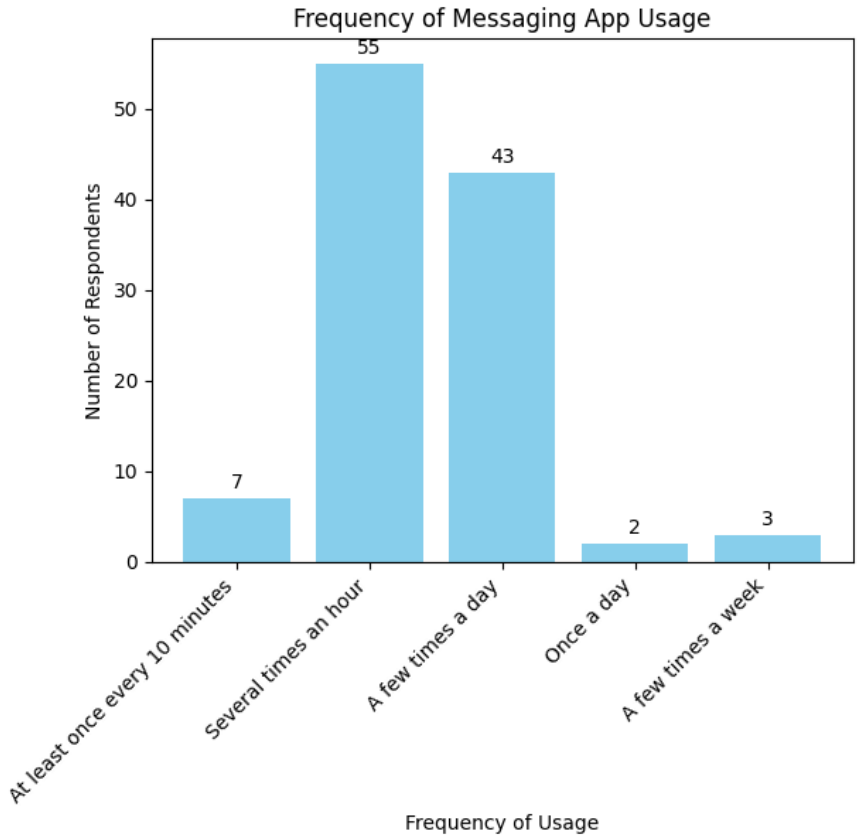

Figure 5.4: Frequency of Messaging App Usage

Figure 5.4 gives insight into the frequency of which respondents use messaging apps for communication purposes. The survey shows that the majority of respondents use messaging apps several times an hour (55), followed by respondents who use them a few times a day. This indicates that most of the respondents are using messaging apps throughout the day.

Which messaging apps do you use at least once a week?

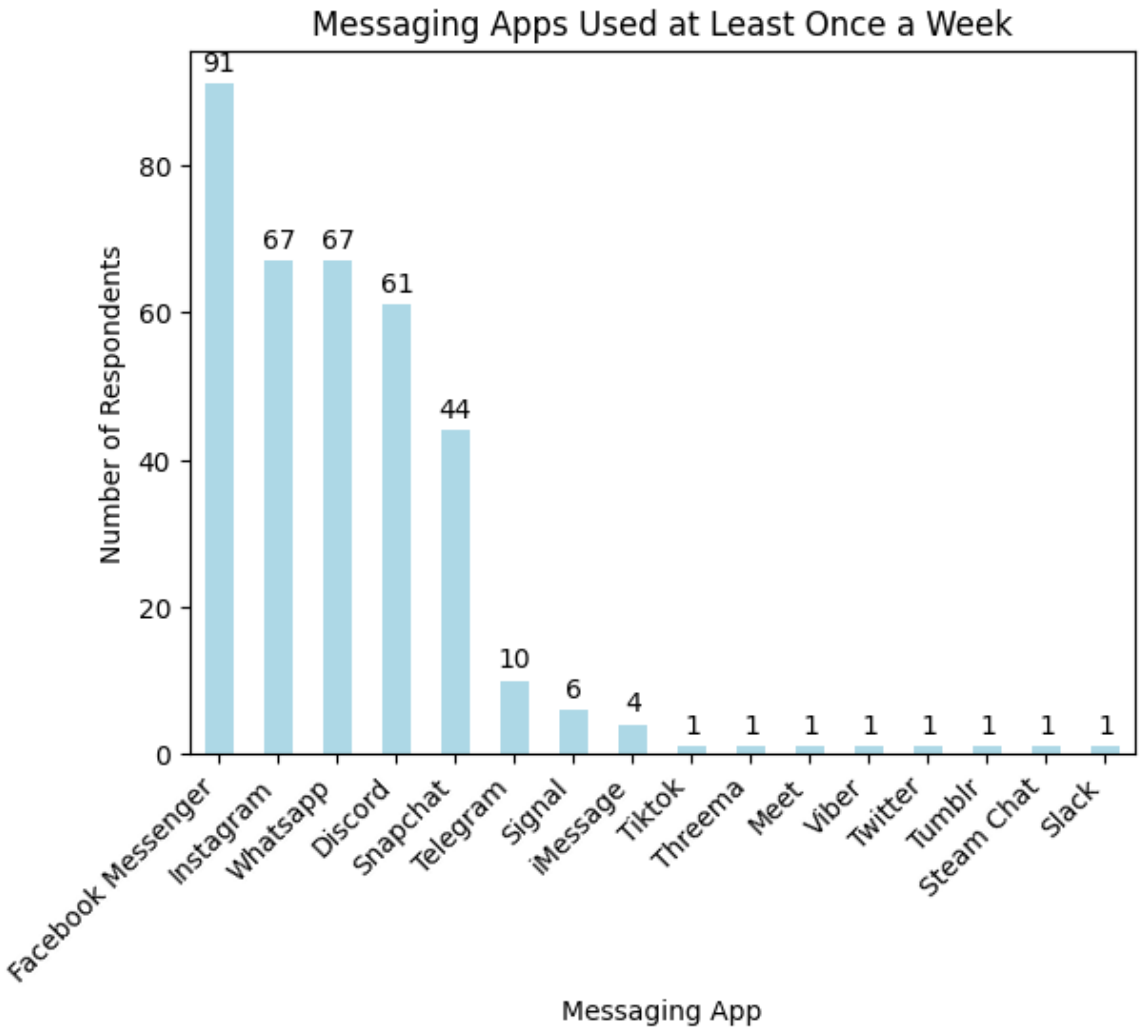

Figure 5.5: Messaging Apps Used at Least Once a Week

Respondents were asked to select every app listed (The options being Facebook Messenger, Instagram, Whatsapp, Snapchat, Telegram, and Discord), and/or fill in the "Other" option if their choice of app was not listed, which they used at least once a week. Figure 5.5 shows us that the top 3 apps were Facebook Messenger (91), Instagram (67), and Whatsapp (67). Interestingly, these three are also all platforms owned and operated by Meta. Discord follows closely behind with 61 responses, which is then followed by Snapchat at 44 responses. This figure shows a diverse but concentrated usage pattern with a few platforms dominating the top.

Are you aware of the privacy policies of the messaging apps you use?

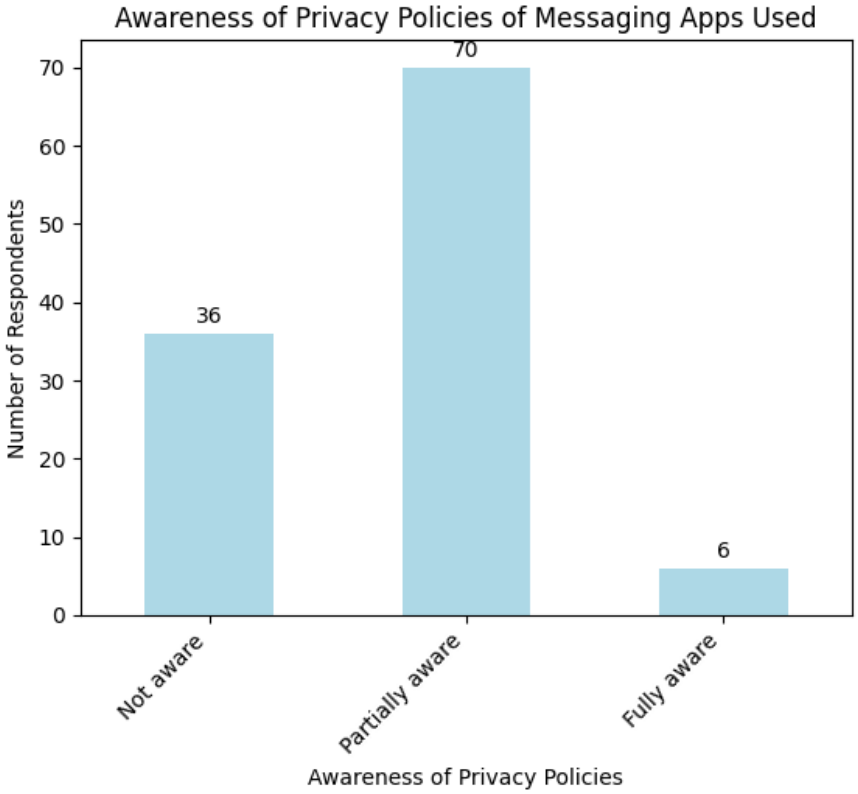

Figure 5.6: Awareness of Privacy Policies of Messaging Apps Used

Figure 5.6 shows the results for when respondents were asked about their awareness of the privacy policies of the messaging apps they use. The majority of respondents were "Partially aware" (70), followed by 36 respondents who were "Not aware". A smaller number of respondents (6) answered "Fully aware". This illustrates a significant gap in the awareness of privacy policies.

5.1.3 Quantitative Data - Privacy Concerns

How concerned are you about privacy in regards to using messaging apps?

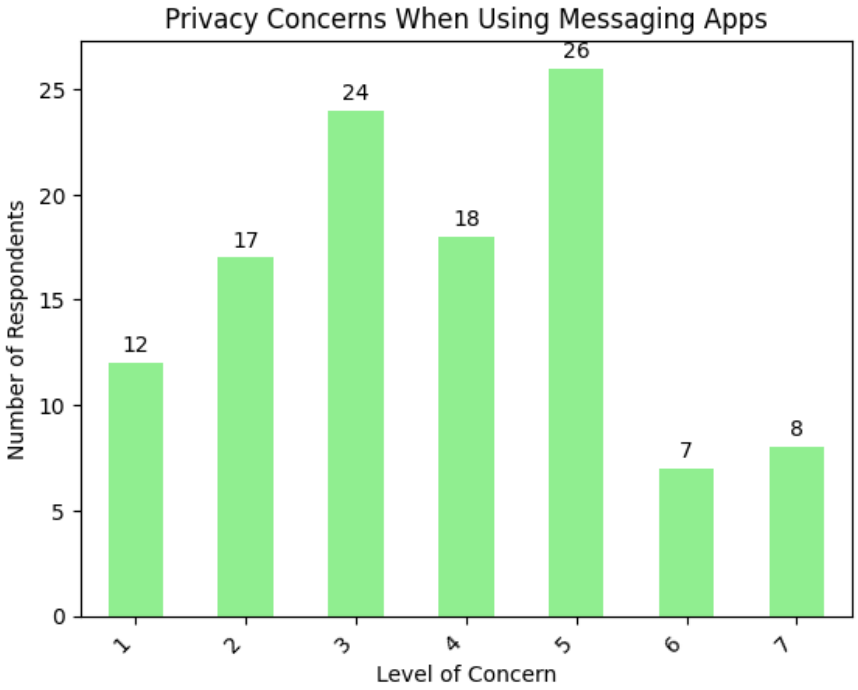

Figure 5.7: Privacy Concerns When Using Messaging Apps

For the survey question "How concerned are you about privacy in regards to using messaging apps?" the scores range from 1 (Not at all concerned) to 7 (Very concerned). We can see in Figure 5.7 that the highest number of respondents scored their concern level at a 5 (26), with the second highest number of respondents scoring it a 3 (24). The average score was 3.75, with a standard deviation of 1.7. Overall, there is a diverse range of scores with the majority of respondents being moderately concerned about their privacy.

What specific aspects of privacy concern you the most when using messaging apps?

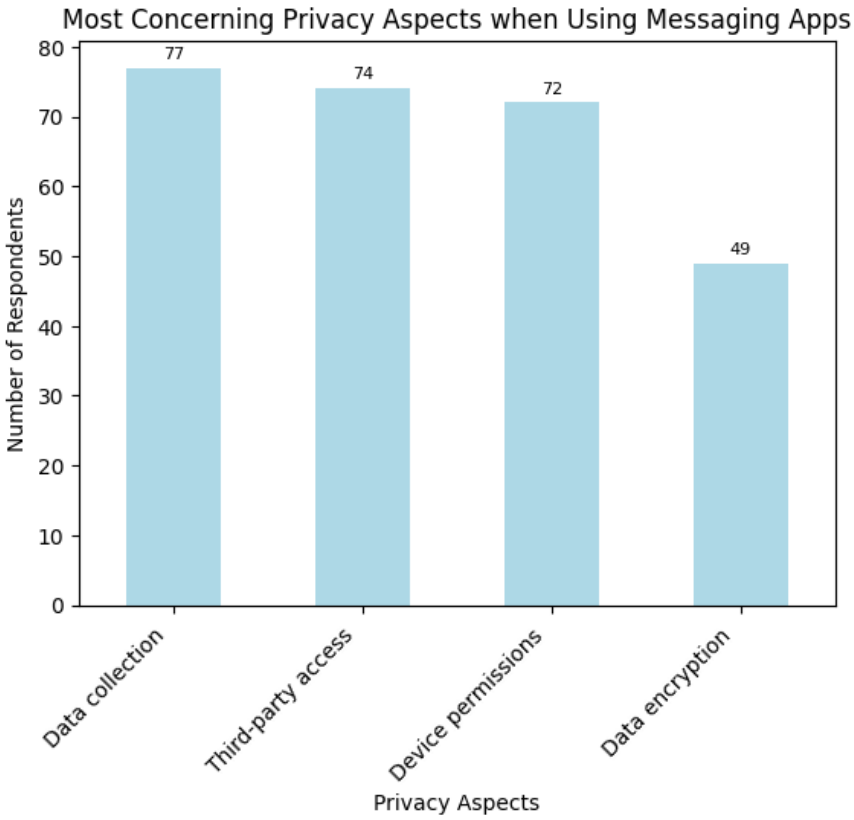

Figure 5.8: Most Concerning Privacy Aspects when Using Messaging Apps

For the question "What specific aspects of privacy concern you the most when using messaging apps?", respondents could choose one or more of the following options:

- **Data encryption (How well your messages are protected from unauthorized access, like having a secure lock)**
- **Data collection (The information the app gathers about you, covering what it knows and stores.)**
- **Third-party access (Other apps potentially getting into your messaging app, raising concerns about external access)**
- **Device permissions (The capabilities your app has on your device, including using the microphone, camera, and accessing your information.)**

In Figure 5.7 we can see that while all four options were scored highly, fewer respondents (49) found Data Encryption to be a matter of concern. Despite this, We can see from

this data that all four of these options are aspects which the respondents find important to consider when using a messaging platform.

How comfortable are you with messaging apps collecting and using your personal data for targeted advertising or other purposes?

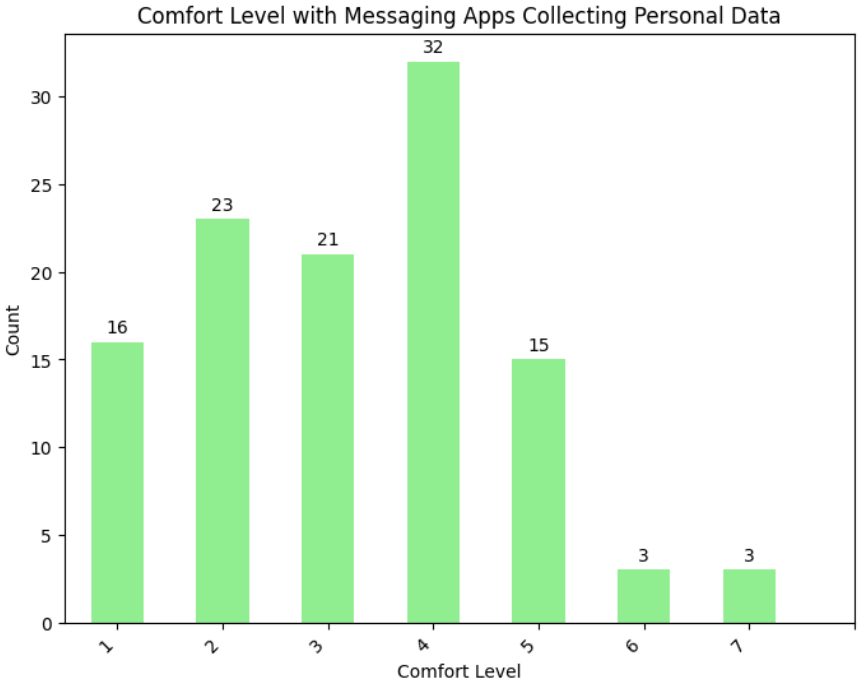

Figure 5.9: Comfort Level with Messaging Apps Collecting Personal Data

In Figure 5.9 we asked respondents to rate their comfort level from 1 (very uncomfortable) to 7 (very comfortable) in regards to messaging apps collecting and using their personal data for targeted advertisement or other purposes.

The highest number of respondents (32) rated their comfort level at a 4, indicating neither discomfort or comfort. The average score was 3.25, with a standard deviation of 1.49. Were we to split the scores into two groups, 1-3 for those who are more uncomfortable and 5-7 for those who are more comfortable, there is a clear majority in the former group with 60 respondents indicating they are more uncomfortable than not. This can be compared to the latter group of 21 respondents who feel more comfortable. This illustrates a clear trend leaning towards respondents being less comfortable with how companies use their personal data.

How confident are you in your ability to protect your privacy while using messaging apps? (e.g., avoiding sharing sensitive information)

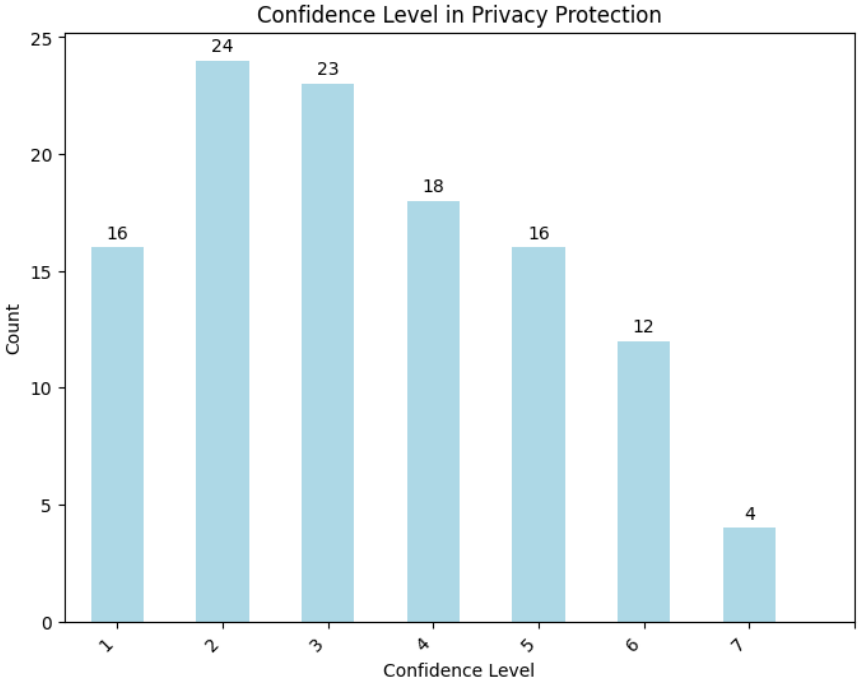

Figure 5.10: Confidence Level in Privacy Protection

When asked to rate their confidence in their ability to protect their privacy while using messaging apps, the majority of respondents scored themselves having low to moderate confidence in themselves. 1 was "Not at all confident" with 7 being "very confident". In Figure 5.10 we can see that the highest number of respondents (24) rated themselves at a score of 2, followed closely by 23 respondents rating themselves at a score of 3. There is an average score of 3.41, with a standard deviation of 1.7. While there are a significant amount of respondents who are confident in their privacy protection abilities, the data does trend towards most people having less confidence in themselves in regards to privacy protection.

5.1.4 Quantitative Data - Interest in Alternatives

Would you be willing to sacrifice certain features or conveniences in exchange for stronger privacy protections in messaging apps?

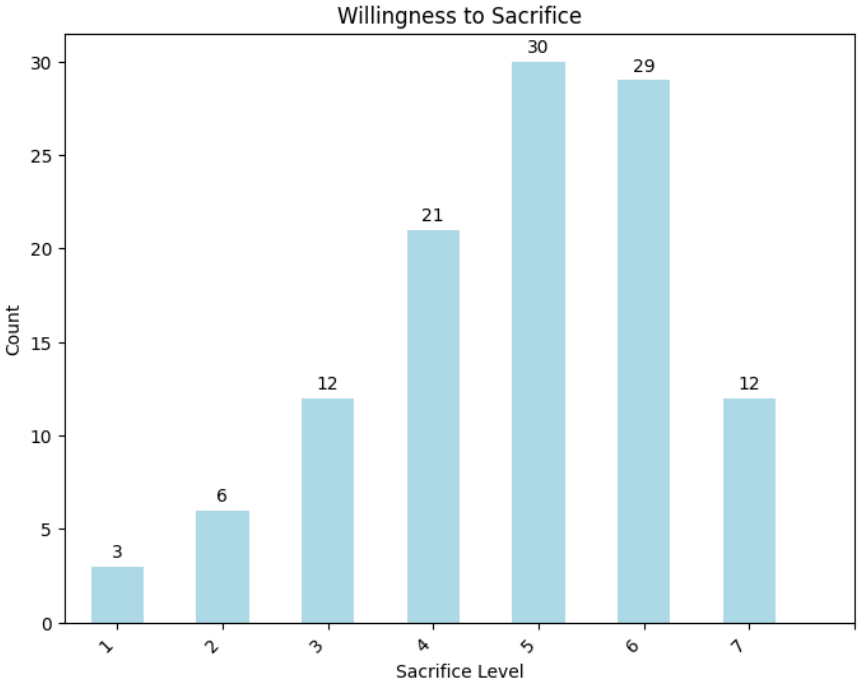

Figure 5.11: Willingness to Sacrifice

Figure 5.11 explores respondents' willingness to sacrifice features for the same of stronger privacy protection. 1 was "Not at all willing" with 7 being "very willing". The highest number of respondents (30) gave a score of 5, followed by 29 respondents who gave a score of 6. The average score was 4.8 with a standard deviation of 1.48. While there are respondents who are less willing to sacrifices features or conveniences in exchange for stronger privacy protection, there is a far great number of respondents who are willing to make these sacrifices.

What are some of the most important aspects or features that prevent you from switching out your current favourite messaging app?

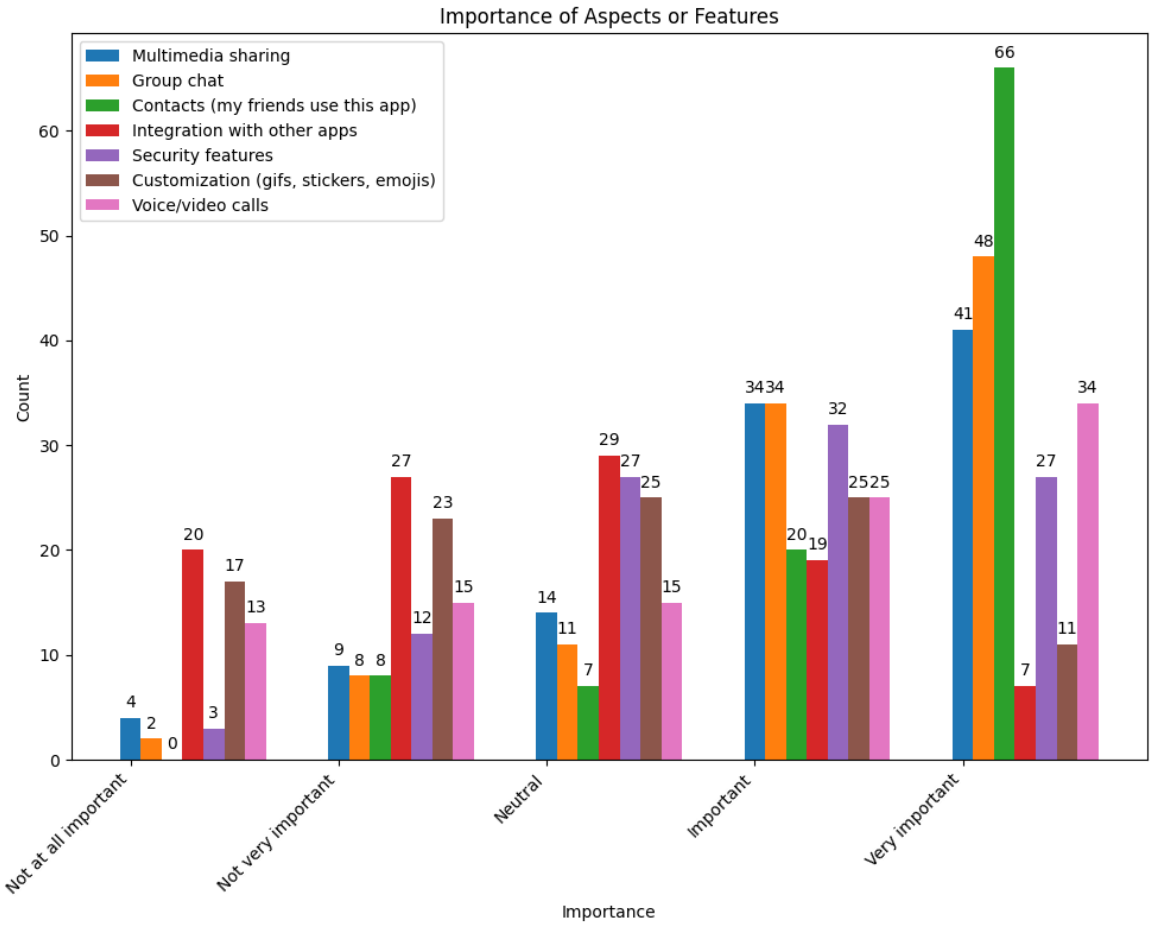

Figure 5.12: Importance of Aspects or Features

For the question show in Figure 5.12, respondents were asked to rate each of the seven features show in the graph from "Not at all important" to "Very important".

The three most important features were rated as "Contacts", "Group Chat", and "Multimedia sharing". "Security" and "Voice/video calls" was rated moderately high between "Neutral" and "Very important".

The features that were deemed least important were "Integration with other apps" and "Customization (gifs, stickers, emojis)"

Would you be interested in a solution that allows you to store your messages on your own hardware, rather than relying on third-party servers?

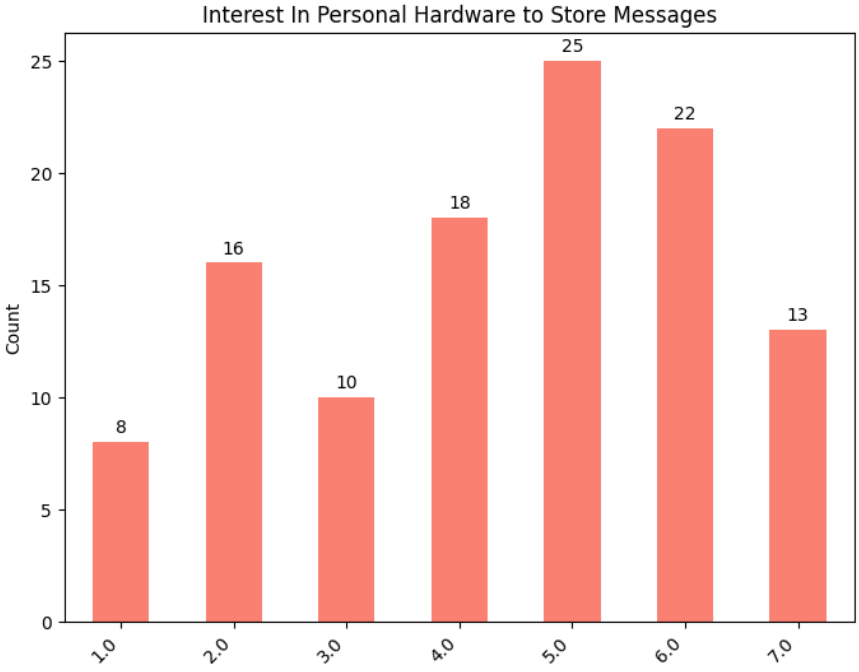

Figure 5.13: Interest In Personal Hardware to Store Messages

Figure 5.13 shows how respondents answered when asked to rate their interested in a solution which would allow them to store their messages on their own hardware instead of replying on third-party servers. The scores were from 1 (Not very interested) to 7 (Very interested). The majority of respondents gave between medium and high interest scores, with the score of 5 receiving the most scores (25). The average score was 4.38 with a standard deviation of 1.8. While this data does present a wide range of scores, they generally lean towards the higher end of the Likert scale.

How much time are you willing to dedicate to the initial setup process for such a privacy-focused messaging solution?

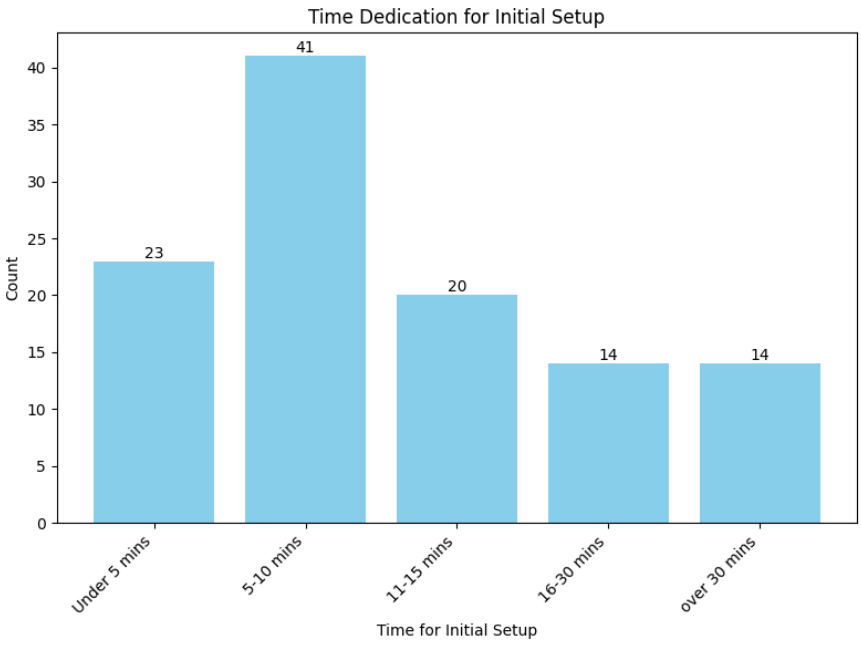

Figure 5.14: Time Dedication for Initial Setup

Figure 5.14 explores how much time respondents are willing to dedicate to the setup process of a privacy focused messaging solution. This graph shows us that the majority of respondents would not be willing to spend more than 10 minutes on the setup of such a solution, "5-10 mins" being the most popular choice for this question (scored by 41 respondents).

How important is it for you to have control over where your message data is stored?

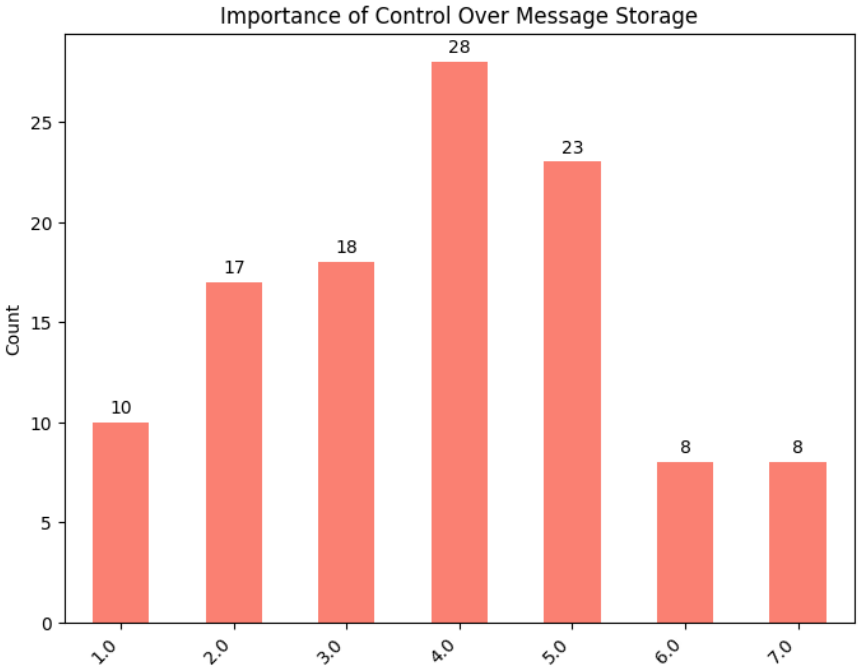

Figure 5.15: Importance of Control Over Message Storage

Figure 5.15 evaluates the importance for respondents to have control over where their message data is stored, scoring the question from 1 (Not very important) to 7 (Very important). The most selected (28) score was 4, with the second highest (23) being 5. The average score was 3.83 with a standard deviation of 1.64. The data shows us that while there are a significant number of respondents who value control over where their data is stored, there is still a moderate variance in the importance of this control.

Would you prefer a quick and easy setup process or a more complex and customizable one (that allows you to tweak every aspect of your private messaging app)?

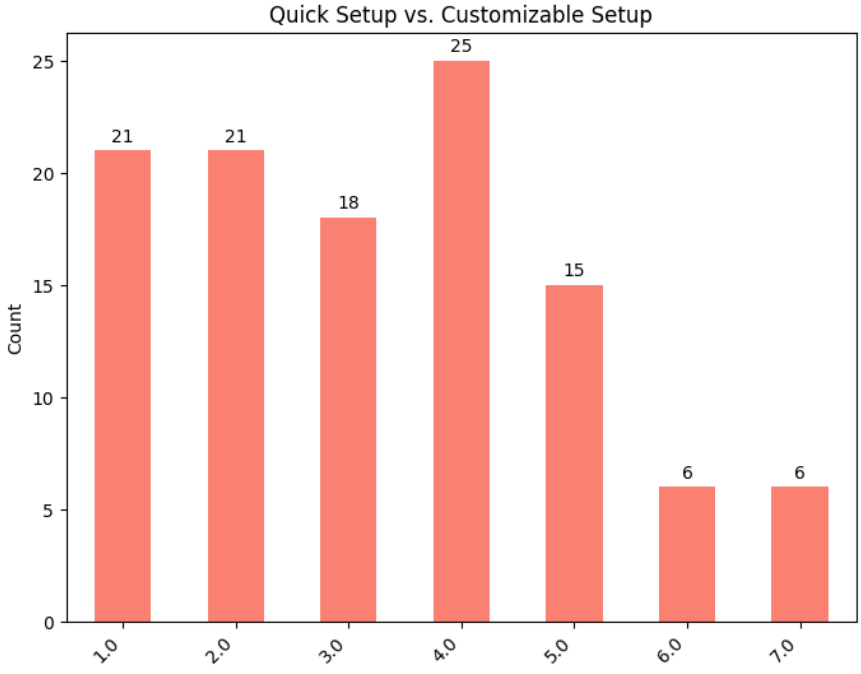

Figure 5.16: Quick Setup vs. Customizable Setup

Figure 5.16 assess whether respondents would prefer a quick and streamlined setup process, or a more complex setup process which allows for greater customization. The scores ranged from 1 (Quick and easy) to 7 (Fully customizable). The highest preference is for level 4, indicated by 25 responses. Tied for second, are 1 and 2 at 21 responses each. The average score was 3.30 with a standard deviation of 1.72.

In this data we see that while many respondents prefer a quicker and easier solution, there are still those who would rather have the option to customize the solution to their needs.

5.1.5 Quantitative Data Analysis

The results from the quantitative portions of the survey have provided valuable insights into the habits, concern, and preferences of respondents in regards to how they interact with messaging apps. The data from the 113 respondents shows that there is a strong preference for frequent usage of messaging apps. The most popular of these apps were Facebook Messenger, Instagram, and WhatsApp, highlighting Meta's dominance in the field of instant messaging.

Despite this widespread usage, there was a notable lack of understanding regarding the privacy policies of the apps respondents used, with most respondents either only partially aware or not aware at all. Conversely, there were moderate to high levels of concern in regards to privacy, alongside moderate levels of discomfort in relation to messaging apps collecting and using personal data. These number line up with Monika Taddicken's findings in relation to the "privacy paradox" [19]. Despite respondents expressing concern with the data privacy in the apps they use, they still continue to use them. Many respondents indicated that they would be willing to sacrifice certain features in exchange for stronger privacy protection, which begs the question "why have they not switched apps already, then?" Is it a matter of the the respondents being truthful to themselves? Or is there perhaps simply not a messaging alternative out there that would support their privacy concerns while offering the features they need?

Technological lock-in is a term used to describe a situation where certain technologies follow specific paths which are difficult for society to escape. Richard Perks uses the examples of the QWERTY-style keyboard or the combustion engine to explain technological lock-in [20]. There are certain technologies that are so ingrained in society and our daily lives that it would be difficult to adopt any alternative technology in the same field unless they adhere to the standards that were previously established. This can also be seen in messaging apps, where respondents made it clear that the aspects most important to them which might prevent them from switching to another messaging app are "Contacts", "Group Chats", "Multimedia Sharing", and "Video/Voice Calls".

Convenience seems to be another trend observed from the results of the survey. While respondents showed interest in a private messaging solution, many respondents required this solution to be quick to setup even if that meant sacrificing customizability.

Overall, the survey highlights a conflicting landscape where there is a high usage of messaging apps, despite significant privacy concerns and a demand for improved privacy protections. These findings show that respondents are unsatisfied with the state of privacy in current messaging apps and might be willing to switch to an alternative if it provides better protection alongside the features we are accustomed to.

5.2 Results of the Survey - Qualitative

In this section we will explore the qualitative open text answers which respondents gave in the survey. This section will be divided up by each of the 4 questions that were posed. To help assess the responses, a thematic analysis was conducted to discover and define patterns throughout the responses.

5.2.1 Have you ever experienced any privacy breaches or concerns while using messaging apps? If so, please describe.

Respondents frequently mentioned themes of **digital deception**, **invasions of privacy**, and **security** when using messaging apps.

Digital Deception

Digital deception is a term used for instances where users have interacted with malicious individuals trying to deceive those users by impersonating people or companies in order to take advantage of victims, for example, by scamming them for money or obtaining their sensitive information. Respondents specifically mentioned scams and phishing attempts in their responses.

Respondent 89 specifically quoted *"A lot of marketplace/blå avis scams"*. A common form of digital deception is when someone on a sales platform such as Facebook Marketplace or the Danish "Den Blå Avis" claims they want to sell a specific item, but as soon as a buyer sends the money, the seller does not send the requested item.

Respondent 87 brings up phishing attacks, saying quote *"phishing attacks from hijacked accounts of people i know, bot attacks"*, which is another form of digital deception where the victim receives a hyperlink claiming to be a person or service the victim is familiar with, and asking them to provide sensitive information. Examples of this is phishing attacks where the scammer pretends to be a bank needing the victim to input their credit card information, or a scammer pretending to be a package delivery company asking for an email and password to deliver a package they ordered.

Respondent 99 brings up unsolicited messages saying quote *"Regarding messaging apps specifically then worst I've really had is some possibly connected unsolicited message requests..."*. These are messages from users not known to the recipient. Phishing attempts are commonly made through unsolicited messages received on messaging platforms such as Facebook Messenger or Instagram.

Invasion of Privacy

In this report we define "invasion of privacy" as instances where a user felt like they had no control over the access and manipulation of their own data. A common theme among respondents was that several of them felt as though the items or concepts that had been discussed when communicating with friends would then appear in the advertisements the respondents would later encounter. **Respondent 38** answered *"My friends and me were talking about a certain subject and i did not look up things about it, and then later, in suggested ads, it was about that subject. It felt like i was spied [on]"*. This phenomenon has been covered extensively in different papers, especially in regards to how users perceive these types of experiences as "creepy" [2][3].

Security

Security is another theme that we noticed throughout the responses. Several respondents noted experiences where their account had been "hacked", typically meaning that a malicious actor came into possession of their password. There are many ways this can happen, one of which is through the previously mentioned "phishing" method. Once a malicious actor has control of another person's messaging account, they are then able to send out further phishing messages from the victim's account to the victim's contacts. **Respondent 43** claimed that *"[...] my Facebook has been hacked twice and did send out messages under my name"* when answering this question. **Respondent 87** also had a similar response: *"phishing attacks from hijacked accounts of people i know, bot attacks"*.

5.2.2 Have you ever switched messaging apps due to privacy concerns? If yes, what motivated the switch?

When asked whether or not respondents had switched messaging apps due to privacy concerns, the common themes of those that answered yes were **Security**, **Company Integrity**, and **Social Landscape**.

Security

Many respondents stated that privacy and encryption where direct reasons for switching or choosing specific apps. It is very important for these respondents that the messages they send are strictly encrypted and that no one other than the sender and recipient would be able to view the messages. While one respondent cited sending legal documents (passport pictures, **Respondent 109**), several respondents cited illicit activity as their reason for switching messaging apps. **Respondent 38** explained *"yes, mostly coz it was about illegal things haha (buying weed in Belgium is a no-no)"*, while respondent 46 simply answered *"I was buying weed."* The security and percieved privacy provided by certain apps are very important aspects for respondents who want to purchase illegal substances.

Public Perception and Platform Reputation

Public perception of the integrity of a company was another reason some respondents chose alternative messaging solutions. If a messaging platform experiences negative publicity regarding its operations, trust in these platforms is often lost from the users. **Respondent 10** cited Tik-Tok as a concern for them, stating *"There had been news articles published about certain messaging apps misusing or not following the ToS they had implied. A good example would be tik tok"*.

Respondent 81 also provides an example of a messaging platform experiencing a security breach, which prompted them to change: *"After observing Skype's blunder, I didn't trust them to have any kind of security. If they make mistakes like exposing IP, what other mistakes have they made?"*.

Social Landscape

A common thread found throughout the answers to the above question was how changing messaging apps was often encouraged by one's social circle; specifically their want for more security. **Respondent 68** explained that *"A group of my friends switched to Discord a few years ago from Facebook messenger, due to privacy concerns around message encryption"*. Another example in the same vein was **Respondent 11** who said *"I switched to Signal briefly, because of a friend's recommendation and promise saying it was more secure..."*.

If one or more friends in a social circle start promoting the security features of certain messaging apps, it seems this can be a catalyst for respondents to switch to other messaging apps. This may be connected to a theme found in the security section 5.2.2 of this question, where those dealing in illicit activities may encourage use of safer messaging platforms.

5.2.3 Are there any other features that would prevent you from switching from your current messaging app?

There were two main themes that were noticed when respondents were asked what would prevent them from switching messaging apps. These were **Social Landscape** and **General Features**.

Social Landscape

The responses we encountered most often for this question dealt with the social landscape. While not a feature, many respondents used this question as an opportunity to state how they would only switch apps if their friends or other contacts were also using the alternative app. **Respondent 26** stated *"If my friends and family dont use the app/have difficulties using it I think it'll be hard for me to switch"*, with **Respondent 101** sharing a similar sentiment: *"Other people need that app then as well. It is important to me that all my friends have the same app"*.

Another theme within the social landscape was that the general widespread adoption of the alternative app would be necessary for them to switch from their current messaging app. **Respondent 43** explained that *"I'd only switch to something other [people] actually use. No use being on a new platform with only 10 people willing to go there"*. **Respondent 83** also stated *"No features but lack of people making the switch as well, since then I would have no one to write"*.

General Features

While **General Features** might seem like a broad theme in itself, it shows that many of the features we take for granted in today's messaging apps would need to also be present in any new alternative in order for some respondents to switch. Among these features are the ability of share files, as stated by **Respondent 13** saying*"If I can text, send links/files and*

I can call, I'm good", or being able to send voice messages and other media as explained by **Respondent 109**: *"If I cannot use the voice message or send pictures, then I wouldn't use another app (my main app is WhatsApp)"*

5.2.4 Do you have any concerns or reservations about the setup process for such a messaging solution? (optional)

The final open text question in the survey asked respondents if they had any concerns or reservations regarding the setup of a privacy-focused, home-owned solution. There were three themes found from the answers the respondents gave: **Security**, **Cost of Switching**, and **Setup Complexity**.

Security

The theme of **Security** is yet again a subject respondents are concerned about. Some of these concerns are focused around the idea of local storage. With a private solution like NanoPOG, the users would need to be responsible for this physical piece of equipment. **Respondent 42** expressed concern in this regard stating that *"Local storage is good but then losing your phone sucks A LOT unless you have your own back-up solution."*

In the realm of cyber-security, there were also some respondents who noted that the privacy and security of their messages were a concern for them. **Respondent 89** explained that *"You would still rely on your isp and phone company to transport your data so the end to end encryption need to be good so it can't just be taped "*

Cost of Switching

The cost of switching was another consideration from respondents. Some respondents were concerned about the power/running costs of a private messaging server. **Respondents 1 and 62** both expressed these concerns stating *"Long term effects, such as running costs"* and *"How much power it would use"* respectively.

Others were also concerned about up-front costs of this type of solution. **Respondent 83** asked *"Is it free?"*, while **Respondent 12** was concerned about the *"Cost and maintenance (updating)"*

Setup Complexity

The final theme we found for this question was regarding the complexity of the setup. There were several respondents who were concerned with how difficult this type of solution would be to setup. **Respondent 70** explained that *"If I need to spend upwards of 15 minutes, that is fine, so long as it is not recurring often. Also the complexity of it is negligible so long as a simple step by step guide is provided!"*

In addition to the ease of setup, respondents often added the caveat that they should also be able to fully customize their setup experience if they'd like. **Respondent 13** stated *"I'd like to say no, but knowing myself, I might lose interest if there isn't an "express" setup option. Then after, if I like the app, I'd probs dig deeper in the settings for additional customisation"*, while **Respondent 71** remarked *"Setup should be easy, further customization should be abstracted to a settings screen"*. **Respondent 80** also suggested incorporating a step-by-step setup wizard, saying *"Would love a quick and easy set up but the options of making it more customizable. Having a set up wizard that makes it easy to walk through the set up step by step would be ideal."*

5.2.5 Qualitative Data Analysis

The answers from the qualitative survey offer an in-depth insight into users' experiences and perspectives on privacy in messaging apps. The analysis identified several major themes: digital deception and security, invasion of privacy, the social landscape, setup complexity, and illicit activity.

Digital deception was a subject which was frequently mentioned, citing online market scams and phishing attacks, highlighting the ongoing risks associated with the messaging apps in use today. This could make a solution like NanoPOG be more appealing, as it is an enclosed ecosystem which can be made inaccessible from outside threats. Security in general was also significant for many respondents, explaining robust encryption was important to them. Additionally, some respondents revealed experiences of themselves or their friends' accounts having been hacked.

The invasion of privacy was another important theme, with several respondents stating their discomfort when they are targeted by aggressive advertisements which are too similar to topics they had previously discussed with friends. These types of experiences often leave users feeling uncomfortable, making them question how and if their data has been accessed without their knowledge.

One of the most prevalent themes was in regards to the social landscape. Several respondents stated how they would be less willing to adopt a messaging application alternative to their current app, unless either their social circle was also using it or unless there was a more widespread adoption of this alternative. Conversely, some respondents had also felt pressure from their social circle to switch messaging apps.

Concerns regarding the setup complexity of a privacy focused messaging solution such as NanoPOG were also noted. A recurring theme was observed with respondents preferring a solution which was quick and easy to setup, but with the caveat that there would also be the opportunity to customize the experience if desired. Some respondents were also concerned about the up front costs of such a solution, as well as the operating costs and maintenance needed.

A theme which caught the team by surprise was illicit activity. There was a notable portion of respondents who were forthcoming in explaining that their privacy concerns and subsequent decisions to switch messaging apps was driven by a need to securely engage

in illicit activities such as purchasing illegal substances. The perceived enhanced security and encryption offered by certain messaging apps were seen as crucial for these users to avoid detection and protect their communications from undesired agents. As developers of this solution, we have a responsibility to consider the ethical concern of how a private messaging solution might be used for illicit activities. While some respondents explained they used more secure messaging alternatives for relatively minor illegal activities such as buying marijuana, there is also a risk that more serious criminals could exploit the platform.

The qualitative responses from this survey have underlined how many were uncomfortable with the instant messaging landscape found today. There seems to be a desire for a secure, private, easy to set up, and cost effective alternative to the current messaging apps.

5.3 Results of the Usability Tests

5.3.1 Completion Times and Learnability

As mentioned in section 4.3.4, participants' completion times were tracked in order to evaluate learnability based on the time limit determined by the survey results presented in section 5.1.4. Figure 5.17 displays the completion times for each of the participants.

Participant	Time
P3	12:15
P4	12:45
P5	14:02
P6	14:52
P7	24:41

Figure 5.17: Completion time of participants

The majority of the participants are within the set limit of 15 min of which we consider the system to posses high learnability. However, P7's time deviates significantly compared to the others. As presented in section 5.3.2, P7 did not experience an unusual quantity of errors compared to the remaining participants. Throughout the usability test P7 found some of the wording to be too technical for the average person, which resulted in several pauses to provide feedback to the interviewer. This leads us to believe that this serves as the basis for the deviation in completion time. Whether P7's completion time is an outlier, or there is an undiscovered pattern remains to be determined, as it would require additional usability tests to confirm. The following sections will explore the satisfaction

and error in the system, by analysing recordings of the usability tests and the following debriefing sessions.

5.3.2 Usability Errors and Thinking Aloud

In this section we explore the observed usability errors collected from the usability tests and thinking aloud method. To determine and evaluate the impact of each error, we have decided to categorize and rank them based on the severity rating matrix pictured in figure 5.18.

		Proportion of users experiencing the problem	
		Few	*Many*
Impact of problem on the users who experience it	*Small*	Low severity	Medium severity
	Large	Medium severity	High severity

Figure 5.18: Severity rating matrix

The severity matrix describes the severity of a usability error based on the impact of the problem on the users who experience it, and the proportion of users experiencing the problem [10]. Based on these determinations each usability problem can be categorized as having low, medium or high severity. As we have completed a total of five usability tests (excluding the two pilot tests), we have adapted the metrics of the model for our use case as follows:

Impact of problem on the users who experience it:

- *Small:* The problem had a small impact on the user
- *Large:* The problem had a large impact on the user

Proportion of users experiencing the problem:

- *Few:* 2 or fewer participants experienced the problem
- *Many:* 3 or more participants experienced the problem

The list of usability errors presented in figure 5.19 has been collected by the project members, by reviewing and analysing the recorded video and audio of each participant.

Usability Problem	Severity	Experienced by				
		P3	P4	P5	P6	P7
Guide is not easily noticed and/or forgotten about	Medium		x		x	
When setting up the dashboard, user is directed to settings page, and is then lost	Medium	x	x			
Went to the settings page when trying to create a normal user	Medium		x			x
When creating admin for dashboard, user assumes "create admin user" in settings is all they need	Medium			x	x	
Went to the newly created NanoPOG domain instead of Element.io to create a user	Low			x		x
When opening a duplicate instance of the web client in a new tab, the NanoPOG server instance appeared as not yet created (even if it had already been setup in the original tab)	Low					x

Figure 5.19: List of usability errors collected from the usability tests

We collected a total of 6 usability errors. 4 of them have been categorized as medium severity, whilst the remaining two have been categorized as low severity.

Guide is not easily noticed and/or forgotten about This error occurred for several of the participants throughout the usability tests. During certain tasks, some participants were unsure how to proceed, overlooking the guide as a means of help, until prompted as a suggestion by the interviewer. Because of the impact this error had on the participants, it has been categorized as being of medium severity, as it caused the participants to get stuck.

When setting up the dashboard, user is directed to settings page, and is then lost As the previous error, this one also affected two of the participants. It occurred during the last task, in which the participants are asked to enable the dashboard. After their initial action of going to the dashboard tab, a notification instructs them to go to the settings page in order to set up the dashboard. On the settings page, users got stuck, as there were no additional instructions to be found. Because of its impact, this error has been categorized as of medium severity.

Went to the settings page when trying to create a normal user During the third task, where participants are asked to create a user for the server, several participants went to the settings and attempted to set up an admin user instead. This error also occurred for two participants, and has been categorized as medium severity.

When creating admin for dashboard, user assumes "create admin user" in settings is all they need After users were redirected from the dashboard tab to the settings page in order to setup an admin user for the dashboard, some participants got confused, when the dashboard was still disabled, after they successfully created an admin account. One of the participants explained their reasoning with "cause it said admin here". This error occurred for two participants and has been categorized as medium severity.

Went to the newly created NanoPOG domain instead of Element.io to create a user This error also occurred for two participants. This error occurred when participants were tasked with creating a user on Element, but mistakenly assumed they had to go to the domain of their Matrix server. As this did not impact the participants in a meaningful way, this error is categorized as low severity.

When opening a duplicate instance of the web client in a new tab, the NanoPOG server instance appeared as not yet created (even if it had already been setup in the original tab) This error happened for one participant when they opened a duplicate tab of the already active web client, which as a result caused some confusion. The error did not impact the participant in a severe way, and is therefore categorized as low severity.

5.3.3 Subjective Satisfaction Questionnaire

As explained in section 4.3.4, our subjective satisfaction questionnaire consists of 8 questions which we asked our participants rate on a Likert scale from 1-7. In Figure 5.20 we show the results of the questionnaire in a table with the addition of heat map colouring. Below is an analysis of the results, where for each column we calculate the **mean, median, standard deviation, and range** *"Please rate how satisfied you are with the overall process of setting up a home server using our NanoPOG solution. (disappointed - satisfied) ."*

Participent ID	Please rate the ease of setting up the NanoPOG unit using the provided software (complicated - Easy)	Please rate the clarity of instructions provided during the setup process (Not clear at all - Crystal Clear)	Please rate the intuitiveness of the user interface for managing server settings. (confusing - Intuitive)	Please rate how satisfied you are with the customization options available for configuring the server. (Lacking - Fully customizable)	Please rate the intuitiveness and clarity of the dashboard (confsuing - intuitive)	Please rate how comprehensive you think the dashboard is. (limited - comprehensive)	Please rate the overall performance of the Setup Wizard in responsiveness and speed (Slow to use - Fast to use)	Please rate how satisfied you are with the overall process of setting up a home server using our NanoPOG solution. (disappointed - satisfied)
3	7	6	7	7	7	5	6	7
4	2	6	6	5	7	5	7	7
5	4	3	5	5	5	5	4	6
6	7	7	5	5	5	6	6	6
7	5	6	6	6	5	4	5	6
Analysis								
Mean	5	5,6	5,8	5,6	5,8	5	5,6	6,4
Median	5	6	6	5	5	5	6	6
Standard Deviation	2,121	1,517	0,837	0,894	1,095	0,707	1,140	0,548
Range	5	4	2	2	2	2	3	1

Figure 5.20: Results from the subjective satisfaction questionnaire

Question 1 - Please rate the ease of setting up the NanoPOG unit using the provided software (Complicated - Easy): The first question received the most varied responses, ranging from 2 to 7, and with a standard deviation of 2.121. This suggests that while some users found the setup to be straightforward, other encountered difficulties. This could be attributed to a difference in technical knowledge by the participants, or specific issues with the setup process itself. This is something that would need to be investigated further.

Question 2 - Please rate the clarity of instructions provided during the setup process (Not clear at all - Crystal clear): The clarity of instructions generally scored high with a mean of 5.6 and median of 6. Despite some variability with a range of 4, participants seemed to find the instructions clear. That said, it is also apparent there is room to improve the clarity of instructions in the future.

Question 3 - Please rate the intuitiveness of the user interface for managing server settings. (Confusing - Intuitive): The intuitiveness of the user interface for managing server settings was rated highly, with a mean of 5.8 and a median of 6. The standard deviation was low (0.837), and the range was narrow (2), indicating that most participants found the UI intuitive.

Question 4 - Please rate how satisfied you are with the customization options available for configuring the server. (Lacking - Fully customizable): Participants rated their satisfaction with the customization options available for configuring the server with a mean of 5.6 and a median of 5. The standard deviation was 0.894, and the range was 2, indicating relatively consistent satisfaction.

Question 5 - Please rate the intuitiveness and clarity of the dashboard (Confusing - Intuitive): The dashboard's intuitiveness and clarity received a mean score of 5.8 and a median of 5, with a standard deviation of 1.095. The range was 2, reflecting general consensus among users.

Question 6 - Please rate how comprehensive you think the dashboard is. (Limited - Comprehensive): The comprehensiveness of the dashboard was rated consistently, with a mean of 5 and a median of 5. The standard deviation was the lowest among the metrics at 0.707, and the range was 2. This indicates that users generally agreed on the dashboard's comprehensiveness, viewing it in a positive light with room for improvement.

Question 7 - Please rate the overall performance of the Setup Wizard in responsiveness and speed (Slow to use - Fast to use): The overall performance of the Setup Wizard in terms of responsiveness and speed had a mean score of 5.6 and a median of 6. The standard deviation was 1.140, and the range was 3. This indicates that while most users

found the Setup Wizard to be responsive and fast, there were some who were not satisfied with the performance.

Question 8 - Please rate how satisfied you are with the overall process of setting up a home server using our NanoPOG solution. (Disappointed - Satisfied): Overall satisfaction with the NanoPOG setup process was high, with a mean of 6.4 and a median of 6. The standard deviation was 0.548, and the range was 1, indicating that participants were consistently satisfied with their experience.

The findings from the subjective satisfaction questionnaire show generally high levels of user satisfaction with the NanoPOG solution. Despite this, the areas where users were least satisfied were in regards to the ease of setup and the clarity of instructions. Next we will discuss the verbal interviews which took place.

5.3.4 Interview

The interview carried out as part of the debriefing was an opportunity to inquire the participants of the usability study about their experiences, thoughts and suggestions, in order to gather a more detailed overview of their actions and reasoning behind them. This section presents the themes expressed during the interviews.

The User Experience of Setting Up The NanoPOG Solution

During the usability test, some participants experienced difficulties when trying to activate the dashboard, which hindered them in completing their task.

> *"When I was given the task of the admin part, creating the admin user, I made the admin user, but then I didn't realize that you used the admin user in element as well. I assumed that all the settings will be done on this place because this is the server that I'm making, right? So I assumed that the settings and everything would be from here" -P4*

As described in the quote given by P4, this participant got confused by the fact that it was required to also complete some additional configuration on an external website (Element), because they assumed that the admin user setting in the settings page was the place to configure everything they needed. In continuation of this, P5 expressed experiencing similar difficulties.

> *"...But that was more because it said I should go in the settings and then I was kind of confused what I was doing in the settings." -P5*

After being redirected to the settings page by the dashboard, this participant lacked further instructions as to what they were supposed to do there. Both P4 and P5 expressed

feeling perplexed after arriving on the settings page, and were lost in regards to what their next action should be. In addition, they were unaware of why they were required to go to Element in order to finish the configuration, because there was no mention of this on the settings page. Instead, they had to discover this on their own, by visiting the guide page. Ultimately, the aforementioned issues were resolved once the participants discovered the guide page. In this regard, the guide page was a helpful tool in solving some of the more complex tasks:

> *"[]...it can be a bit confusing, but of course with I think the guide is really helpful to give you a kind of a step to step guide, so you're not of course completely clueless in what you need to do" -P5*

As described by P5, they thought that the guide page was a helpful tool, aiding them in completing their tasks in situations where they were stuck. Although the guide appeared useful, several of the participants were unaware of its existence, until prompted with a hint from the interviewer.

> *"But yeah, no, once I remembered it was there (the guide) I just followed it. It tells me how to use element IO to set it up. It was pretty straightforward" -P4*

However, not all participants were equally impressed with the guide.

> *"The one point in the guide could have been more clear where I actually need to select my own server that obviously makes sense. But it's definitely something I forgot so that could be more clear" -P7*

P7 mentioned that some parts of the guide could benefit from a few more details. Even though a step might seem logical and straightforward to others, P7 felt it would have been nice to include it in the guide anyways, to serve as a reminder.

Satisfaction and Useful Features

When asked about which feature was the most useful, the guide was in large majority mentioned positively by P3, P5, and P6.

> *"I think the guide is very nice, as well as the pictures" -P3*

In addition to the guide, the blue information bubbles seen throughout the wizard were also mentioned.

> *"I like those always to know a bit more about what, like those question marks, to not make it too full, but explain if I want to. That was very nice." -P3*

P3 appreciated the ability to get more information in regards to a particular feature or information field if needed, without it taking up a large chunk of the UI. In regards to the UI of the wizard itself, the majority of the participants expressed a general consensus that it was clean simple and minimalistic, specifically from P3, P4, P5, P6.

> *"I think the Setup Wizards UI is simple. There's not too much going on. So it's very clean. Even if I didn't immediately know where I was going, it takes about half a second to just look at the rest of the elements and just be like, yeah, obviously if I'm setting up, I need to go to Setup." -P4*

Although minimalistic, the information provided on the dashboard seemed sparse according to one participant.

> *"And of course it's a bit barren, but I'm not sure if that's fine. For me, it's fine. It doesn't need to have anything flair-special or something for me." -P6*

P6's expected the dashboard to contain more information and statistics, and thought it felt somewhat empty in its current state. Another participant, P3, expressed concern in regards to the overall response time of the system.

> *"Sometimes I had a bit of the impression that I was lagging a bit. So I was, or when I was clicking to the dashboard, it was loading only five seconds after. It was maybe this one second too long where I would, as an end user, would be a bit worried that I did something wrong or would go back already because I think it's not working." -P3*

The slow response time gave the participant the impression that something might have gone wrong with their requests, and the wizard was not working properly. This caused P3 uncertainty in whether they should wait for it to load, or go back and try again.

Improvements and Future Use

Participants were also inquired about suggestions as to how the previously mentioned usability errors could be addressed in a meaningful way. One participant suggested to improve the flow of the setup experience itself, to provide a more streamlined experience.

> *"It's just the flow, just a bit more direction from the wizard itself. From step to step. It doesn't have to hold my hand the whole way, but it would be nice that when you go in and you don't have a server set up, it'll be like, 'hey, would you like to set up a server immediately' instead of having to look to the left? And then after the setup, you have no users because you just made it, just a call to action saying 'go check out guides for the user registration' or something" -P4*

In addition, P4 also mentioned that it could be beneficial to include some "call to action" notifications which point the user towards their next action, and where to go next, instead of having to look around. Another participant had a similar comment, as they also felt they were missing a bit of guidance.

> *"With the setup guide I feel like, you know, when, when you, what's it called, like when you start looking into something and they give you like, here's the go through how to get like comfortable with this Apple website or something, that would be cool. I think. Like the guides being like, you know, one picture and then you can click next and then you have the other picture." -P5*

As seen in the quote, this participant suggests an experience more on par with the tutorial used in many modern apps and websites, where the users have the option to complete a guided tour through the UI, with the purpose of introducing them to key features and concepts. This could improve upon the usability errors of participants overlooking the guide page, as the essential features and the location of these would be known from beginning.

Another UI element overlooked by some participants were the "success" notifications.

> *"It was kinda small" "Yeah. Maybe like, it was like in the middle of the screen. Success. Yeah. Yeah. Cause I was kind of looking here because it was like saying something about it's working It's not working. And then I was just focusing on there and I didn't notice it was down here. But if it kept being over here and it didn't just disappear, that's fine. But if it disappeared without you saying it was there, then I'm probably still a bit confused. Yeah." -P5*

P5 expressed that the success notification that is displayed upon finishing the server setup or admin user was too discrete. This was troublesome because if overlooked, it could cause a user to be uncertain as to whether or not their action was successful. To address this, P5 suggested to move the notification panel to the centre of the screen, as the users focus is already on that area.

When inquired about their interest in future use of the product, four out of five participants answered "yes". Three out of the four were only interested in it as a possible solution if they were still able to communicate with their social circle, either if they also used the product, or if it was possible link to different platforms.

> *"I could on one condition. If those who I want to talk with are able to, like if I'm able to communicate with the ones who I specifically want to talk with, either they have a reason to also sign up or even if they don't sign up, there's still a way to communicate with them through using the NanoPOG solution, right?" -P4*

The participant declining being interested in future use reasoned it with their lack of concern in regards to their online privacy.

> *"I guess for me, I probably wouldn't, but I could see it be useful for some people, of course, but I probably wouldn't for myself. " "I guess, for me, it's, I guess I'm just not too concerned about my private data and all that. So for me, I wouldn't, I guess, bother to set it up because I guess I don't really mind it, but so, from that point of view." -P6*

This could be a reflection of the issues in regards to recruiting participants mentioned in section 4.3.1, as they are not part of the target demographic. Although not interested, P6 acknowledged the potential value the product could provide other users.

As highlighted in this section, several participants experienced issues during their interactions with the dashboard and the settings page. When lost, there was a general consensus that the guide was a good tool, although it was easy to overlook and forget it exists. The favoured features were the guide and information bubbles placed around the UI. The design of the UI was perceived as simple and minimalistic, but there was room for improvement. Suggestions include: guide the user a little more during the setup, calls to action, and a guided tour of the UI when a user launches the application for the first time. All participants could see themselves using it in the future, except for one participant who attributed it to their lack of concern for privacy. This concludes the qualitative analysis of the results from the usability study. The next step is to improve the setup experience based on these findings.

Chapter 6

Second Design Iteration

6.1 Converting Usability Test Results into UI Improvements

The three sections of the usability tests (the thinking aloud test, the interview, and the subjective satisfaction questionnaire) provided us with a good understanding of what critical errors the design of the system caused and what features would significantly improve the user experience. We observed the most common issues our test participants ran into and tried to identify their root causes.

First of all, both the suggestions expressed during the interview and the errors encountered during the test revealed one extremely common class of issues: failure to use the guide when trying to figure out the next step. In other words, participants often got stuck during the installation and configuration process and forgot there is a user guide that can help them along. Instead, they tried to either figure out the step on their own, often mistaking the element they were supposed to interact with, or they remained stuck until the interviewer helped out.

Secondly, some participants expressed the opinion that they did not receive enough feedback from the system. They either weren't sure their action got registered at all, or, if it did get registered, they didn't know what impact that had on the system. This experience was caused by the long loading times after the "finish" or "save" buttons were clicked, during which the system did not display any indication that something was happening in the background. Furthermore, after the NanoPOG server was created, the user received no hints from the system about what they can or should do next. This lack of direction is confusing and can interrupt the workflow for the average user.

We found two possible strategies for tackling the problems identified during the usability tests. One potential improvement is to increase the visibility of the guide and provide more encouragement for the user to access that page and read it. Another is to streamline the installation process and subsequent operations by offering more hints regarding what the next step could be. This can be achieved by including more informative messages or by increasing the visibility of certain elements, drawing the user's attention towards

them. The importance of guiding users along the workflow necessary for completing a particular task is also highlighted in previous usability works, stressing the negative effect that interruptions and a lack of continuity in the process can have on the efficiency of the user [12].

6.2 Updates in the Second Design Iteration

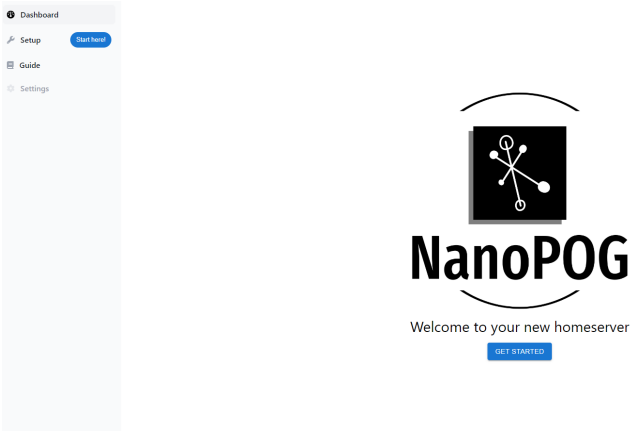

Figure 6.1: The landing page in the second iteration of the NanoPOG UI

The landing page now contains a "Get started" button to give an indication on the starting point of the installation. This button leads to the setup page and is only present if the NanoPOG is not yet active. Similarly, the "Setup" button in the navigation menu now displays an indicator that the user should go to that page to begin the installation process. It disappears once the server setup is complete.

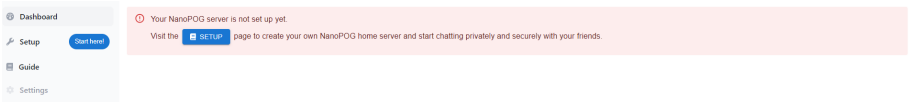

Figure 6.2: The dashboard in the second iteration of the NanoPOG UI (server not yet set up)

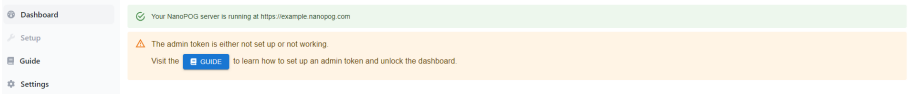

Figure 6.3: The dashboard in the second iteration of the NanoPOG UI (admin token not set up or not working)

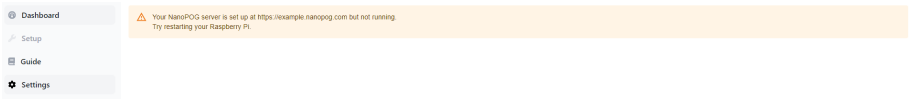

Figure 6.4: The dashboard in the second iteration of the NanoPOG UI (server is set up but not running)

The error messages on the dashboard page have been improved to show directions towards the most likely fix. If the NanoPOG server is not yet set up, the error message will point towards the setup page, including a button that links to it. If the server is running, but the token is not set up or not working, the error message will instead lead to the guide so that the user can learn the steps required to enable the dashboard. Finally, if the server is set up, but not running, a restart of the Raspberry Pi is recommended. The state of the dashboard where everything is running correctly remains unchanged (see fig. 3.6 for a depiction of it).

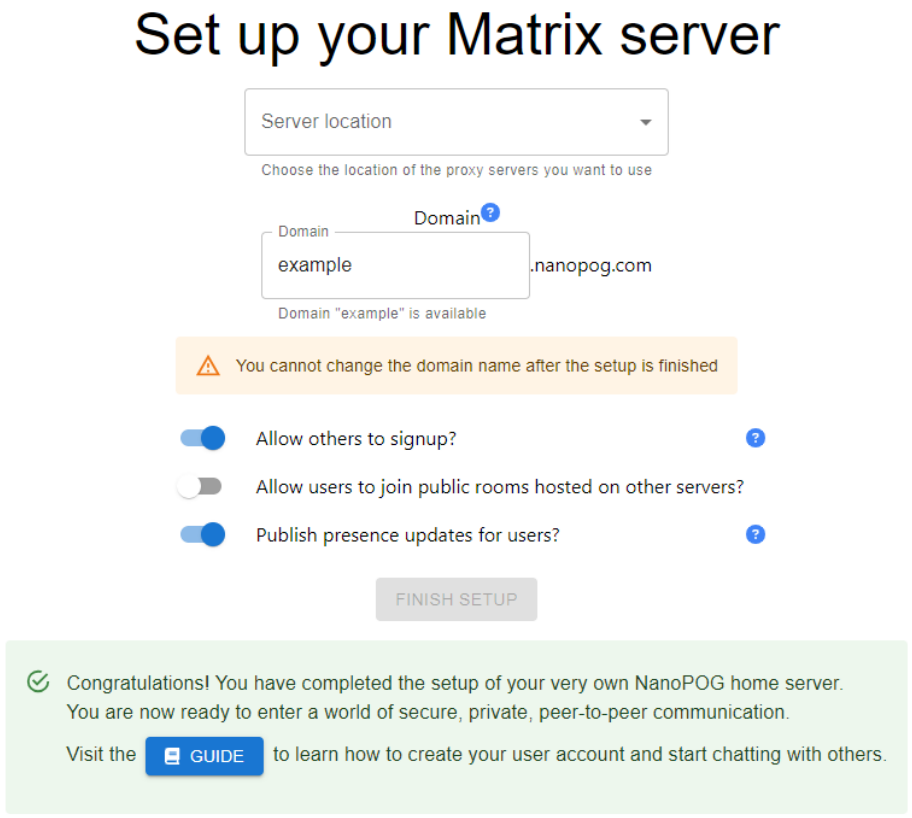

Figure 6.5: The setup page in the second iteration of the NanoPOG UI

The setup page remains mostly the same as in the initial version of the UI, with the exception of a success message displayed after the NanoPOG server is correctly initialized. The page will become inaccessible once this happens, but the user is not immediately

redirected away from it to avoid confusion and to show a clear state of the system. Instead, the success message points the user to the guide to learn how an account can be created on their new home server, which is the next logical step in the process.

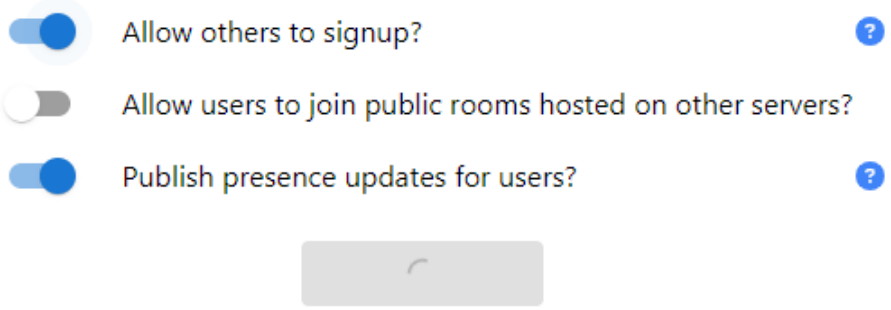

Figure 6.6: The loading animation in the second iteration of the NanoPOG UI

Additionally, the "Finish setup" button now displays a loading animation after it is clicked to increase system transparency. During the usability tests we've observed that the time required for the system to set up a new instance of a server (usually, 3 to 7 seconds) caused confusion, some participants wondering if their input was registered at all. The loading animation should now prevent that.

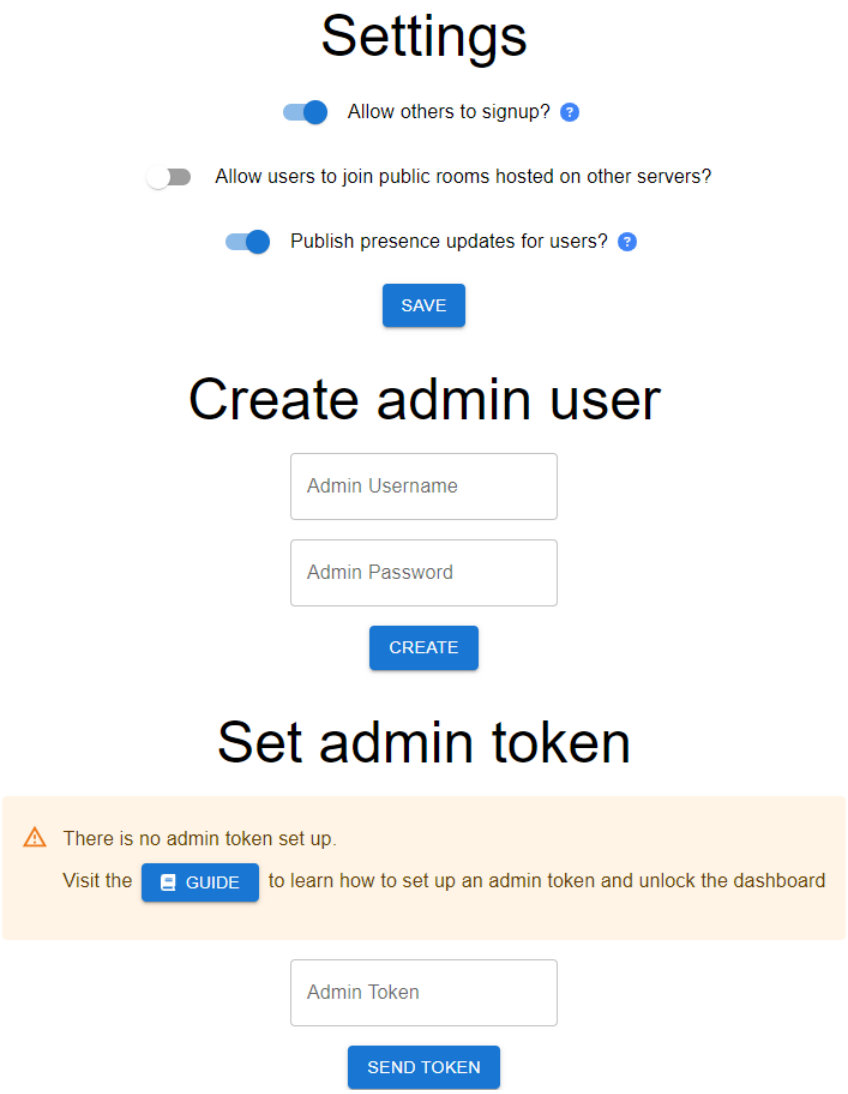

Figure 6.7: The settings page in the second iteration of the NanoPOG UI

The settings page now includes a message pointing the user to the guide if the token is not set up, in order to give an indication towards the next step for the more advanced users who wish to enable the dashboard. The loading animation is present on all action buttons on the page.

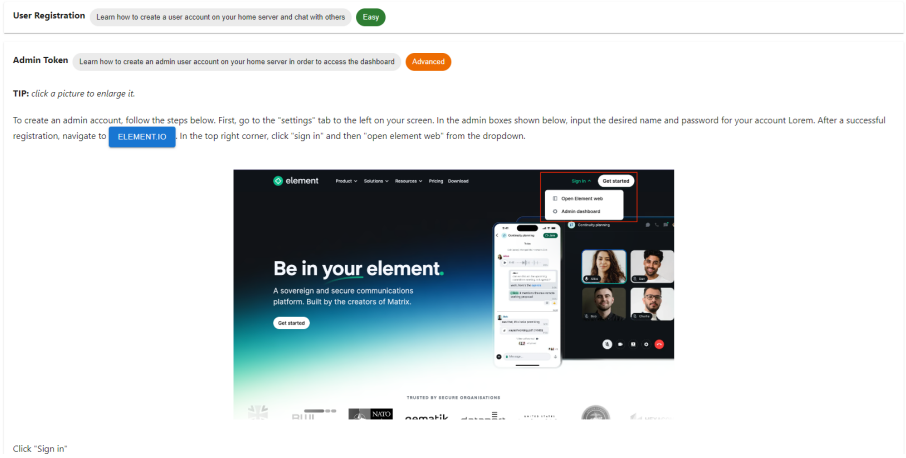

Figure 6.8: The guide page in the second iteration of the NanoPOG UI

A summary for each section has been added to the guide page, along an indicator for the difficulty level of that section (easy for user registration and advanced for the admin token setup). This should give a clear idea of what each section of the guide is for, without having to expand and read through it. Furthermore, the links in the guide sending the user to an external webpage (such as element.io for the messaging client) are now styled as interactable buttons, to remove any confusion about the option to click them and open a new browser tab.

6.3 Addressing the Usability Test Errors and Suggestions

We believe the changes introduced in the second iteration of the user interface to be a two-pronged solution for the issues encountered during the usability tests. We set out to increase the visibility of the guide and encourage users to read it, while improving the flow of the installation and configuration process. Let us go through the steps of this process and see if this goal was achieved.

When the user first boots up the Raspberry Pi and visits the NanoPOG client, they see the landing page (fig. 6.1). There, the "Get started" button (as well as the indicator in the navigation menu) should send them to the setup page. There is no link from the setup page to the guide, but the abundance of informative messages accompanying the input fields should suffice for providing a smooth installation experience. Once the setup is complete, the user is pointed towards the guide to learn how to create an account on their new NanoPOG server (fig. 6.5). From there, they should be able to access all of its basic functionality, invite other people on the server, and chat with them. While on the guide, the user may be curious to read about the process for enabling the dashboard. Otherwise, if they end up on a broken dashboard page or on the settings page (where they might find the admin token section confusing), they should be redirected to the guide by any of the

information/error messages they encounter (fig. 6.2 and fig. 6.7). Additionally, the state of the system should now be visible and clear for the user at all times, given all the status messages and the new loading animations (fig. 6.6).

The scenario described above proves that a streamlined flow has now been achieved for all functionality that the NanoPOG solution provides, as well as an increased coverage of all potential error states that the user might find themselves in.

Time constraints limited the design of the user interface to just two iterations and a single round of usability tests. If more time was available to us, we would continue with additional tests and further iterations of the UI. The dashboard would be our first priority, where an overhaul is needed to add the functionality for editing and deleting user and groups. The following chapter goes into more detail about the challenges and limitations of this project.

Chapter 7

Discussion

7.1 Answering the Research Questions

At the beginning of this this report, in section 1.2, we posed two research questions which formed the basis of this thesis. In this section we will address those questions.

How can we design, build, and evaluate an installer tool with a user-friendly interface capable of setting up a home server to be used for decentralized messaging?

To try to answer this question, a large portion of this project focused on creating a user-friendly installation solution which simplifies the setup of a Matrix Synapse private server running on a Raspberry Pi. This was named the NanoPOG solution. When constructing the NanoPOG solution, we focused on creating a user interface that was simple and straightforward. The design choices we made were guided by established usability principles. In addition to this, we focused on automating much of the server setup to reduce the need for the users to interact with anything technical.

The evaluation of the NanoPOG solution was conducted using usability testing with 5 participants. The participants were asked to set up the server using our installation tool. After the usability test, participants were asked to fill out a subjective satisfaction questionnaire, and then, finally, partake in an interview.

The results from the evaluations were positive. Both the interview and the subjective satisfaction questionnaire indicated that the majority of participants found the NanoPOG solution easy to use with clear instructions. With the findings from the usability test, a second design iteration was created, which addressed the pain points participants experienced. Based on the results from the usability test, as well as the modifications made in the second iteration of the NanoPOG solution, we believe that our installer tool meets the goal of creating a user-friendly solution which can be used to set up a decentralized messaging home server.

Would such a tool encourage mainstream adoption of secure and decentralized private communication?

To determine whether a tool such as the NanoPOG solution could encourage mainstream adoption, we used surveys and interviews to gauge user interest.

The survey which was sent out received 113 responses and revealed that a significant amount of people were concerned about privacy issues and the current centralized messaging ecosystem they find themselves in. There was a strong interest in a privacy-oriented messaging alternative to the platforms respondents currently use, with the caveat that this new alternative should have most, if not all of the features of current messaging applications. Additionally, many respondents noted that, in order for them to switch to such an alternative, their social circle would also need to be using it.

The interviews conducted after the usability tests support these findings, with 4 out of 5 participants stating that they would be interested in using such an application. Yet, again, many of those participants stated they would also require their social circle to be using this application before they would consider adopting it.

In conclusion, the data we gathered suggests that the creation of a user-friendly installer tool such as NanoPOG could encourage the mainstream adoption of decentralized private communication. While more research and development would be needed to create a definitive tool that could point the current zeitgeist towards a more decentralized and privacy-focused direction, we believe that it is definitely possible.

7.2 Addressing Limitations and Challenges

During the development of this project, there were some challenges and limitations encountered along the way which will be explored in this section.

7.2.1 User Testing

Our initial aspiration was for the NanoPOG solution to become a viable alternative for privacy-aware people, interested in alternative technologies. The plan was also to evaluate the system with members of this group, by recruiting individuals based on their response to the survey. However, during participant selection, we quickly realized this would not be feasible. After filtering the responses based on our initial goal setting, the participants were narrowed down to approx. 20 qualified respondents. This was more than enough, as we only needed 5 participants for the usability study, excluding the pilot tests. However, of the 20 respondents only 2 replied to the invitation email, and of those only 1 was able to participate. Due to the time frame and resources of this master thesis, we were therefore constrained to include participants from our social circle, despite not being a member of the target audience. For this reason, it is not feasible to generalize the results gained from the usability study to the target audience, which is a limitation to our initial goal. In addition, due to the size of this qualitative study, we were only able to inquire a

small number of people as to whether our solution influenced their willingness to adopt a privacy-oriented alternative.

7.2.2 Barrier of Adoption Conundrum

Results from the survey and debriefing interviews suggested that the biggest barrier of adoption was whether friends and family used the service. These results correlate with the results from a previous paper on mobile instant messenger adoption highlighted in section 2.1. An interesting solution to this barrier, which could potentially help in bridging the gap, would be to develop plugins for all major messaging services, making it possible for users to still communicate with friends and family whilst using the NanoPOG solution. However, this would mean that the external messenger services would also keep a copy of user data, essentially deeming the home server redundant. On the other hand, this could potentially ease the transition of moving away from known and comfortable instant messengers, into the unknown territory of self-hosting, and perhaps even influence a user's social circle to do the same. This solution would enable users to still have locally-hosted private chats, whilst being able to engage in chats with external contacts. This highlights an interesting conundrum, since the biggest hurdle in adopting the NanoPOG solution is directly contradicting with the incentive of the NanoPOG solution, which is the ability to retain ownership over user data, instead of relying on conglomerate cloud servers such as Meta.

Survey Bias

We recognize that there is potential for bias in connection with the survey results. As explained in section 4.2.2, the survey was distributed to many people in our social circles using various social media platforms, and was also showcased on fliers and posters. These posters and fliers were distributed between several of the Aalborg University campus buildings, yet due to the size of the university and its campuses spread around the city, we focused primarily on the Computer Science campus and the Media Technology and Architecture campus. The students at these sites may be more technologically inclined than others, and as such may have answered differently to people from outside the educational sphere. To get a less biased dataset, a larger focus should have been placed on a more diverse distribution of advertisement for our survey.

Chapter 8

Conclusion

8.1 Summary of Contributions

This project offers two major classes of contributions to the field of Human-Computer Interaction. First, there is the technical solution that allows people to set up their own home server quickly and easily, and communicate with their friends via a private channel, while retaining control over their data. Secondly, the survey and the usability tests offer insight into the privacy concerns of the average Internet user and their interest in a potential privacy-oriented alternative.

The NanoPOG solution offers an answer to the problem of exposing a private home server to the Internet for the purpose of connecting and communicating with others via messaging clients. This can be challenging due to ISP restrictions or the user's lack of technical knowledge. Our system aims to overcome these problems by providing a seamless, smooth process from opening the box to logging into an account on a privately-owned server and chatting with others. We started out by designing a way to bypass ISP limitations and expose the home server to the Internet. We set up a publicly visible proxy server and connected the private server to it via a VPN tunnel. The full details of this setup can be found in section 2.2 and in our preliminary research report [1]. Then, we implemented an automated process that can establish this connection with minimal input from the user, whose architecture is detailed in section 3.1. Finally, we built an intuitive user interface that can guide people of all technical skill levels through the setup process. The first iteration of this interface was built solely on previously established theoretical concepts and guidelines, as explained in section 3.3. The second iteration was instead built upon the feedback received in the usability tests, as can be seen in chapter 6.

The results of the survey are part of the second contribution of this project and offer valuable insight into how the average Internet user views their data and responds to the privacy breaches regularly performed by companies owning established messaging apps. While the survey itself is subject to some limitations (for example, a bias of the respondent group towards young tech students), we believe the data it provides can be used as start-

ing points towards building privacy-centric alternatives or towards other, more extensive studies in the same area. The full results of this survey can be found in sections 5.1 and 5.2. This data was used to validate the construction of the NanoPOG solution and also to select a few candidates for our usability tests. These tests were then used in building the second iteration of the user interface. Additionally, they showed how people possessing varying technical knowledge interact with such a system, what features they are most fond of or would have preferred to see, and how the existence of such a solution influenced their willingness to switch to a privacy-oriented alternative instead of the traditional messaging apps they use currently. The summary of this contribution can be found in section 5.3 and, while the accuracy of the results is naturally limited by the sample size, it can be used for future studies that investigate potential improvements of our solution or entirely new solutions inspired by it. The following sections will cover available avenues of further research and development that his project unfolds.

8.2 Applications

The research and development that has gone into the NanoPOG solution has resulted in a solution which focuses on personal data control and privacy. In this sector there are several applications which could be built from our findings.

A solution such as NanoPOG could have consumer applications for anyone in a society that does not support freedom of information or speech. Citizens from countries with strict censorship or government surveillance could potentially be interested in a messaging solution which the authorities might not be able to observe.

NGOs or activist groups operating in dangerous locations where communication and data privacy are crucial may also find applications for an easy to set up and use private server solution.

A solution such as NanoPOG and the findings in this report could also be used in an educational setting as a tool to demonstrate the importance of data ownership and secure communication. In addition, it can show how data privacy does not need to be a privilege left for the technologically-savvy.

In section 5.2.5 it was discussed how several respondents used specific messaging applications when buying illicit substances due to the privacy and security they provided. If people are seeking out more secure and private messaging solutions for relatively low impact crimes such as buying marijuana, it is fair to assume that those seeking to commit crimes of greater scopes would also be interested in messaging solutions which provide data privacy and control. Terrorist groups, organized crime groups, and political radicals are just a few examples of groups which could greatly benefit from a private messaging solution where the owners have complete control over their own data. This creates an ethical question of how a tool such as NanoPOG could be used for evil, and what responsibility the creators have for such a tool.

8.3 Recommendations for Future Work

There are several aspects of the NanoPOG solution which are viable avenues for future work. One aspect could be to make NanoPOG open-source, in order to gather feedback from a larger group of people who have interacted with the product. This could potentially validate or clarify the current feedback, and allow us to gain a more nuanced interpretation of the adoption rate.

Another aspect could be to focus on improving the server infrastructure such as creating a network of proxy servers that coordinate resources amongst each other, in order to improve the efficiency and stability of NanoPOG. In addition, an evaluation of relevant attributes such as load balance resource expenditure of such an implementation could be interesting.

A third aspect could be to make the solution more attractive to individuals concerned about disconnecting from their social group, by developing plugins which would enable communication with external contacts, with the goal of easing an eventual transition to fully depend on the NanoPOG solution.

8.4 Reflection and Final Thoughts

In conclusion, this thesis explored the possibility of using home servers as an alternative to traditional centralized messaging services. We developed a solution that simplifies the installation process of a Matrix server on a privately owned Raspberry Pi and is capable of handling various messaging clients, such as Element. The resulting NanoPOG solution shows promise in addressing the growing concerns over data privacy in today's digital climate.

The survey we conducted proves that the interest in alternative privacy-oriented messaging solutions is real, while an important caveat to consider is people's reluctance to abandon their applications of choice that their social circles are using. The results of this survey helped shape our system, despite the limited variety of the respondents' demographic. Future research can address this shortcoming by focusing on different age ranges and fields of interest.

The usability tests proved the potential of our proposed solution, while indicating a direction for crucial improvements to focus on, in the second and any future iterations. Additionally, it reinforced our conviction that a proper privacy-oriented solution, with an intuitive user interface, can expand the interest in this, as of yet, niche area of communication.

Moving forward, further research and development is required to refine the NanoPOG solution or other ideas born from this concept. Our work provides a solid foundation for future investigation in this critical area of Human-Computer Interaction, with the ultimate goal of building a more secure and autonomous digital communication landscape.

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Appendix A

Survey Questionnaire

NanoPOG

Thank you for participating in our survey!

We are a group of Computer Science(IT) students seeking to gain insight into users' messaging habits and privacy concerns, to include in our master thesis. In today's world, the majority of communication is done through messaging apps such as Facebook Messenger, Discord, Instagram and other such platforms. In our thesis we investigate the possibilities of introducing a user-friendly solution (which we named NanoPOG) that empowers individuals, regardless of their technical expertise, to effortlessly set up and deploy a private server at home, to enable self storage of messages and increase control over privacy. By creating a solution with a simple setup, we aim to provide an alternative to modern day messaging solutions by expanding the use of private home servers, making secure and private communication accessible to everyone.

By participating you have a chance at winning the JBL Clip 4 bluetooth speaker as seen below.

1. Mailadresse *

JBL Clip 4 bluetooth speaker

2. Age

Markér kun ét felt.

- ◯ Under 18
- ◯ 18-24
- ◯ 25-35
- ◯ 36-45
- ◯ 46-55
- ◯ Over 55

3. Gender

Markér kun ét felt.

- ◯ Male
- ◯ Female
- ◯ Prefer not to say
- ◯ Andet: _____

4. What is your current field of education/work

_____

Communication Habits

5. How often do you use messaging apps for communication purposes?

Markér kun ét felt.

- ◯ At least once every 10 minutes
- ◯ Several times an hour
- ◯ A few times a day
- ◯ Once a day
- ◯ A few times a week

6. Which messaging apps do you use at least once a week?

Markér alle, du er enig i.

- ☐ Facebook Messenger
- ☐ Instagram
- ☐ Whatsapp
- ☐ Snapchat
- ☐ Telegram
- ☐ Discord
- ☐ Andet: _____

7. Are you aware of the privacy policies of the messaging apps you use?

Markér kun ét felt.

- ◯ Not aware
- ◯ Partially aware
- ◯ Fully aware

Privacy Concerns

8. How concerned are you about privacy in regards to using messaging apps?

Markér kun ét felt.

	1	2	3	4	5	6	7	
Not	◯	◯	◯	◯	◯	◯	◯	Very concerned

9. What specific aspects of privacy concern you the most when using messaging apps?

Markér alle, du er enig i.

- [ ] Data encryption (How well your messages are protected from unauthorized access, like having a secure lock)
- [ ] Data collection (The information the app gathers about you, covering what it knows and stores.)
- [ ] Third-party access (Other apps potentially getting into your messaging app, raising concerns about external access)
- [ ] Device permissions (The capabilities your app has on your device, including using the microphone, camera, and accessing your information.)

10. How comfortable are you with messaging apps collecting and using your personal data for targeted advertising or other purposes?

Markér kun ét felt.

	1	2	3	4	5	6	7	
Very	◯	◯	◯	◯	◯	◯	◯	Very comfortable

11. How confident are you in your ability to protect your privacy while using messaging apps? (e.g., avoiding sharing sensitive information)

Markér kun ét felt.

	1	2	3	4	5	6	7	
Not	◯	◯	◯	◯	◯	◯	◯	Very confident

12. Have you ever experienced any privacy breaches or concerns while using messaging apps? If yes, please describe.

Interest in Alternatives

13. Have you ever switched messaging apps due to privacy concerns? If yes, what motivated the switch?

14. Would you be willing to sacrifice certain features or conveniences in exchange for stronger privacy protections in messaging apps?

Markér kun ét felt.

	1	2	3	4	5	6	7	
Not	◯	◯	◯	◯	◯	◯	◯	Very willing

15. Are there any other features that would prevent you from switching from your current messaging app?

16. What are some of the most important aspects or features that prevent you from switching out your current favourite messaging app?

Markér kun ét felt pr. række.

	Very important	Important	Neutral	Not very important	Not at all important
Multimedia sharing	◯	◯	◯	◯	◯
Group chat	◯	◯	◯	◯	◯
Contacts (my friends use this app)	◯	◯	◯	◯	◯
Integration with other apps	◯	◯	◯	◯	◯
Security features	◯	◯	◯	◯	◯
Customization (gifs, stickers, emojis)	◯	◯	◯	◯	◯
Voice/video calls	◯	◯	◯	◯	◯

17. Would you be interested in a solution that allows you to store your messages on your own hardware, rather than relying on third-party servers?

Markér kun ét felt.

	1	2	3	4	5	6	7	
Not	◯	◯	◯	◯	◯	◯	◯	Very interested

18. How much time are you willing to dedicate to the initial setup process for such a privacy-focused messaging solution?

Markér kun ét felt.

- Under 5 mins
- 5-10 mins
- 11-15 mins
- 16-30 mins
- over 30 mins

19. How important is it for you to have control over where your message data is stored?

Markér kun ét felt.

	1	2	3	4	5	6	7	
Not								Very important

20. Would you prefer a quick and easy setup process or a more complex and customizable one (that allows you to tweak every aspect of your private messaging app)?

Markér kun ét felt.

	1	2	3	4	5	6	7	
Quic								Fully customizable

21. Do you have any concerns or reservations about the setup process for such a messaging solution? (optional)

Thank you for participating in our survey!
In the coming months, we will be carrying out usability tests of the afformentioned solution. If you would like to participate, please let us know below, and we will reach out via the provided email. The test will take approximately 30-40 min.

22. Would you like to participate in a usability test?

Markér kun ét felt.

- Yes
- No

Appendix B

NanoPOG Preliminary Research Report (Nanoservers and the Fediverse)

Link to PDF: https://drive.google.com/file/d/18kYZoymD8ap0qy3DbYh7FfLqc-mnispd/view?usp=drive_link