

Master Thesis



**Czech  
Technical  
University  
in Prague**

**F3**

**Faculty of Electrical Engineering  
Department of Computer Science**

## **Accessible application for traveling for blind and visually impaired users**

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**Field of study: Open Informatics**

**Subfield: Software Engineering**

**May 2024**



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Master's thesis title in English:

**Accessible application for traveling for blind and visually impaired users**

Master's thesis title in Czech:

**P ístupná aplikace pro cestování nevidomých a jinak zrakov postižených uživatel**

Guidelines:

The aim of the thesis is to create an accessible travel application for blind and visually impaired users. Analyze the obstacles and challenges encountered by blind and visually impaired individuals across various modes of transportation. Based on the analysis, define the user's requirements and develop a design for the accessible travel application prototype, emphasizing intuitive navigation, clear information presentation, and compatibility with assistive technologies. Design the architecture of the application and select appropriate development tools and frameworks for building the application. Implement application prototype with respect to accessibility standards and user requirements. Test the application's prototype with users.

Bibliography / sources:

1. Elizabeth Goodman, Mike Kuniavsky and Andrea Moed (2012). Observing the User Experience. Elsevier.
2. Colin Ware (2019). Information Visualization, perception for design. Morgan Kaufman.
3. Bill Buxton (2010). Sketching User Experiences. Morgan Kaufman.
4. Miroslav Disman (2011). Jak se vyrábí sociologická znalost: P íru ka pro uživatele. Karolinum Press.

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Assignment valid until: **15.02.2026**

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## Acknowledgements

I would like to express my gratitude to my supervisor, doc. Ing. Zdeněk Míkovec, Ph.D., for his invaluable guidance, support, and encouragement throughout the course of my master's thesis. I want to express my gratitude to each and every volunteer involved in the research for their time and for offering me a completely different perspective on the world. I am also deeply thankful to all closest people for their unwavering support and understanding during this journey.

## Declaration

I hereby declare that I have written the submitted thesis myself and I quoted all used sources of information in accord with Methodical instructions about ethical principles for writing academic theses.

Prague, May 10, 2024

## Abstract

The travel sector faces numerous challenges when it comes to providing information, navigation, and safety solutions for blind and visually impaired individuals. Despite various accessibility guidelines and legal requirements, existing travel solutions often fall short in addressing the unique needs of this user group. This research examines the current state of accessibility in travelling, identifies the specific needs of blind and visually impaired travelers, and proposes a new application aimed at enhancing their travel experiences.

Based on in-depth user interviews and analysis of existing solutions, a prototype of a multi-modal travel search application was developed and tested. By incorporating user-centered design principles, the proposed application aims to provide a more inclusive and seamless travel experience. The prototype application integrates various features, including personalized travel preferences, or the ability to request assistance directly through the app. Initial testing with visually impaired users indicated that these features could improve their ability to travel independently and confidently.

**Keywords:** visual impairment, travel, accessibility, transportation

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## Abstrakt

Odvětví cestovního ruchu čelí mnoha výzvám, pokud jde o poskytování informací, navigace a bezpečnostních řešení pro nevidomé a zrakově postižené osoby. Navzdory různým směrnícím a právním požadavkům na přístupnost stávající řešení v oblasti cestování často neuspokojují jedinečné potřeby této skupiny uživatelů. Tento výzkum zkoumá současný stav přístupnosti v oblasti cestování, identifikuje specifické potřeby nevidomých a slabozrakých cestujících a navrhuje novou aplikaci zaměřenou na vylepšení jejich dojmu z cestování.

Na základě hloubkových rozhovorů s uživateli a analýzy stávajících řešení byl vyvinut a otestován prototyp multimodální aplikace pro vyhledávání dopravy. Začleněním principů designu zaměřeného na uživatele si navrhovaná aplikace klade za cíl poskytnout inkluzivnější a bezproblémový zážitek z cestování. Prototyp aplikace integruje různé funkce, včetně personalizovaných cestovních preferencí, nebo možnosti požádat o pomoc přímo prostřednictvím aplikace. Počáteční testování s uživateli se zrakovým postižením ukázalo, že tyto funkce by mohly zlepšit jejich schopnost cestovat samostatně a jistěji.

**Klíčová slova:** zrakové postižení, cestování, přístupnost, doprava

**Překlad názvu:** Přístupná aplikace pro cestování nevidomých a jinak zrakově postižených uživatelů

# Contents

<b>1 Introduction</b>	<b>1</b>	3.4 Discussion . . . . .	15
<b>2 Analysis</b>	<b>3</b>	3.5 User Stories . . . . .	16
2.1 Visual impairment . . . . .	3	3.6 Hierarchical task analysis . . . . .	17
2.2 Challenges Faced by Blind and Visually Impaired Individuals in Transportation . . . . .	4	<b>4 Design of the Transportation Search Application</b>	<b>19</b>
2.3 Accessibility in web and mobile applications . . . . .	5	4.1 Overview of Principles . . . . .	19
2.3.1 How visually impaired access digital information . . . . .	5	4.2 Requirements . . . . .	21
2.3.2 Relevant accessibility Standards and Guidelines . . . . .	7	4.2.1 Target platform discussion . . . . .	21
<b>3 Understanding User Needs</b>	<b>11</b>	4.3 Key components and features analysis . . . . .	22
3.1 Research topics . . . . .	11	4.4 Prototype design validation . . . . .	23
3.2 Participants . . . . .	12	4.5 First prototype version . . . . .	24
3.3 Key Findings . . . . .	13	4.6 Second prototype version . . . . .	26
3.3.1 Transportation within City . . . . .	13	4.7 Third prototype version . . . . .	29
3.3.2 Intercity transportation . . . . .	14	4.7.1 User testing . . . . .	30
3.3.3 Air transportation . . . . .	15	4.8 Discussion . . . . .	31
		<b>5 Architecture and Technology Selection</b>	<b>33</b>
		5.1 High level architecture . . . . .	33

5.2 Selection of Development Tools and Frameworks .....	35	<b>8 Conclusions</b>	<b>49</b>
5.2.1 React Native Accessibility Options .....	35	8.1 Future work .....	50
5.3 Algorithm for sorting and filtering the search results .....	36	<b>A Tree of attached documents</b>	<b>51</b>
<b>6 Implementation</b>	<b>39</b>	<b>B Interview Transcripts</b>	<b>53</b>
6.1 Features implemented .....	39	B.1 Respondent R1 .....	53
6.2 Overview of key React components .....	41	B.2 Respondent R2 .....	55
6.3 Code overview .....	41	B.3 Respondent R3 .....	57
6.3.1 Navigation .....	41	B.4 Respondent R4 and R5 .....	59
6.3.2 Enhancing the information for screen reader .....	42	B.5 Respondent R6 .....	61
6.3.3 Assistance button implementation .....	43	B.6 Respondent R7 .....	62
6.3.4 Explanation of user preferences to the user .....	43	<b>C Bibliography</b>	<b>65</b>
<b>7 User Testing and Evaluation</b>	<b>45</b>	<b>D Project Specification</b>	<b>69</b>
7.1 Overview of Testing Methodology	45		
7.2 Key Findings .....	46		
7.3 Discussion .....	47		



## Figures

2.1 Mobile vs Web Applications usage by Screen Reader users in 2023, retaken from WebAIM survey [29] .	6	6.2 React Navigation for the prototype . . . . .	42
3.1 VPN transmitter used by visually impaired to activate audio signals. Source: [25] . . . . .	14	6.3 Using accessibility options to enhance the information for screen reader . . . . .	43
3.2 Hierarchical task analysis, created using Drawio [8] . . . . .	17	6.4 Code snippet of requesting assistance functionality . . . . .	44
4.1 Factors influencing search results, created using Whimsical [30] . . . . .	22	6.5 Code snippet of infoboxes about user preferences . . . . .	44
4.2 Prototype screens and transitions between the screens, created using Whimsical [30] . . . . .	23		
4.3 First prototype design in Figma [10] . . . . .	24		
4.4 Second prototype version, created using Figma [10] . . . . .	28		
4.5 Travel Preference Setting references in Filters, created using Figma [10]	29		
5.1 Architecture proposal, created using Drawio [8] . . . . .	34		
6.1 Prototype application screenshots	40		

## Tables

3.1 Interview Participants . . . . . 13

4.1 Requirements for prototype design 20



# Chapter 1

## Introduction

The current accessibility efforts are predominantly focused on compliance with various guidelines and legal requirements. However, these approaches often overlook the nuanced needs and abilities of specific user groups, such as blind and visually impaired individuals. While legal mandates and standardized guidelines provide a crucial foundation for accessibility, they do not fully address the lived experiences and specific challenges encountered by these individuals in their daily lives, especially in the context of travel. For blind and visually impaired people, travelling can be an especially difficult task fraught with numerous obstacles that sighted individuals might not even consider.

This thesis aims to examine the problem of travelling for blind and visually impaired individuals from a more in-depth perspective. It will investigate the current research on this topic in order to gain an understanding of the existing problems and potential for improvement. Furthermore, this study will conduct interviews with a target audience of blind and visually impaired travelers to garner firsthand insights into their experiences. These interviews will provide an understanding of what is truly important for them when they are travelling, beyond what is typically captured by compliance-driven approaches.

The objective of this thesis is to identify the challenges faced by blind and visually impaired individuals and to pinpoint potential areas for improvement in current travel solutions. By considering the specific preferences and needs of these individuals, this research aims to propose a more effective, user-centered application for travelling. As part of the thesis, a prototype of this

application will be designed and implemented. Ultimately, the goal is to contribute to a more inclusive society where all individuals, regardless of their visual abilities, can enjoy the same level of independence and accessibility in their travels.

The thesis is composed of the following chapters:

- **Analysis** chapter 2 delves into the current research on travel for blind and visually impaired individuals. This chapter also clarifies essential terms and references key accessibility guidelines.
- Chapter 3, **Understanding User Needs**, summarizes the interviews conducted with blind and visually impaired individuals and highlights the key findings from these interviews.
- Based on the previous findings, Chapter 4 about **Design**, is dedicated to creating an accessible travel application.
- **Architecture and Technology Selection** 5 chapter proposes the application's introduction and selects the tools and technologies for implementation.
- Chapter about **Implementation** 6 is dedicated to the creation of first prototype of the application.
- Last 7 summarize the **User Testing**, and provides a detailed report of the testing conducted with real users.



## Chapter 2

### Analysis

The objective of this chapter is to establish a foundation for subsequent chapters by defining key terms and examining the current research on the challenges faced by individuals with visual disabilities when travelling. The initial section explains the term visual impairment 2.1, after which we present a summary of the key challenges identified in the current research about travelling of individuals with the visual impairment 2.2 . Subsequently, we will present some of the guidelines 2.3.2 for the creation of digital content for blind and visually impaired users, along with an explanation of the methods by which visually impaired users access it.



### 2.1 Visual impairment

In the context of discussing various forms of visual impairment, the resources usually differentiate two categories: blindness and low vision. The distinction between low vision and blindness relates to the extent and nature of vision loss. Low vision is defined as significant visual impairment that cannot be fully corrected with standard glasses, contact lenses, medication, or surgery, yet allows for some usable vision. In contrast, blindness denotes a complete or near-complete lack of sight. Low vision includes a variety of disabilities that affect the ability to see, including visual acuity, light sensitivity, contrast sensitivity, and field vision loss. Both low vision and blindness present challenges when it comes to traveling and accessing related online information [18].

## ■ 2.2 Challenges Faced by Blind and Visually Impaired Individuals in Transportation

Traveling can be especially challenging for blind and visually impaired individuals, as they encounter various difficulties across multiple aspects of accessibility, including physical infrastructure and the availability of essential information and support services. These issues affect their ability to travel independently and confidently [31].

*“Many individuals with impairments face difficulties with independent travel and access to public spaces, which considerably shape their social inclusion, employment prospects, and quality of life.”*  
[31]

Research on the limitations faced by visually impaired individuals during travel has highlighted several key issues. Studies on the accessibility of London’s public transport indicate that, due to increasing awareness of digital accessibility, visually impaired individuals can now plan their trips online. However, the research also reveals the absence of a single source of information, necessitating the use of multiple sources to gather all necessary details. Another significant problem encountered when planning trips is the lack of live information about journeys, such as delays or disruptions [15].

Visually impaired individuals rely on mobile devices for navigation in unfamiliar places, yet these applications often contain crucial information visible only to sighted users. When they become lost or need to navigate door-to-door, it is convenient to use ride-hailing services, although these are frequently associated with higher costs [31].

When navigating unfamiliar areas, visually impaired individuals are heavily dependent on assistance from others, which they find inconvenient as they seek greater independence while also having safety concerns about traveling alone [16]. When traveling alone via public transport, they may require assistance to navigate stations during transfers or when exiting. Booking such assistance presents limitations since it often needs to be arranged well in advance, reducing their travel flexibility [15] [16].

Consistency is particularly crucial for visually impaired travelers. Variations in the layout of public transport vehicles can make it difficult for them to find a

place to stand or sit. Additionally, receiving adequate audio information about the current status of their journey is vital. Information about delays, current, and upcoming stations is not always provided in audio form. Sometimes, the audio signals are not loud enough to be heard in noisy environments or are not provided with sufficient notice, leaving visually impaired individuals with inadequate time to exit the vehicle. Although GPS applications attempt to compensate for the lack of a robust audio signal system, they also have limitations [15]. These travel constraints significantly influence the choices of transport mode and journey planning for visually impaired individuals [16].

## 2.3 Accessibility in web and mobile applications

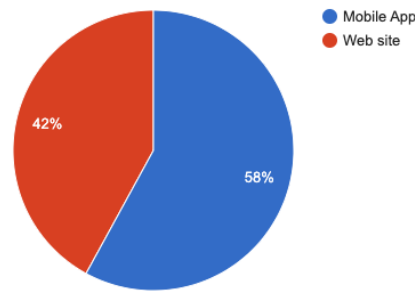
Accessibility in web and mobile applications refers to the practice of designing and developing digital content and interfaces that can be used by people of all abilities and disabilities. The goal is to ensure that everyone, regardless of their physical, sensory, or cognitive impairments, can perceive, understand, navigate, and interact with the digital world effectively [28].

*The information provided on screen must be presented in a way that can be interpreted by any kind of access technology. This is what is referred to as “accessible Web design,” “design for all,” or “universal design.”* [1]

To design and develop accessible applications, it is crucial to understand how visually impaired individuals access digital information through assistive technologies and what are the specifics of designing mobile and web applications for this group, as highlighted in Section 2.3.1. This section also presents current trends in assistive technologies and their popularity. There are numerous web accessibility initiatives providing guidelines to ensure digital inclusively. Subsequently, Section 2.3.2 discusses relevant accessibility guidelines to enhance usability for visually impaired users.

### 2.3.1 How visually impaired access digital information

The degree of vision loss determines the necessity for visually impaired individuals to utilise assistive technologies when accessing digital content.



**Figure 2.1:** Mobile vs Web Applications usage by Screen Reader users in 2023, retaken from WebAIM survey [29]

The term 'assistive technology' encompasses a diverse range of products designed to enhance the quality of life of individuals with disabilities and to compensate for the challenges associated with their disability [19].

In terms of the design of accessible applications, our primary interest lies in software assistive technology for blind and visually impaired individuals, which can have an impact on how our applications should be designed and implemented. There are two primary technologies that low vision and blind individuals may utilize: magnifying software and screen readers [26].

*Magnifying software* can be employed by individuals with low vision to enhance the visual presentation of content on websites and mobile devices. From an implementation perspective, this entails ensuring that applications remain functional and aesthetically pleasing across different screen sizes and resolutions. This process is closely aligned with the principles of responsiveness when developing applications [11].

A *screen reader* is a software program that reads information on a computer screen aloud. In order for a screen reader to function properly, certain steps must be taken during the implementation process when developing web or mobile applications. For instance, providing textual alternatives for images. The general guidelines for developing applications that are compatible with screen readers will be presented in a subsequent section 2.3.2.

When attempting to identify trends in screen readers, it is possible to obtain valuable insights from the data provided by WebAIM WebAIM<sup>1</sup> in their survey on this topic [29]. There are many options when choosing a screen

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<sup>1</sup>WebAIM is a non profit organization focused on web accessibility founded in 1999 [29].



reader, and the choice can be influenced by the operating system, which can be seen from the data collected by WebAIM. In 2023, the most commonly used desktop screen readers were JAWS [22], NVDA [22] and VoiceOver [13]. For mobile, Apple's VoiceOver [13] and Android's TalkBack [12] were dominant. In terms of operating system choice, the majority of respondents (86%) chose Windows for desktop, while Apple products dominated for mobile (70.6%). Figure 2.1 illustrates the preferences of users in determining the most appropriate platform for online tasks such as banking or online shopping. There is a clear trend of increasing preference for mobile applications over web applications, with 58% of users opting for the former in 2023.

### 2.3.2 Relevant accessibility Standards and Guidelines

The Web Content Accessibility Guidelines (WCAG) [2] are a set of technical standards on web accessibility established by the World Wide Web Consortium (W3C) [28]. WCAG is a widely recognised and adopted international standard, with some countries even incorporating it into their legislation, example being USA accessibility act [17]. The primary goal of these guidelines is to enhance the accessibility of web content, applications, electronic documents, and other digital media for individuals with a wide array of disabilities, encompassing sensory, cognitive, learning, and physical challenges.

WCAG distinguish between different *levels of conformance*, namely A, AA, and AAA. Each subsequent level not only incorporates but also builds upon the criteria of the previous levels. Level AA includes all Level A requirements and introduces additional requirements and retrospectively [2].

- **Level A** is base conformance level. Web content meeting Level A requirements will still likely contain some accessibility barriers.
- **Level AA** is commonly applied in a wide range of accessibility standards and regulations.
- **Level AAA** compliance maximizes accessibility, it is not generally required by accessibility regulations due to it's strictness.

As previously stated, WCAG addresses the accessibility issues faced by individuals with a wide range of disabilities. In light of the fact that this study is concerned solely with the various forms of visual impairment, it is appropriate to present here the recommendations of WCAG that are pertinent

to the target group. The reference number serves to identify the proprietorial section taken from the WCAG 2.0 standard specification [2].

### ■ Level A recommendations

- 1.4 Use of color: Color is not used as the only visual means of conveying information.
- 2.11 Keyboard: Content is operable through keyboard.
- 2.4.1 Bypass Blocks: Facilitates easier and quicker navigation for users who traverse content sequentially, allowing them direct access to the main content without the need to navigate through repeated blocks such as navigation links, headers, and advertising frames.
- 2.4.2 Page Title: Content contains titles that help users identify their current location without the need to interpret its content.
- 2.4.3 Focus Order: Aims to ensure that users navigating sequentially through content encounter information in an order that preserves its meaning.
- 2.4.4 Link Purpose: Purpose of the links can be determined from the text of the link.
- 3.1.1 Language of Page: Language is programmatically determined.
- 3.2.2 On Input: ensures that changes to any user interface component occur predictably when data is entered or a control is selected, minimizing unexpected context shifts.
- 3.3.1 Error Identification: Input error is automatically detected and presented to user in understandable form.
- 3.3.2 Label or Instructions: User is informed when content requires his input.

### ■ Level AA recommendations

- 1.4.3 Contrast: Defines minimal contrast ratio for text and images of text.
- 1.4.4 Resize text: Text can be resized up to 200 % without losing the functionality.







## Chapter 3

### Understanding User Needs

To gain a deeper understanding of the travel habits and challenges faced by our target group, we conducted qualitative research using semi-structured interviews. Our objective was to explore their travel experiences and their use of technologies across different contexts and modes of transport. Sections 3.1, 3.2, 3.3, and 3.4 summarize the research topics, key findings, and discussions of the interview results. The individual transcripts of the interviews can be found in appendices B. Building on these insights, section 3.5 develops user stories. Finally, chapter 3.6 presents a hierarchical task analysis.



#### 3.1 Research topics

In order to comprehensively understand the travel behaviors and challenges faced by our target group, we focused our qualitative research on several key areas. These areas encompass various aspects of travel, from urban navigation to intercity and air travel, as well as the technical tools used by individuals. By examining these topics, we aimed to uncover insights into the experiences and difficulties encountered by users, as well as their interactions with different technologies. The following list outlines the specific research topics explored in the interviews.



	Vision Level	Age	Occupation	Location
<b>R1</b>	Blind	30-40	Accessibility Consultant, Masseur	Olomouc
<b>R2</b>	Low Vision	40-50	Computer Instructor	Plzeň
<b>R3</b>	Blind	30-40	Lawyer, Psychotherapist	Hradec Králové
<b>R4</b>	Blind	40-50	Masseur	Prague
<b>R5</b>	Blind	40-50	Masseur	Lovosice
<b>R6</b>	Blind	70-80	Retired Teacher	Prague
<b>R7</b>	Blind	50-60	Memory Trainer	Prague

**Table 3.1:** Interview Participants

## 3.3 Key Findings

This section presents a summary of the key findings obtained during the interviews. The findings are presented based on the individual topics mentioned earlier in the section on research topics 3.1.

When travelling within the city, the majority of participants were able to travel to *familiar places independently*. All of the blind participants were utilising a VPN transmitter, which is an aid for the blind and partially sighted people, the illustration image can be seen in the figure 3.1. This transmitter can be used to send commands for remote control of acoustic orientation and information devices, such as turning on the audio signalisation on the traffic lights, in the public transport, determining the direction of escalators or informing public transport drivers about their boarding [21]. The primary obstacle identified by a greater number of respondents is the limitations imposed by construction works and other alterations to the streets and public transport hubs, which coincide with the findings of the research regarding the consistency mentioned in the section 2.2. *"When the subway is closed due to construction, it would be helpful to have some assistance that could show us the exit,"* says respondent R7.

### 3.3.1 Transportation within City

In contrast to the study conducted with visually impaired individuals in London [15], none of the respondents in this research reported using assistance within the city. This difference could be attributed to the less complex public transport infrastructure in the Czech Republic. Some respondents have



**Figure 3.1:** VPN transmitter used by visually impaired to activate audio signals.  
Source: [25]

indicated that they are utilising various forms of *navigation assistance*, which assist them in orienting themselves in unfamiliar locations. These include verbal guidance provided by relatives with the use of digital street view maps, and the use of navigation centre SONS capable of creating *itineraries*. The itinerary is a written description which includes both walking directions and public transport connections [23]. Two of the participants indicated that the services of navigation assistance had become subject to a fee, which resulted in them either stopping the use of the service entirely or using it with less frequency.

#### ■ 3.3.2 Intercity transportation

When planning trips outside of the city by either bus or train, participants were able to find the necessary information about their connections online. They *lacked experience with booking connections* due to the fact that Czech transportation has dedicated places in public transport vehicles for people with disabilities, which eliminates the need to book most of their travels in advance. In instances where it is necessary to purchase a ticket or reserve a seat in advance, individuals often seek assistance from their relatives due to their inability to book their ticket online. During the booking process, many individuals experience feelings of overwhelm or *encounter accessibility barriers*.

The respondents indicated a preference for *direct* connections, even if this necessitated a longer journey. When multiple-leg connections were required, they preferred to have *sufficient time for the transfer* and to use familiar stations. The handling of transits differed among the respondents. Some used assistance services, some handled transfers independently, and some preferred to ask someone for help. Multiple respondents expressed concerns about



booking assistance. The respondents weren't either *confident about which assistance service to use for different transportation providers* or expressed concern about the possibility of assistance services not arriving.

According to the results of an interview with respondents, some older public transport vehicles lack an adequate audio signalisation system. Consequently, passengers are utilising alternative mobile applications that provide real-time location information and details of the next station, based on GPS data. *"Sometimes public transport drivers forget where we're getting off, so it's better to check,"*, says respondent R4.

### ■ 3.3.3 Air transportation

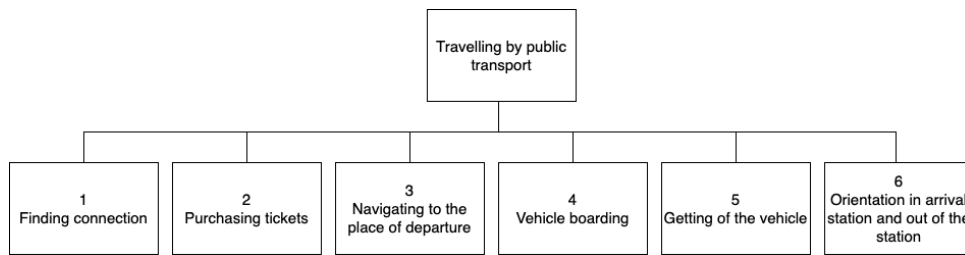
In terms of air transportation, the respondents exhibited the greatest lack of independence. Firstly, it is challenging for them to search for flights. Secondly, the booking process represents the greatest obstacle, with some steps requiring vision. The blind people either have to ask for help from their relatives, use the services of travel agencies, or call the airline directly. This ultimately leads to increased expenditure on travel, as they are unable to fully evaluate all available options. R1 states: *"Currently I feel like there is no good solution for booking flights which I would be able to use"*.

The individuals interviewed had primarily travelled abroad with individuals who were normally sighted. Some of them also shared their experiences of flying alone. In general, they had positive experiences, although they did encounter some communication difficulties with airport staff.

## ■ 3.4 Discussion

In accordance with the aforementioned research 2.2, visually impaired individuals are capable of searching for digital information. Nevertheless, they continue to encounter obstacles to accessibility. There is a lack of clarity regarding the availability of assistance services and the manner in which they can be utilised. A preference for direct journeys over multiple legs and for journeys with longer transfers has been identified.





**Figure 3.2:** Hierarchical task analysis, created using Drawio [8]

where and how to buy tickets for the first train. From Austria, they would then like to go to Slovenia and find that the mobile applications they are normally used to using to find connections in the Czech Republic don't work for foreign connections. In addition, there are multiple carriers operating in Austria, so they would like to compare several different ones in order to buy tickets at the best possible price. They try to search, but not all sites are accessible for the blind. In the end, they settle for the first option they find. They wish there was an something where they could search for trains and buses like they are used to in the Czech Republic.

## 3.6 Hierarchical task analysis

This section presents hierarchical tasks analysis (HTA) which allows us to break down traveling by public transport into manageable and detailed subtasks. Figure 3.2 presents only the top-level structure of the diagram; the complete diagram can be found in the appendices A. In the context of travelling by public transport, HTA identifies six primary tasks that can be completed in order to complete a journey. Each of these tasks can be further broken down into smaller, more manageable steps. The breakdown of the tasks is presented in the following list, along with the list of all top-level tasks.

- **Finding Connection:** Identifying the appropriate transportation options.
  - Subtask 1.1:** Open transportation search app
  - Subtask 1.2:** Enter search parameters (location, date, time)
  - Subtask 1.3:** Select the preferred route
- **Purchasing Tickets:** Acquiring the necessary tickets for the journey.

- **Navigating to the Place of Departure:** Reaching the departure point.
- **Vehicle Boarding:** Entering the chosen mode of transport.
- **Getting Off the Vehicle:** Exiting the transport at the destination.
- **Orientation in Arrival Station and Out of the Station:** Finding one's way within the arrival station and exiting.



## Chapter 4

# Design of the Transportation Search Application

As previously discussed in the section on hierarchical task analysis 3.6, the initial stage of travel is often the identification of an appropriate connection. For individuals with visual impairments, this can present a significant challenge. That for, this section is dedicated to designing an accessible and inclusive user interface for multimodal transportation platform, starting with the initial step of finding a connection. The following section 4.1 is dedicated to the inclusive principles used for design. After that, we define the functional and usability requirements 4.2. The section 4.3 breaks down the design into multiple components. Finally, the sections 4.4, 4.5, 4.6, and 4.7 are dedicated to creating a prototype of the application.



### 4.1 Overview of Principles

In the analysis chapter, a number of guidelines and recommendations were presented 2.3.2 with regard to the implementation of accessibility. This section presents a series of principles in a more generalised manner, rather than in terms of their implementation, with the intention of consideration during the design phase. The list of principles is taken from [24].

1. **Provide comparable experience:** It is necessary to ensure that users with disabilities are able to have comparable experiences when accessing digital content, taking into account the different tools and approaches that they might use.
2. **Consider situation:** The application should be designed in a manner that allows for its use in a variety of contexts and by individuals with varying levels of experience. One possible example of this would be to provide explanations for tasks that they might be facing.
3. **Be consistent:** It is of the utmost importance to be consistent in terms of uniform layout, ways of interaction, and so forth.
4. **Give control:** It is recommended that users be permitted to customize their preferences, with the proviso that content changes will only occur if the user initiates them.
5. **Offer choice:** Multiple methods of performing tasks and accessing information are available to users.
6. **Prioritize content:** The user is able to direct their attention to the most crucial tasks and information by presenting them in a manner that prioritises their importance. This can be achieved through the use of well designed layout.
7. **Add value:** The addition of features should enhance the user experience without overwhelming them.

Functional requirements	Usability requirements
User can enter departure and arrival location	Focus on interface consistency
User is able to set and modify travel preferences	Focus on ease of navigation
Search results are presentend in simple and understandable form	Follow WCAG accessibility guidelines (AA compliance)
User can select mode of transport	Prepare onboarding process
Search result contains assistance information	Ensure that users can complete tasks with a minimum number of steps and interactions
	Every information and component should be self-explicative
	User shoudn't be overload with information

**Table 4.1:** Requirements for prototype design

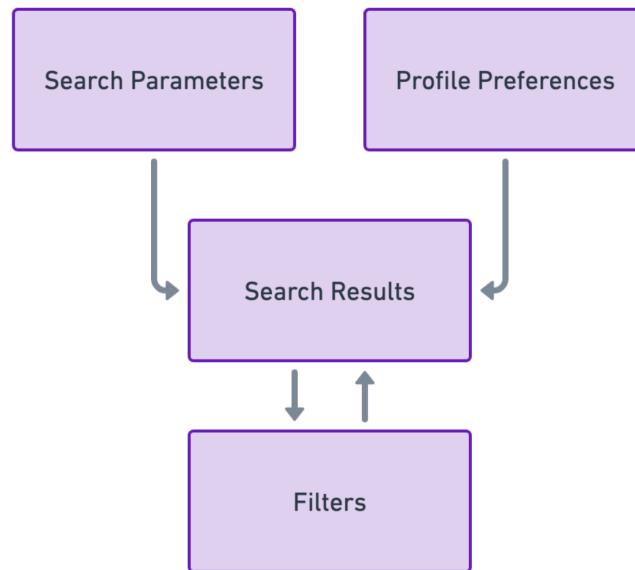
## ■ 4.2 Requirements

This section presents a summary of the requirements for a transport search prototype. All requirements can be found in the table labelled "Requirements" and are divided into two categories: functional and usability requirements. At this point in the discussion, it is appropriate to define the difference between accessibility and usability. According to W3C [27], *"Usability is about designing products to be effective, efficient, and satisfying. Usability includes user experience design. This may include general aspects that impact everyone and do not disproportionately impact people with disabilities."* The concept of accessibility is concerned with the needs of individuals with disabilities. However, the implementation of accessibility guidelines can simultaneously enhance the usability of an application. There is a considerable degree of overlap between the concepts of accessibility and usability.

### ■ 4.2.1 Target platform discussion

In the following sections and chapters, we have elected to concentrate our efforts on the design and implementation of an application for iOS. This decision was based on a number of factors, including the increased popularity of mobile applications over web applications within our group and the popularity of iOS, as discussed in the section on current screen reader trends 2.3.1. In addition to these data points, we have also considered the context in which our users will be using the application. In circumstances where users must travel spontaneously or rapidly ascertain information regarding their connection, they are more likely to utilise a mobile device than a desktop device.

The functional requirements were established on the basis of the information gathered during the interviews. With regard to the usability requirements, we have followed some of the principles for increased usability when interacting through screen readers [14].



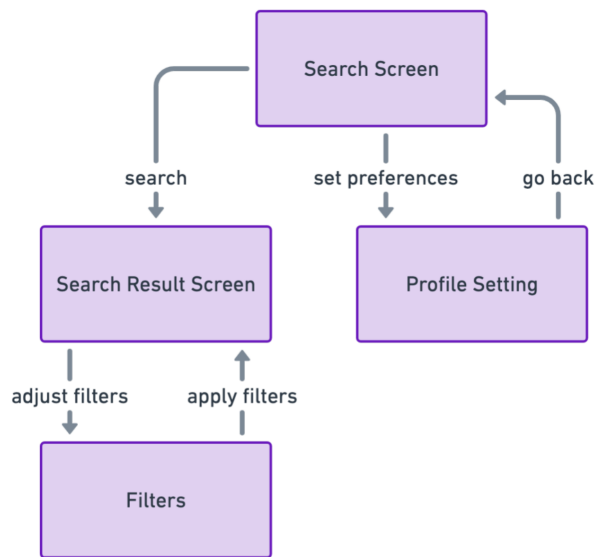
**Figure 4.1:** Factors influencing search results, created using Whimsical [30]

### 4.3 Key components and features analysis

Prior to the construction of a prototype for the application, it was necessary to identify the factors that will affect the search results presented to the user and in what form the search results will be presented. We have separated them into three categories, as illustrated in the accompanying figure 4.1. All of these factors have an impact on the search results displayed to the user. Each of them is used to configure specific parameters and can be applied in different phases of search.

- **Search parameters** - The most fundamental data required to facilitate the search for results, such as the location of departure and arrival, as well as the dates of departure and arrival, must be provided.
- **Profile preferences** - Optional configurations permit users to adjust their travel preferences, such as extending the transit time or modifying the information displayed, such as accessibility information for individuals with wheelchairs.
- **Filters** - The filters allow the user to refine their search based on the results already obtained, such as adjusting the price range, number of transits, and so forth.





**Figure 4.2:** Prototype screens and transitions between the screens, created using Whimsical [30]

Each of these factors will be configurable on separate screens. The individual screens, along with the high-level transitions between them, are illustrated in Figure 4.2. The list below presents the main four screens for the design.

1. **Search Screen:** This screen is utilised to set the previously outlined search parameters.
2. **Search Result Screen:** The screen displays search results for the connection based on search parameters and profile settings.
3. **Profile Settings Screen:** User can configure his profile preferences on this screen.
4. **Filters Screen:** This screen contains all the filters that can be applied to refine the search results.

## 4.4 Prototype design validation

The validation of the prototypes was conducted against inclusive design principles and WCAG standards. Some aspects of the design were reviewed in consultation with an accessibility consultant. Finally, the prototypes

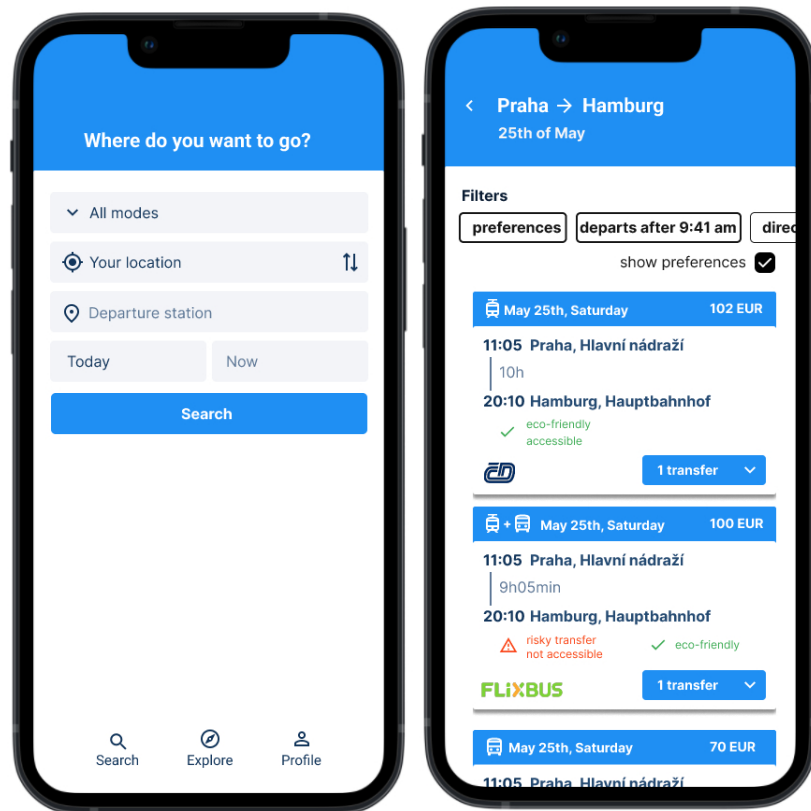


Figure 4.3: First prototype design in Figma [10]

underwent testing with a user to gather practical feedback. The following sections will describe the individual stages of the prototype and identified issues with the prototype in each stage.

## 4.5 First prototype version

The first version of the Search Screen and Search Result Screen can be seen in the figure 4.3. In the initial iteration, we have excluded the Profile Preferences and concentrated on the core functionality of the application. The search screen, visible on the left in the figure, fulfils the minimum requirements for selecting departure and arrival times and dates. The second screen on the right fulfils the minimal requirement for presenting search results and some additional requirements, such as filters and sorting.

We want to first draw attention to the header bar of the application design. When the user is using the assistive technology, it's the first component

converted from text to speech. That's why the header should express clearly what is the purpose of the screen. In the case of the Search Results screen, the header also contains information about selected search parameters in the previous step *to recapitulate the information for the user*. At the top of the search result screen, a navigation button is provided, allowing users to return to the previous screen. This button remains in the same position throughout the application, adhering to the consistency principle previously discussed in the section 4.1, and also goes along with the WCAG recommendation 3.2.4 mentioned in the section about guidelines 2.3.2.

### Added features

- **Swapping departure and arrival destinations button:** User can utilise the button to swap the locations, thereby providing a more efficient process than retyping both locations again, especially for the users using screen reader.
- **Pre-filling the departure location:** The departure location is automatically set to the user's location.
- **Show preferences check box:** The search results display supplementary information based on the user's preferences, such as warnings if the transit is too short or if there are multiple legs to the journey. This information could potentially be a source of delay for some users who use screen readers. When the checkbox is unchecked, less information is displayed, allowing the user to browse between the results more rapidly.

### Identified issues

- **Accessibility of horizontal filtering:** The prototype employs horizontal filtering, whereby applied filters move to the left on the screen when selected. Unused filters are located on the right-hand side and are often hidden from the main screen area unless the user slides right. For screen reader users, these hidden filters can be accessed by tapping over the applied filters. This approach contravenes the consistency design rule, as the layout of filters will undergo a transformation, which may prove confusing to the user, who lacks the visual information about the change. This hypothesis was validated by the accessibility consultant, who recommended the use of an alternative approach with a static order of filters.
- **Uncertainty about 'Show preferences' checkbox:** The copyrighting may prove confusing to users with vision impairments regarding the functionality of the checkbox. In contrast to the a normally vision user, whose typical behavior would be to attempt to check and uncheck

items on the screen to observe the resulting changes, the process is more challenging for users without vision. This is in violation of the general guideline of providing clear textual alternatives 2.3.2. It would be beneficial to provide a more transparent method of presenting this information.

- **No transportation options left:** The preliminary prototype raised questions regarding the optimal approach to addressing a scenario in which the user has exhausted all search results due to the application of filters. The application should inform the user of its functionality and offer the user alternative options if possible.

## 4.6 Second prototype version

The second prototype iteration, see figure 4.4, introduces primarily user preferences and addresses issues identified during the previous iteration.

### Fixed issues from previous iteration

- **Accessibility of horizontal filtering:** The filters have been relocated to a distinct page. This page can be accessed by clicking the newly introduced 'Filter' button, which has been incorporated into the design. The order of the filters remains unchanged even when some filters are in use.
- **Uncertainty about 'Show preferences' checkbox:** The description was amended to "Detailed results," which more accurately reflects its function. The checkbox was also modified to a toggle button, which more effectively demonstrates the purpose.
- **No transportation options left:** When determining the optimal implementation strategy, we considered two options: infinite scrolling, which displays additional results as the user scrolls to the end of the list, and a 'show more' button, which initiates this action when the user presses the button. Ultimately, the latter option was selected, as illustrated in the figure on the middle screen. This decision was made on the basis of the inclusive Give control, which counsels against making any changes unless the user initiates them. In the event that this approach is adopted, the user will be able to determine whether they wish to modify their filters or to display a more results.

## Added features

- **Sorting:** We have added sorting options for the search results, such as sorting by price or sorting by departure time.
- **Order assistance button:** We have added an order assistance button to each search result, which will take the user to the relevant website.
- **Adding travel preferences:** The user will be able to adjust his travel preferences. The preferences were separated into two categories - Must-haves and Nice to have. The must-have category covers travel preferences that the user wouldn't travel without, such as an inaccessible train or a transfer that is too short. If any of the search results violate any of the preferences, they will be filtered out. However, they will be placed in the 'show more' section if the user runs out of search results. Nice to have is for information purposes only. For example, if the user selects the green travel preference, the search results will show whether the connection is green or not.

## Identified issues

- **Remind user about travel preferences settings:** In the prototype, the user is prompted to set their travel preferences during the initial onboarding dialogue. However, the challenge lies in ensuring that users remember and actively update these preferences in the future. Currently, user preferences can be modified by accessing them through the bottom menu on the default search screen. Our hypothesis is that users relying on screen readers may not access this feature frequently. This is because screen reader *users typically navigate pages sequentially* [14, p. 63] and may not explore the bottom of the page. To address this issue, the next prototype version will introduce an additional method for accessing profile settings. This aligns with the inclusive design principle of providing multiple access options, thereby enhancing accessibility and user engagement.
- **Find a way of communicating travel preferences to our users:** The current design introduces uncertainty regarding the potential implications of travel preferences on search results. It is therefore necessary to identify an effective method of informing users about the impact of their preferences.

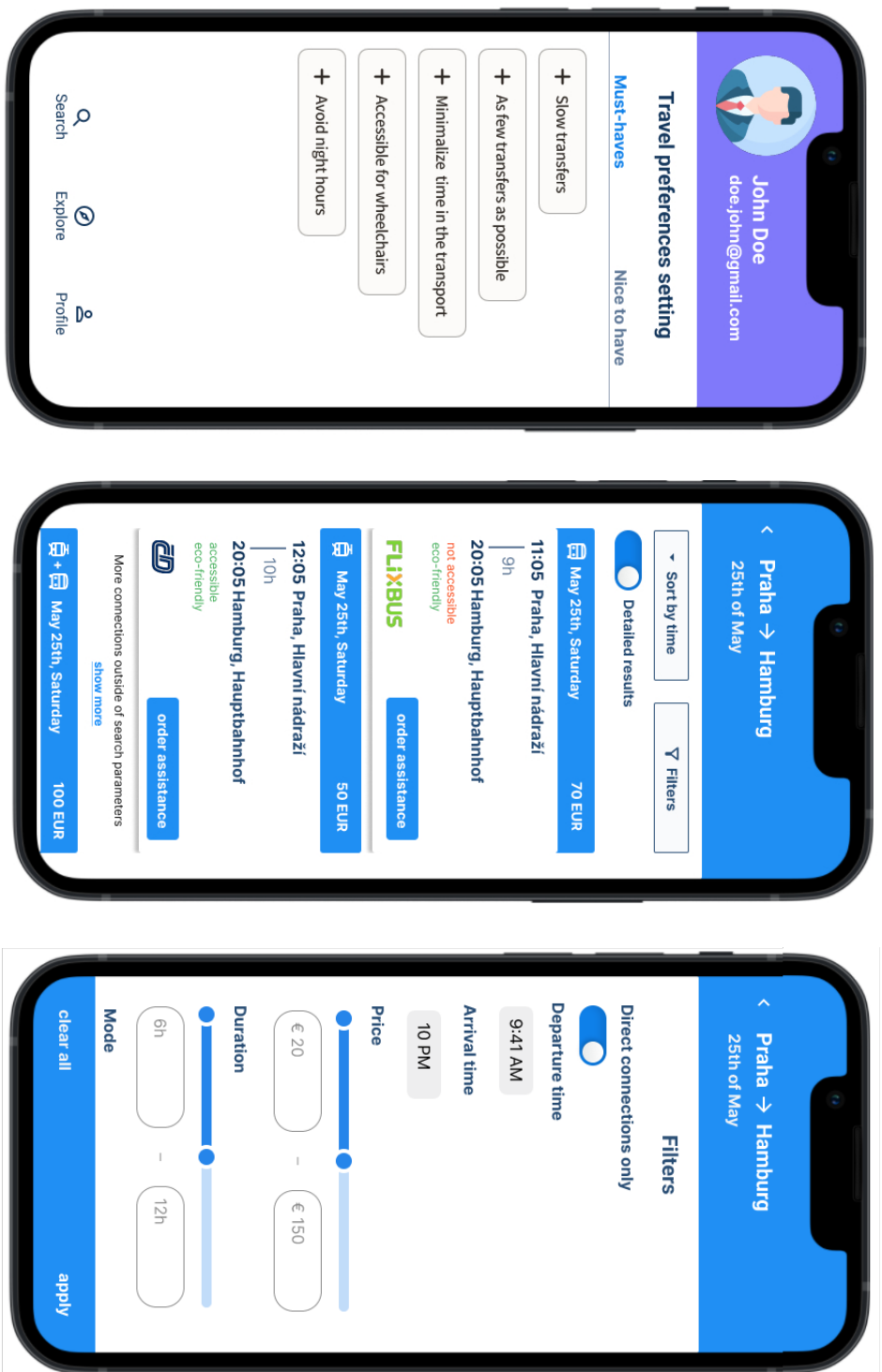
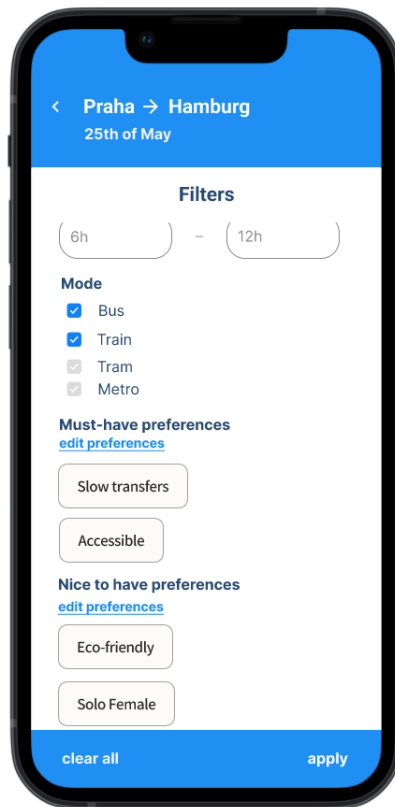


Figure 4.4: Second prototype version, created using Figma [10]



**Figure 4.5:** Travel Preference Setting references in Filters, created using Figma [10]

## 4.7 Third prototype version

In the third prototype iteration, the previously identified issues have been addressed, and a user test was conducted with a one user.

### Fixed issues from previous iteration

- Remind user about travel preferences settings:** A decision has been made to enhance the Filters Screen by linking it to the Preferences Screen. Should a user wish to modify filters associated with travel preferences, the relevant screen will be opened. More clarificatory illustration, can be found in the figure 4.5.
- Find a way of communicating travel preferences to our users:** The onboarding dialogue was added to the prototype to clarify the purpose of travel preferences.

### ■ 4.7.1 User testing

We have conducted a testing of the prototype with one blind user. The biggest obstacle connected to the testing was that Figma's accessibility mode does not work for mobile or mobile web prototypes [9]. This is at odds with the target platform outlined in section 4.2.1. The testing was conducted in a provisional setup where the user was required to make gestures on his phone and, based on his input, we informed him of his current location on the screen. With the user we have tested the following scenarios.

#### Testing scenarios

1. Setting travel preferences during the onboarding process
2. Search for the connection from Prague to Hamburg
3. Find cheapest connection from search results
4. Modify filters for search results
5. Modify travel preferences

#### Feedback collected during testing

In the initial scenario, the user was initially confused about the introduction dialog for setting travel preferences, expecting a search function instead. However, the introduction dialog was understandable, and the user was able to choose. The user selected the option for longer transfers and as few transfers as possible, which confirmed the conclusions from the interviews chapter 3.4. Non-essential preferences were often skipped, indicating they were not relevant to the user.

In searching for a connection, the user was able to determine the subsequent input fields based on his previous experiences with similar applications. Additionally, she did not require much audio input. In the initial stages of the search process, user bypassed the sorting and filtering options and detailed results option. The user reviewed all the connections listed. The order of information in the search results was satisfactory.

During the testing of Scenarios 2 and 3, the user was able to identify the location of these options with relative ease, as she had previously reviewed them during the browsing of search results. Generally, the user would not



open the filter section, finding it easier to review results directly. From the available filter options, she selected those that met her needs and would use them. She expressed a preference for having some of the filters available on the search screen.

## ■ 4.8 Discussion

The user testing was generally successful. User was able to achieve the main goal of finding connection. There are some small improvements that could be incorporated into the prototype.

- At the start of the introduction, we can tell the user that we need some details before he proceed to search to avoid confusion.
- We can move some filters to the main search screen, but also keep them in Filters to offer more choices.
- Minimize the number of steps needed to perform sorting. Currently, sort options are hidden under a button. Display them directly on the screen for easier access.



## Chapter 5

# Architecture and Technology Selection

This chapter is devoted to the selection of architectural and technological solutions. Initially, the section on high-level architecture 5.1 will present an architecture of the application, with potential for future extension. The subsequent section 5.2 will focus on selected frameworks and technologies for implementation. Finally, the concluding section 5.3 will address the design of an algorithm for filtering and sorting search results, which was previously highlighted in the design 4 but not fully specified.

### 5.1 High level architecture

This section presents the architectural design of the application. The proposed architectural approach is based on service-oriented architecture [20], which entails the provision of distinct business functionality by each service. While the previous design chapter 4 solely addressed the search functionality, the architectural diagram illustrates potential extensions for the booking component.

The subsequent list enumerates the functionalities of each component included in the design:

- **User Interface (UI):** The user interface serves as the entry point for the applications, enabling users to initiate searches and, in the future, bookings.

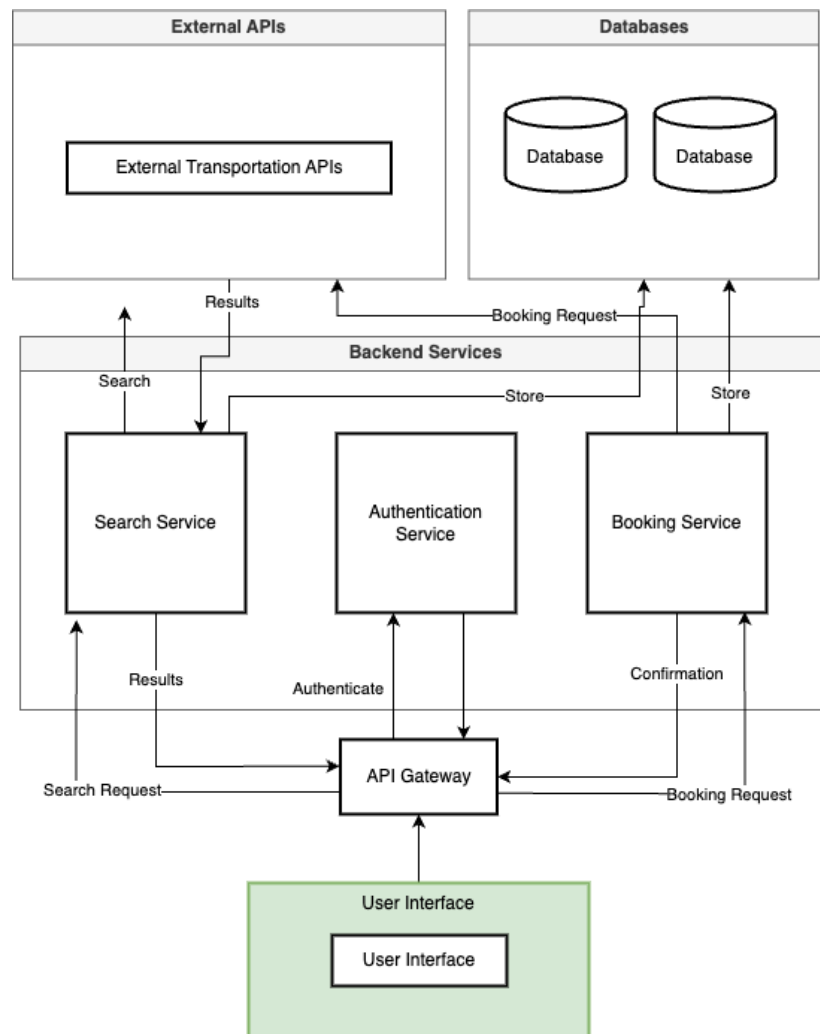


Figure 5.1: Architecture proposal, created using Drawio [8]

- **API Gateway:** Acts as a single entry point for client requests, forwarding them to the appropriate services.
- **Authentication Service:** Ensures that users are authenticated before they can perform search or booking actions.
- **Search Service:** Handles search request by real-time request to the external APIs, saves the responses into the database for caching.
- **Booking Service:** Handles booking operations, communicates with 3rd part booking APIs and saves the booking confirmation details into the databases.
- **Database:** Stores search, transportation, and user data.
- **Externals APIs:** External APIs used to query data from different route providers and for booking connections.

## 5.2 Selection of Development Tools and Frameworks

For the implementation of the user interface, we have selected React Native framework [4]. The main advantages of React Native lie in its cross-platform nature. The framework is well known, maintained and has a large community base. In addition to our use case, it offers some accessibility features that will be introduced in the following subsection 5.2.1. The application was additionally developed using Expo, an open-source platform that streamlines the React Native development process by providing a suite of tools and services [6]. Expo offers an Expo client, a mobile application that streamlines the application on a mobile device. Furthermore, the Expo client is compatible with a screen reader, enabling it to be used with our target group.

### 5.2.1 React Native Accessibility Options

React Native offers a number of accessibility features which enable digital information to be modified in a way that is compatible with screen readers. This section presents some of these features, which may differ based on the target platform, since the TalkBack and VoiceOver handle them differently. [4] The following list presents the options which are related to iOS, since we defined it earlier as our target platform 4.2.1.

- **Accessibility Labels:** Accessibility labels provide textual descriptions for UI elements, which are read by VoiceOver to help users understand the app's interface. For example, a button that submits a form should have a label like "Submit Form" rather than just "Submit." This helps users quickly understand the functionality of each element. In order to set an accessible label, it is necessary to utilise the `accessibilityLabel` keyword.
- **Defining Roles:** Roles help assistive technologies understand the purpose of UI elements. React Native uses the `accessibilityRole` property to define roles such as button, header, image, and more. On iOS, this assists VoiceOver, in providing users with contextual information about the elements they interact with.
- **Managing States and Properties:** State and property management is essential for conveying dynamic information about UI elements. Properties like `accessibilityState` and `accessibilityValue` provide information about the current state and value of components. For example,

indicating whether a switch is on or off helps users understand the current settings and make necessary adjustments.

- **Focus Management:** Managing focus is critical for creating a seamless navigation experience. React Native provides methods like `focus()` and properties like `accessibilityLiveRegion` to control focus behavior.

### 5.3 Algorithm for sorting and filtering the search results

In the design section 4, we have identified the factors that influence the search results, including the behaviour of users who have exhausted the available options and must relax the conditions to display more results. Previously, we have divided the factors into three main categories: search parameters, user preferences, and filters. The search parameters represent the most crucial aspect of the search process, as they cannot be altered by the user even when the results have been exhausted. This implies that if the user is searching for a specific destination or at a particular time, the parameters will remain unchanged.

In the event that there is a necessity to relax the conditions, we will begin with relaxing the filters that have been set on the search results page, i.e. price and number of legs. If, even after this, there are no further results, we will relax the user preferences. Relaxing the user preferences should be the last option, as the user preferences represent items that the user would not travel without, such as a train that is not wheelchair accessible. The pseudocode of this logic can be observed in Algorithm 1, which illustrates the search rule engine that could be employed to generate the results with correct filters and sorting. It should be noted that the real implementation should function on the basis that, in the event that users set a new travel preference or a filter, a new condition is registered.

---

**Algorithm 1:** Generate and Filter Search Results

---

**Input:** results, searchParams, userPrefFuncs, filterFuncs

**Output:** Sorted Search Result

```

1 begin
2   Function generateSearchResults(results, searchParams,
   userPrefFuncs, filterFuncs):
3     filteredResults ← applyFilters(results,
   [searchParams.filterFunc]);
4     filteredResults ← applyFilters(filteredResults,
   userPrefFuncs);
5     filteredResults ← applyFilters(filteredResults, filterFuncs);
6     sortedResults ← sortResults(filteredResults);
7     if sortedResults is empty then
8       sortedResults ← applyShowMoreLogic(results,
   searchParams, userPrefFuncs, filterFuncs);
9     end
10    return sortedResults;
11
12   Function applyShowMoreLogic(results, searchParams,
   userPrefFuncs, filterFuncs):
13     relaxedFilterFuncs ← relaxFilters(filterFuncs);
14     filteredResults ← applyFilters(results, relaxedFilterFuncs);
15     if filteredResults is empty then
16       relaxedUserPrefFuncs ←
17         relaxUserPreferences(userPrefFuncs);
18       filteredResults ← applyFilters(filteredResults,
   relaxedUserPrefFuncs);
19       filteredResults ← applyFilters(filteredResults,
   relaxedFilterFuncs);
20     end
21     return sortResults(filteredResults);
22
23   userPrefFuncs ← registerUserPreference(userPrefFuncs,
   newPrefFunc);
24   filterFuncs ← registerFilter(filterFuncs, newFilterFunc);
25   finalResults ← results, searchParams, userPrefFuncs, filterFuncs;
26 end

```

---





# Chapter 6

## Implementation

This chapter is devoted to the implementation of the user interface for the multimodal search platform. It begins with a section 6.1 that describes the features included in the prototype and those that were excluded. It then presents a high-level overview 6.2 of the frontend components created, followed by a section 6.3 that highlights the most noteworthy aspects of the code, in terms of technology or accessibility implementation.

### 6.1 Features implemented

The video recording of the prototype application is provided in the attached files alongside the source codes A. The prototype implementation included the implementation of the user interface previously mentioned in the chapter about architecture 5.1. The Travel Preferences and Search Results screens can be seen in the figure 6.1.

As part of the prototype, the user interface comprises the following functionalities:

- Filling departure and arrival station
- Selecting date and time
- Search Results cards

## 6. Implementation

- User preferences
- Reference through filters to user preferences
- Assistance ordering button
- Show less detailed results functionality

From the initial design, those features are not included in the current prototype version:

- The filters and sorting functions are present in the Search Result UI, but they are not functional.
- Choosing mode of the transport.
- Filters such as price range and number of legs.

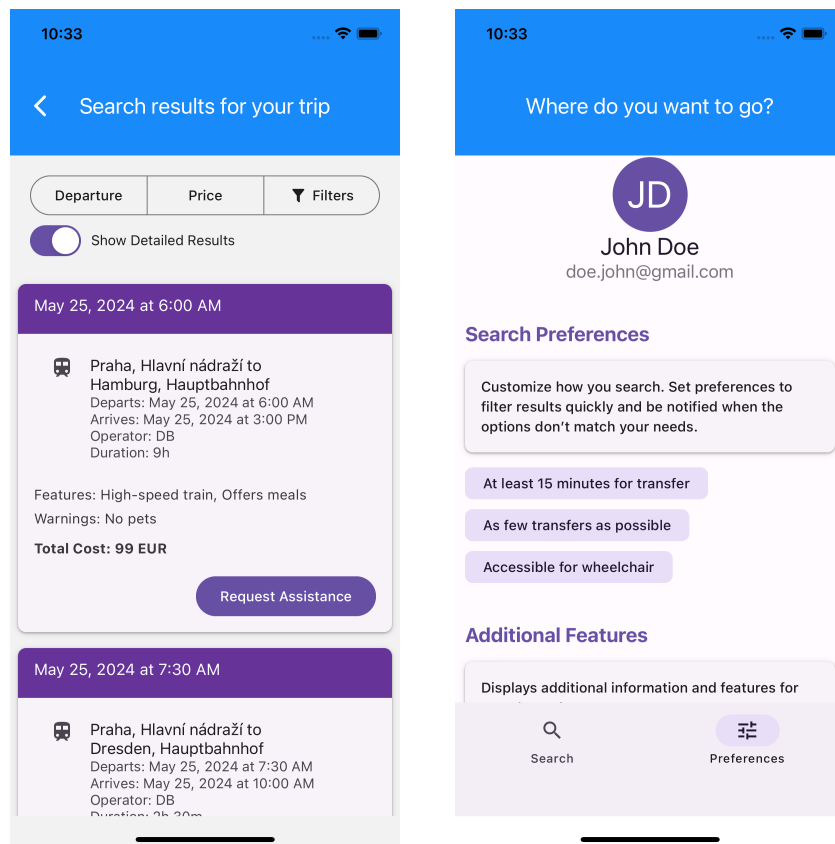


Figure 6.1: Prototype application screenshots

## 6.2 Overview of key React components

This section gives a highlevel overview of components used for creating application prototype.

- The `TravelPreferenceChip` component is an interactive chip that allows users to select or deselect travel preferences. It makes use of the `Chip` component from `react-native-paper` and manages its state to reflect selection changes. The component can be seen in the figure 6.1, as it is used for adding or removing the travel preferences.
- The `TimePicker` and `DatePicker` component provides a modal for users to pick a time and date.
- The `NavigationBar` component serves as the application's top navigation bar. It can be seen on both of the screens in the figure 6.1.
- The `GooglePlacesInput` component provides an autocomplete text input for places using the Google Places API [7].
- The `SortSegmentedButton` component presents segmented buttons that are intended fo sorting of the results.
- The `SearchResultCard` component displays search results in a card format. Each card includes details of the trip legs, total cost, and options to request assistance. In can be seen in the figure 6.1 on the left screen.

## 6.3 Code overview

This section presents a selection of the most noteworthy aspects of the prototype implementation and highlights the accessibility implementation for the prototype.

### 6.3.1 Navigation

The application uses `react-navigation` to sets the navigation for the application [5].It includes the main screens: `SearchScreen`, `PreferencesScreen`,

```

<NavigationContainer>
  <Stack.Navigator
    initialRouteName="SearchScreen"
    screenOptions={{
      header: (props) => <NavigationBar {...props} />,
    }}
  >
    <Stack.Screen
      name="PreferencesScreen"
      options={{ title: "Your preferences" }}
      component={PreferencesScreen}
    />
    <Stack.Screen
      name="SearchScreen"
      options={{ title: "Where do you want to go?" }}
      component={SearchScreen}
    />
    ...
  </Stack.Navigator>
</NavigationContainer>

```

**Figure 6.2:** React Navigation for the prototype

SearchResultScreen, and FilterResultScreen. The highlight of the implementation can be seen in the figure 6.2. The `<NavigationContainer>` component manages the navigation state and links the app with React Navigation, serving as the top-level container for the navigation structure. The `<Stack.Navigator>` and `<Stack.Screen>` components define a stack-based navigation system, allowing transitions between screens.

### 6.3.2 Enhancing the information for screen reader

A number of components required additional information regarding their functionality for the screen reader. An example is the `SortSegmentedButton` component, which can be seen in Figure 6.1. Without further clarification, it would not be evident to screen reader users what the purpose of this button is. Such information enhancement can be seen in the code snippet in the figure 6.4. In this example, we are adding additional explanation for the sort button to explain the purpose of the button using React's `accessibilityLabel`.

```

<SegmentedButtons
  ...
  buttons={[
    {
      value: "Departure",
      label: "Departure",
      accessible: true,
      accessibilityLabel: "Sort search results by departure time",
    },
    ...
  ]}
/>

```

**Figure 6.3:** Using accessibility options to enhance the information for screen reader

### 6.3.3 Assistance button implementation

The assistance request functionality is implemented in the `SearchResultCard` component, which holds information about a single connection. This component manages user state with `useState` to track if assistance has been requested and to control the visibility of a `Snackbar` for user feedback. The `handlePress` function sets `assistanceRequested` to true and displays the `Snackbar`, while `onDismissSnackbar` hides it.

### 6.3.4 Explanation of user preferences to the user

Prior to the user preferences setting, an infobox is displayed 6.1 on the user preferences screen, which explains the purpose of user preferences. The related code can be seen in the 6.5.

```
<Card>
  {/* Other card content */}
  <Card.Actions>
    <Button
      onPress={handlePress}
      disabled={assistanceRequested}
    >
      Request Assistance
    </Button>
  </Card.Actions>
  <Snackbar
    visible={snackbarVisible}
    onDismiss={onDismissSnackbar}
    duration={3000}
  >
    Assistance has been requested.
  </Snackbar>
</Card>
```

**Figure 6.4:** Code snippet of requesting assistance functionality

```
<InfoBox title="Customize how you search... />
<View style={styles.preferenceSection}>
  <TravelPreferenceChip>
    At least 15 minutes for transfer
  </TravelPreferenceChip>
  ...
</View>
```

**Figure 6.5:** Code snippet of infoboxes about user preferences

# Chapter 7

## User Testing and Evaluation

This chapter presents a description of the use testing methodology employed and an evaluation of the results obtained. Section introduces the testing methodology employed throughout the testing process, while Section presents a summary of the key findings obtained during the testing phase. Finally, Section provides a discussion of the results obtained.

### 7.1 Overview of Testing Methodology

The user test involved three participants, two blind and one partially sighted. The participants had varying levels of technical ability. We tested the following scenarios with the participants.

1. Search for a connection from Prague to Hamburg.
2. Find the cheapest connection from search results.
3. Go to filters for search results.
4. Modify travel preferences.
5. Initiate new search on a different date.

The first four scenarios were tested with enough time to complete them so that the participants could get to know the application prototype. The fifth scenario was tested under pressure and the participant was asked to imagine that they were looking for a connection and needed to get away as quickly as possible. During the testing phase of the prototype, participants were encouraged to verbalise their thoughts, which enabled us to identify any misunderstandings regarding the functionalities.

## 7.2 Key Findings

- *Departure and arrival station selection:* The participants were able to successfully identify the input fields for search parameters and all participants were able to select a departure and destination location.
- *Selecting date and time:* One blind participant encountered difficulty in selecting a time and date. In the subsequent discussion, it was revealed that the participant was accustomed to native iOS pickers, which formed part of his preferred applications. In contrast, the low vision participant found the date and time picking process to be user-friendly and expressed satisfaction with the overall experience.
- *Search results clarity:* The search results were well-received by blind individuals, who appreciated the way in which they were presented. Both users found it useful to have some of the details repeated by the screen reader, such as the departure date. The low vision participant would have benefited from larger text, as this would have made it easier for him to read the results.
- *Assistance information:* All participants liked the idea of assistance button for requesting assistance directly through the application.
- *Navigation:* All participants were able to successfully navigate the application, initiate a search, return to a previous page, and locate the settings.
- *User preferences:* The low vision participant was able to identify the travel preferences with ease, both through filters and the bottom navigation, and to select them. Both blind participants were able to locate the user preferences. One blind participant initially exhibited confusion about the travel preferences, but upon listening to the infobox several times, he was able to comprehend their purpose.
- *Contrast:* Low vision participants was sensitive to high contrast, he would appreciate dark mode feature.



- *Expendable layout*: The users expressed satisfaction with the predictable layout of the Search Screen and the Search Result Screen, which enabled them to anticipate the content and location of information.

## 7.3 Discussion

The testing process was generally successful, although a few areas for improvement were identified. Based on the user testing, it would be beneficial in the future to replace the current date and time handling with the iOS native components, as users are more familiar with them. Currently, there is no dark mode option available, which can be challenging for some low vision users. The prototype lacked certain features, including the ability to select a mode of transport and functional sorting and filtering. These features were not included in the prototype, but they have been incorporated into the final design.

The participants found the option for ordering assistance to be particularly useful and mentioned that it would be a significant time saver for them. Furthermore, they expressed that it would increase their confidence in the reliability of the assistance arriving. Both blind users expressed gratitude for the application's focus on blind and visually impaired users, as they frequently have to inform transportation providers about inaccessible features in their application. Unfortunately, these issues are often not addressed promptly, leaving them without option to find connection.

The user testing yielded valuable insights into the usability of the application for blind and visually impaired users. Admittedly, it would have been beneficial to include more participants in the testing, but this was not possible due to the difficulty of finding suitable participants and the time constraints we had.





## Chapter 8

### Conclusions

In conclusion, this thesis has explored the unique challenges faced by blind and visually impaired individuals in their travel experiences. Through a analysis of current research, user interviews, and the development of a prototype application, several key findings have emerged.

It is evident that while existing travel applications and services provide a foundational level of accessibility, they often fall short in addressing the nuanced needs of visually impaired users. This ultimately leads to a greater dependence of such individuals on others. Some of the obstacles encountered were the necessity of consulting multiple sources to obtain travel information and the difficulties associated with booking and uncertainty regarding the availability of assistance. Conversely, there was a strong desire to travel, yet the visually impaired lacked the requisite confidence.

The developed prototype demonstrated that integrating user preferences into the design not only enhances usability but it could also increase the confidence and independence of visually impaired travelers, as some of the users mentioned during the user testing. Features such as the assistance request button, detailed travel preferences, and clear information presentation were particularly well-received by users during testing.

Finally, while the prototype shows a promise, further development and extensive testing with a larger user base are necessary to refine its functionality and ensure it meets the diverse needs of all visually impaired users. It is hoped that this work will contribute to the broader research on this issue and help create a more inclusive environment where blind and visually impaired

individuals can enjoy equal rights when traveling. This includes the ability to travel spontaneously, without fear or additional costs associated with their disability.

## 8.1 Future work

There are many way how the prototype can be improved.

- More extensive user testing to help us identify the spaces for improvements.
- Implementing the missing search functionality.
  - Implementation of the full search result algorithm filtering and sorting functionality.
  - Enhancing the available filters and user preferences.
  - Offer dark mode.
- Connecting the prototype to 3rd party API for obtain real searching data.
- Collaboration with assistance services to be able to really book the travel assistance directly trough the application.
- Support booking trough the travel application.
  - Implementation of the full search result algorithm filtering and sorting functionality.
  - Enhancing the available filters and user preferences.
- Focus on travel experience and post travel experience.
  - Implement notifications for alerting user on when to get out of the vehicle.
  - Help user to navigate trough the correct station and terminal.

# Appendix A

## Tree of attached documents

```
/
├── HTA
│   └── hta-travelling.pdf ..... full version of HTA
├── videos
│   ├── prototype-video.mov ..... video of prototype in Figma
│   └── app-video.mov ..... video of application prototype
├── figma-prototype
│   ├── prototype-figma.pdf ..... exported Figma prototype in PDF
│   └── prototype-figma-format.fig ..... Figma prototype
└── source-codes
    └── travel-app-frontend.zip ..... source code for the prototype
```



## Appendix B

### Interview Transcripts

#### B.1 Respondent R1

- accessibility konzultant & masér
- věk přibližně 30 let
- nevidomý od narození
- bydlí v Olomouci
- samostatně podniká

##### Cestování v rámci města

- Při navigaci po městě používá aplikace Lazarillo a GoogleMaps
- Lazarillo hlásí názvy křižovatek, ulic, obchodů

##### Cestování vlakem a autobusem

- Používá aplikaci CgTransit na vyhledávání spojů
- V CgTransit lze zapnout notifikace, které hlásí nadcházející stanice (to konkrétně nepoužívá)

- Zpoždění vlaku a stanici, kde má vystoupit, sleduje v aplikaci MůjVlak
- Většinou si objednává jízdenky přes MůjVlak
- Z autobusů zkoušel dopravce Regiojet, včetně zakoupení jízdenky
- Má rád všechno naplánované a koupené dopředu, necestuje impulsivně
- Když si není jistý, jak se dostat z A do B, hledá spojení přes CgTransit
- Upřednostňuje spíše vlak před autobusem, kde se snaží vybírat si spoje bez přestupu. Pokud je trasa s přestupy, snaží se, aby měl 30 min až hodinu na přestup
- Zásadně se vyhýbá výlukám (přestupy na autobus)
- Asistenci při přestupu si objednává přes službu OneTicket (musí se tam objednat asistence alespoň 36 hodin dopředu)

## Létání

- Cestuje letecky i sám.
- Rád by příští rok letěl do Japonska.
- Obecně letenky zvládne vyhledat, nezvládne je ale sám objednat (check-in, vybírání sedadla apod., protože nejsou přístupné).
- "Toto je jediné, co v rámci cestování nezvládnou udělat."
- Buď mu někdo s objednáváním pomáhá, nebo zavolá letecké společnosti a objedná si letenky po telefonu.
- Je pro něj výhodnější objednat si letenky přímo přes leteckou společnost, protože rovnou zařídí i asistenci na letišti.
- Některé letecké společnosti nabízí zařízení asistence přímo u objednávání letenek, některé ne.
- Na vyhledávání letenek používá webovou stránku SkyScanner.
- Většinou létá s někým, kdo vidí, takže nemusí asistenci řešit.
- Hodila by se mu alternativa k aplikaci NaVlak pro letiště.
- S asistencí někdy bývá problém, protože nemluví anglicky (špatná zkušenost v Neapoli).
- Asistenci často chybí znalost o tom, jak se chovat k lidem s handicapem - např. nucení na invalidní vozík (děje se na letišti, i při přestupu na vlak)
- Rád létá, protože je to pro něj výzva.



### Technická část

- Používá převážně iPhone a iPad.
- Poslední dobou nemá dobrou zkušenost s MacOS, zvažuje návrat k Windows.
- Používá aplikace Firefox nebo Google Chrome.
- Oblíbené aplikace: BeMyEyes – textová forma k fotkám, CgTransit.

## ■ B.2 Respondent R2

- invalidní důchod
- lektor pro kurzy počítačů pro nevidomé/slabozraké
- věk přibližně 40 let
- bydlí v Plzni
- slabozraký následkem úrazu v 21 letech (slabozraký, zúžené zrkové pole, vidí jen přímo před sebe, prakticky nevidomí podle zprávy od lékaře, nemusí používat „screen readers“)

### Cestování v rámci města

- nenapadá ho nic specifického

### Cestování vlakem a autobusem

- často cestuje vlakem za rodiči (bydlí asi 60 km od Plzně)
- Vlak tam jezdí přímo.
- Preferuje spíše vlak, ale nemá žádný konkrétní důvod.
- Jízdenky si kupuje přes MůjVlak.
- Hledání místa ve vlaku bývá problém.
- Stává se mu, že vlaková souprava je otočená a není si tedy jistý, na jaké straně soupravy se nachází jeho místo.

- Rád používá aplikaci NaVlak, kde si zjistí, odkud jeho vlak odjíždí (nevidí na tabule na stanici).
- Má rád i Regiojet vlaky, protože si tam může objednat jídlo přes aplikaci.
- Když jezdí od rodičů mezinárodním rychlíkem, neví dopředu zpoždění.
- Občas dojíždí za klienty, které učí.
- Když dopředu nezná cestu, jak se někam dostat vlakem/autobusem, na mapách.cz najde jejich adresu, zkoumá, jestli je poblíž nějaká zastávka a potom najde cestu přes Idos.
- Jednou si objednal jízdenku přes OneTicket – vybírá nejdražší varianty jízdenek, finančně nákladné.

## Létání

- Letos byl na dovolené v Egyptě.
- Většinou cestuje s někým, kdo vidí, ale cestoval i se skupinou nevidomých – měli zařízenou asistenci na letišti.
- Dovolené zařizuje přes cestovní kancelář, postarají se i o zařízení asistence.
- Problémy s asistencí – letadlo mělo zpoždění, asistence neměla čas, takže je nechala čekat a pak na ně zapomněla (musel se zeptat jiného zaměstnance na letišti).
- Jednou špatná zkušenost s cestovní kanceláři, která zapomněla zařídit asistenci.

## Technická část

- Technická část
- Nemusí používat odcítače, protože má ještě zbytky zraku.
- Stres mu působí, když má na něco časový limit.
- Používá Windows a Android.
- ZoomText pro zvětšování obsahu na internetu – má rád tuhle konkrétní aplikaci, protože si v preferencích může nastavit i konkrétní zvětšení pro různé aplikace na Windows.
- Preferuje, když může cokoliv přepnout do tmavého (dark mode), protože mu používání klasického módu působí nepohodlí (příliš ho oslňuje).

- Většinu věcí dělá na počítači, na telefonu spíš jen používá aplikaci MůjVlak.
- Trvá mu dlouho vyplnit formuláře, preferuje a když si může uložit údaje v prohlížeči.
- Oblíbené aplikace: MůjVlak, ZoomText.

## ■ B.3 Respondent R3

- právník, psychoterapeut
- věk přibližně 30 let
- bydlí v Hradci Králové
- natáčí videa na youtube, podcasty
- ve volném čase se věnuje programování, hudbě
- nevidomý od 18 let

### **Cestování v rámci města**

- Navigace po městě – když má šanci připravit se dopředu, projde si cestu s někým z rodiny, nebo s přítelkyní. Podívají se na Street View v Google Maps a popíše mu cestu.
- Pokud nemá čas, tak většinou používá Idos.
- Má rád mapy.cz, protože ho dovedou ze správné strany domu (katastrální podklady). Google mapy občas dovedou na špatnou stranu.

### **Cestování vlakem a autobusem**

- Cestuje často (většinou průměrně 2x týdně), jelikož v rámci jeho zaměstnání dojíždí k soudům.
- Raději jezdí vlakem, na vlakových nádražích se líp orientuje.
- Vlakové stanice mají vždy podobné rozložení – musí najít podchod a pak už je to jednoduché.

- Nepoužívá asistenci, maximálně se doptá.
- Autobusem jezdí spíš výjimečně, protože se většinou pohybuje Hradec – Praha nebo v Kolíně.
- Zatím se mu stalo jen jednou, že by nastoupil do špatného vlaku.
- Upřednostňuje vlakové spojení bez přestupu (pokud časový rozdíl není příliš velký).
- Při cestě z Hradce Králové do Prahy má dvě možnosti – vlak 1h 40min., který jede přímo a vlakové spojení přes Pardubice s přestupem za 1h15m (upřednostňuje přímé spojení).
- Cestování po ČR tolik neplánuje.

### Létání

- Ještě sám neletěl, ale plánoval to.
- Vždycky zatím do zahraničí cestoval s někým vidícím.
- Letos byl na Mallorce.
- Neví, jak by se na letišti orientoval, většinou tam chybí vodící linie a nejsou přístupné.
- Je schopný letenky vyhledat (SkyScanner, Kiwi).
- Byl na Erasmu ve Francii.

### Technická část

- Používá Android a Windows.
- Preferuje spíš telefon.
- Na telefonu se mu těžko píše, jinak by tam mohl dělat všechno.
- Oblíbené aplikace: cokoliv od Google je dobře přístupné, aplikace Gps-ForBlind

## B.4 Respondent R4 and R5

- oba pracují jako maséři
- věk přibližně 40 let
- žena bydlí v Lovosicích (R4)
- muž v Praze (R5)
- oba nevidomí

### Cestování v rámci města

- R5: Navigace po Praze - Když jde na nové místo, většinou dokáže poskládat trasu z úseků, kde už to zná. Hodně se doptává. Většinou se snaží jít po paměti.
- Oba: Rádi používají aplikaci Uber, když mají jet někam, kde to neznají. Cesta tam je složitější, na cestu zpátky už bývá jednodušší se zeptat, protože kolemjdoucí zvládnou nasměrovat k MHD (na konkrétní adresu je to komplikovanější).

### Cestování vlakem a autobusem

- R5: Jezdí mimo Prahu pravidelně, za matkou na Severní Moravu (Bohumín) a Lovosice (přítelkyně).
- R5: Z Prahy do Lovosic jezdí raději Elefantem, přestože rychlík je asi o 40 min rychlejší, protože odjíždí z Masarykova nádraží, a je to nová souprava, takže při výstupu otevírá dveře na správnou stranu, a ne do kolejiště.
- R5: Ve vlaku vystupuje podle hlášení ve vlaku nebo používá aplikaci Lazarello (poslední dobou mu Lazarello moc nefunguje a otevírají se přes něj Google Mapy).
- R4: S Lazarello má problémy, nejde ji používat. Neví, jakým směrem má držet telefon.
- R5: Když to jde, snaží se vyhýbat spojením s přestupem. Pokud nějaký přestup má, nevyužívá asistenci, ale poptá se během cesty. Asistenci používá minimálně.

- R5: Zmiňuje špatnou zkušenost s asistencí, když se snažil objednat přes ČD asistenci, ale navazující vlak nebyl ČD, takže mu nebyli schopni asistenci zařídit.
- R5: Na vlak si nekupuje jízdenku online, neumí to.
- R5: Pokud jede za rodinou na severní Moravu, jízdenku mu kupuje rodina (Leoexpress). Do Lovosic si jízdenku kupuje ve vlaku.
- R4: Zkoušela Dukapku (doprava Ústeckého kraje) - ne moc dobrá zkušenost, šlo jí koupit jízdenku, nestačí internetová registrace, je třeba dojít někam na přepážku?
- Oba: Oba používají NaVlak, kontrolují si odkud odjíždí vlak.
- R4: V Lovosicích nefunguje VPN na tabule a předčítání stanic, takže se autobusům vyhýbá. Řidiči často zapomenou zastavit. Na vystoupení se dá používat Lazarello, ale jí Lazarello nefunguje.
- R4: Chtěla by se podívat někam vlakem po Evropě. Láká jí představa, že přijede rovnou do centra města a nemusí ještě cestovat z/na letiště.
- R5: Do zahraničí jel vlakem pouze na Slovensko, ale to byly dva páry s vidícím člověkem. Nic nemusel zařizovat.

## Létání

- R5: Nemluví anglicky, takže má strach cestovat sám. Vždycky cestoval s někým.
- R5: Má rád letiště - "Klidně by se jen proletěl a letěl zase zpátky"
- R4: Dříve cestovala sama, využívala asistenci na letištích. Když letěla do Nice, asistenci se nechtělo jet s ní z jednoho terminálu na druhý, takže zastavil kolemjdoucí a poslal ji s nimi.
- R4: Do letadla je většinou nasadí první nebo poslední.
- R4: Nikdy nelétá nízkonákladovkami, nemá v ně důvěru. Bála by se letět například Raynair.
- R4: Má pocit, že když se připlatí za letenku, tak s ní budou zacházet líp.
- R4: Nevadí jí, když asistence nemluví anglicky. Většinou pomohou jiný pasažéři.
- R4: Letenky kupuje po telefonu, nadiktuje číslo karty.
- R4: Zatím letěla s Lufthansou, Swiss, měla pozitivní zkušenost s personálem.

- R4: Víc než cena, tak je pro ni důležitý vědomí, že bude všechno v pořádku.
- R4: Má asistenčního psa. “Přivede mě spíš do hrobu, než někam”.
- R4: Když by někam jela pouze na kratší cestu, tak by ho nevzala, protože je to komplikované

### Technická část

- Oba: oba spíše používají telefony, oba mají Iphone
- R4: na notebooku jenom edituje text
- R4: Oblíbené aplikace: NaVlak, VoiceDream (čtení knížek)

## ■ B.5 Respondent R6

- dříve pracoval jako učitel, teď v důchodu
- 70 - 80 let
- bydlí v Praze
- oslepl po ukončení university, vrozená vada sítnice

### Cestování v rámci města

- Využívá navigačního centra SONS, když musí někam, kde to nezná. Sepíše mu podrobný itinerář. Dříve to bylo bezplatné, teď už není, protože nenašli vhodné financování.
- Jinak se po městě zvládá navigovat samostatně na místech, kde to už zná.

### Cestování vlakem a autobusem

- Cestuje do Třebíče za bratrem. Může jet autobusem i vlakem, ale má radši vlaky (přístupnější záchody).

- Vyprávěl historku, jak pomáhal paní (vidící) přestoupit na vlak do Pardubic v Havlíčkově Brodě.
- Co se týče přestupů, spoléhá se vždycky na to, že se s někým domluví při cestě. Většinou s průvodcím nebo s nějakým spolucestujícím.
- Jízdenky si kupuje buď přímo v autobuse/vlaku, nebo si dopředu dojde např. na Florenc na přepážku.
- Umí si sám vyhledat spoj na internetu. Důležité jsou pro něj přestupy. Nevadí mu přestupy, zařizuje i asistenci, ale chce si nechat dostatečně času. Má problémy s vyhledávači, protože mu ukazují spoje i s krátkých přestupem.

### Létání

- Nelétá.

### Technická část

- Používá výhradně počítač.

## **B.6 Respondent R7**

- trenérka paměti
- nevidomá od narození
- věk 40 - 50 let

### Cestování v rámci města

- V rámci města cestuje sama.
- Když byly bezplatné, používala služby navigačního centra SONS.
- Dělá jí problém, když je nějaká změna na cestě, např. rozkopaný Florenc. Hodilo by se jí, kdyby byla při takových změnách na stanici byla asistence.



### **Cestování vlakem a autobusem**

- Preferuje autobusy, vlaky nemá moc ráda.
- Ráda cestuje, vždycky ale cestuje s někým.
- Umí si vyhledat spoj na Idos, ale poslední dobou má s Idos problém.
- Používá jako náhradu CgTransit.

### **Létání**

- Ráda létá a cestuje.
- Má teď v plánu letět do Londýna.
- Kamarád ji vždy bookuje letenky.
- Sama to neumí.

### **Technická část**

- Používá Iphone.





## Appendix C

### Bibliography

- [1] Peter Brophy and Jenny Craven. Web accessibility. *Library trends*, 55(4):950–972, 2007.
- [2] Alastair Campbell, Chuck Adams, Rachael Bradley Montgomery, Michael Cooper, and Andrew Kirkpatrick. Web content accessibility guidelines (wcag) 2.2. <https://www.w3.org/TR/WCAG22/>, 2023. World Wide Web Consortium (W3C) Recommendation.
- [3] Mike Cohn. *User stories applied: For agile software development*. Addison-Wesley Professional, 2004.
- [4] React Native Contributors. React native documentation. <https://reactnative.dev/>, 2024. Accessed: 2024-05-24.
- [5] React Navigation Contributors. React navigation documentation. <https://reactnavigation.org/>, 2024. Accessed: 2024-05-24.
- [6] Expo Developers. Expo documentation. <https://expo.dev/>, 2024. Accessed: 2024-05-24.
- [7] Google Developers. Google maps places api documentation. <https://developers.google.com/maps/documentation/places/web-service/overview>, 2024. Accessed: 2024-05-24.
- [8] draw.io. Flowchart maker and online diagram software. <https://www.draw.io/>, 2024. Accessed: 2024-05-24.
- [9] Figma. Accessible prototypes in figma. <https://help.figma.com/hc/en-us/articles/7810391964695-Accessible-prototypes-in-Figma>, 2023. Accessed: 2024-05-23.

- [10] Figma. Figma: Collaborative interface design tool. <https://www.figma.com/>, 2024. Accessed: 2024-05-24.
- [11] Regine M Gilbert. *Inclusive design for a digital world: Designing with accessibility in mind*. Apress, 2019.
- [12] Google. Use talkback, the screen reader for android. <https://support.google.com/accessibility/android/answer/6007100?hl=en&sjid=1141682474600113946-EU>, 2024. Accessed: 2024-05-23.
- [13] Apple Inc. *VoiceOver User Guide*, 2024. Accessed: 2024-05-23.
- [14] Barbara Leporini and Fabio Paternò. Increasing usability when interacting through screen readers. *Universal access in the information society*, 3:57–70, 2004.
- [15] Wai-Ying Low, Mengqiu Cao, Jonas De Vos, and Robin Hickman. The journey experience of visually impaired people on public transport in london. *Transport Policy*, 97:137–148, 2020.
- [16] An Neven and Wim Ectors. “i am dependent on others to get there”: Mobility barriers and solutions for societal participation by persons with disabilities. *Travel behaviour and society*, 30:302–311, 2023.
- [17] U.S. Department of Labor. Americans with disabilities act. <https://www.dol.gov/general/topic/disability/ada>, 2024. Accessed: 2024-05-24.
- [18] National Technical Assistance Center on Blindness and Low Vision. Definitions of blindness and low vision. <https://www.ntac.blind.msstate.edu/resources/definitions-blindness-and-low-vision>, 2024. Accessed: 2024-05-20.
- [19] World Health Organization. Assistive technology fact sheet. <https://www.who.int/news-room/fact-sheets/detail/assistive-technology>, 2024. Accessed: 2024-05-23.
- [20] Randall Perrey and Mark Lycett. Service-oriented architecture. In *2003 Symposium on Applications and the Internet Workshops, 2003. Proceedings.*, pages 116–119. IEEE, 2003.
- [21] Centrum pro nevidomé. Vše o vysílačích povelů. <https://www.centrumpronevidome.cz/subdom/bariery/bariery/vysilace.htm>. Accessed: 2024-05-18.
- [22] Freedom Scientific. Jaws (job access with speech). <https://www.freedomscientific.com/products/software/jaws/>, 2024. Accessed: 2024-05-23.
- [23] SONS. Sons navigační centrum. Available at <https://www.sons.cz/navigace>. Accessed: 2024-05-19.

- [24] Henny Swan, Ian Pouncey, Heydon Pickering, and Léonie Watson. Inclusive design principles. <https://inclusivedesignprinciples.info/>, 2024. Accessed: 2024-05-20.
- [25] Tyflopomůcky. Ovladač dálkový vpn 02. <https://eshop.tyflopomucky.cz/ovladac-dalkovy-vpn-02-0712/>, 2024. Accessed: 2024-05-19.
- [26] NE Low Vision. *Introduction to Screen Reading and Magnification Software: A Comprehensive Guide to Assistive Technology Assessment*. 2024. Accessed: 2024-05-23.
- [27] World Wide Web Consortium (W3C). Accessibility, usability, and inclusion. <https://www.w3.org/WAI/fundamentals/accessibility-usability-inclusion/>, 2024. Accessed: 2024-05-23.
- [28] W3C Web Accessibility Initiative WAI. W3c accessibility standards overview. <https://www.w3.org/TR/low-vision-needs/#visual-impairments>. Accessed: 2024-05-18.
- [29] WebAIM. Webaim: Web accessibility in mind. <https://webaim.org/>, 2024. Accessed: 2024-05-23.
- [30] Whimsical. Whimsical: The iterative workspace for product teams. <https://whimsical.com/>, 2024. Accessed: 2024-05-24.
- [31] Sandy Wong. Traveling with blindness: A qualitative space-time approach to understanding visual impairment and urban mobility. *Health & Place*, 49:85–92, 2018.



## I. Personal and study details

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Study program: **Open Informatics**  
Specialisation: **Software Engineering**

## II. Master's thesis details

Master's thesis title in English:

**Accessible application for traveling for blind and visually impaired users**

Master's thesis title in Czech:

**P ístupná aplikace pro cestování nevidomých a jinak zrakov postižených uživatel**

Guidelines:

The aim of the thesis is to create an accessible travel application for blind and visually impaired users. Analyze the obstacles and challenges encountered by blind and visually impaired individuals across various modes of transportation. Based on the analysis, define the user's requirements and develop a design for the accessible travel application prototype, emphasizing intuitive navigation, clear information presentation, and compatibility with assistive technologies. Design the architecture of the application and select appropriate development tools and frameworks for building the application. Implement application prototype with respect to accessibility standards and user requirements. Test the application's prototype with users.

Bibliography / sources:

1. Elizabeth Goodman, Mike Kuniavsky and Andrea Moed (2012). Observing the User Experience. Elsevier.
2. Colin Ware (2019). Information Visualization, perception for design. Morgan Kaufman.
3. Bill Buxton (2010). Sketching User Experiences. Morgan Kaufman.
4. Miroslav Disman (2011). Jak se vyrábí sociologická znalost: P íru ka pro uživatele. Karolinum Press.

Name and workplace of master's thesis supervisor:

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Date of master's thesis assignment: **01.03.2024** Deadline for master's thesis submission: **24.05.2024**

Assignment valid until: **15.02.2026**

doc. Ing. Zden k Míkovec, Ph.D.  
Supervisor's signature

Head of department's signature

prof. Mgr. Petr Páta, Ph.D.  
Dean's signature

## III. Assignment receipt

The student acknowledges that the master's thesis is an individual work. The student must produce her thesis without the assistance of others, with the exception of provided consultations. Within the master's thesis, the author must state the names of consultants and include a list of references.

\_\_\_\_\_  
Date of assignment receipt

\_\_\_\_\_  
Student's signature