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Towards Smart and Inclusive Cities: MOBILAÎNÉS Project - Innovating Age-Friendly Mobility Solutions for Older Adults

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Abstract— **Exploring the intersection of mobility challenges faced by older adults reveals the nuanced issues accompanying advancing age. Existing trip planning tools often fall short in addressing the unique preferences and needs of older adults. This paper delves into an initiative committed to developing an Age-Friendly trip planner platform for smart cities tailored to meet the distinctive mobility requirements of the aging population. The paper introduces the Mobilaînés project (a user-centric solution addressing the unique needs of older adults in Transportation Planning), highlights the key co-creation phase elements of the project, presents the proposed architecture, and shares insights from usability tests. By embracing smart city principles, this initiative strives to redefine the urban mobility landscape for older adults, offering an innovative solution to their specific challenges.**

Keywords— Smart City; Mobility; Older Adults; Age-Friendly; Trip Planner

I. INTRODUCTION

Smart cities [1], [2], [3] can play a key role in helping older adults overcome the age-related challenges and disabilities, mainly in moving around freely, which can result in enhanced sociability, well-being and healthy Aging in age-friendly urban environments.

The World Health Organization indicated a continuous increase in the proportion of older adults over the years [4]. This demographic shift is notably pronounced in Canada. In 2024, individuals aged 60 years or older constitute around 26.9% of the total Canadian population, and forecasts anticipate a further ascent to 29.4% by 2035. According to statistics Canada [5], mobility-related disabilities affect a significant portion of the older population in Canada, with around 16% of individuals aged 65 and over experiencing mobility impairments. Similarly, seeing-related disabilities impact approximately 7%, and hearing-related disabilities affect about 8%. The need for accessible and affordable transportation options for older adults is underscored by the myriad difficulties and barriers associated with mobility that often accompany aging [6]. These challenges span various aspects, including walking limitations, fears related to public transportation use, cognitive and sensory abilities, and financial constraints [7], [8]. As individuals age, their ability to move around safely and independently is impeded,

impacting their social lives and overall well-being [9], [10]. Thus, there is a need to provide accessible and affordable transportation options and support older adults in transportation planning and selecting the means of transport that best fit their needs and preferences [11]. Various transit planning tools around the world were developed to help people to get easily to their destination and provide information about various modes of transport [12]. While these transit tools serve adequately for general purposes, they do not cater to the diverse and specific needs of older adults. In response to the challenges faced by older adults, our living lab study, Mobilaînés project (*a User-Centric Solution Addressing the Unique Needs of Older Adults in Transportation Planning*) [13], is dedicated to developing an Age-Friendly Trip Planner web platform which incorporates different modes of transportation services, to help older adults move around where, when, and how they wish. We argue that enriching the concept of smart cities with a trip-planning tool that provide personalized maps in terms of textual and graphical presentation, and incorporating adapted paths, contributes to accommodating the physical, sensory and cognitive capacities of older adults, with specific attention to optimizing the user interface.

In the subsequent sections, we provide insights from a review of existing trip planner tools, outline the phases of the Mobilaînés project, present the initial prototype of the Age-Friendly Route Planner, and share results from two usability tests conducted with older adults.

II. RELATED WORK

Existing e-tools in the domain of transportation planning [12] often prioritize factors like the shortest or fastest route, neglecting the reality of people with special needs such as older adults. There is a misalignment between the functionalities of existing planning tools and the actual needs of older adults in trip planning. To analyze this gap, we conducted a scoping review of 42 e-tools, comparing them based on 10 functionalities that were chosen to reflect the unique requirements of older adults and aligning with their reality, ensuring a comprehensive evaluation [12]. These functionalities include:

- Time Autonomy: 6 tools addressed the option of choosing a departure date and time.
- Walkability: 13 tools provided the option of minimizing distance or walking.
- Crowd Avoidance: 6 tools offered information about road traffic or parking, and 1 tool estimated the crowd on the bus.
- Incline Avoidance: 2 tools considered inclines a barrier to avoid.
- Weather Consideration: 1 tool displayed information about temperature.
- Dark Avoidance: None of the tools addressed dark avoidance.
- Winter Obstacle Avoidance: 1 tool considered icy sidewalks a barrier to avoid.
- Amenities Inclusion: 6 tools had options to display relevant amenities near the address given, and 2 tools considered toilets and bench facilities.
- Taxi Driver's Information: None of the tools provided information about taxi drivers.
- Support Affordance: None of the tools offered support affordance.

In reviewing these tools, we found that most prioritize conventional factors like time and distance, often overlooking crucial elements such as walkability, crowd avoidance, and amenities inclusion, which are vital for older adults. This review highlighted both strengths and limitations in existing e-tools, emphasizing the crucial need for a more tailored and user-centric solution.

III. MOBILAÎNÉS

Mobilaînés represents a Mobility as a Service (MaaS) e-tool in a smart city, functioning as an integrated platform that consolidates diverse transportation modes and services to offer a comprehensive solution for the mobility needs of older adults. Rooted in a living lab co-design methodology [14], [15], [16], Mobilaînés initiative fosters collaboration among stakeholders from scientific, public, and private sectors, as well as older citizens. This collaborative effort aims to create, validate, and test innovative technologies, services, products, and systems in real-life scenarios, streamlining interactions with older adults [10], [11], [12]. Following are the key elements of the project phases.

A. Exploration: Defining Older Adults' Mobility Needs and Preferences

The first phase of the project focused on identifying and comprehending the specific mobility needs of older adults, utilizing a comprehensive approach that blends literature reviews and co-design workshops. This involves a multi-faceted strategy, encompassing the identification of mobility barriers and ways to overcome them in urban cities (the city of Sherbrooke, Quebec, Canada for our deployment). Along with our stakeholders, including seniors, we rigorously examine existing gaps in transportation services and outline the functionalities crucial for the development of Mobilaînés. The outcomes of this exploration phase play a pivotal role in unraveling the main profiles of potential users of Mobilainés, taking into consideration, among others, diverse levels of technological literacy. To delve deeper into the mobility experiences and preferences of older adults, the Mobilaînés team conducted immersive workshops and phone interviews with six participants in the project's region. These interactions systematically document mobility experiences, understand perceived barriers and facilitators, and capture the nuanced needs and preferences that will inform an ideal solution for our population. Following the two key categories of the resulted features:

1) Algorithmic Influencers:

Algorithmic Influencers are integral components within Mobilaînés' algorithm that actively shape the suggested

routes based on specific criteria. These features directly influence the planning and generation of routes, ensuring a personalized experience for older adults. The key Algorithmic Influencers include:

- Walking Speed Adaptation: Aligning with comfort, the algorithm sets a walking speed of 1 m/s based on literature findings [17].
- Distance Avoidance: Limiting walking distances to approximately 400 meters accommodates older adults' preferences and physical capabilities.
- Crowd / Traffic Avoidance: aims to recommend less congested routes, alleviating concerns about heavy traffic.
- Incline Avoidance: By incorporating Tobler's Hiking Function [18], the algorithm adjusts walking distances based on terrain incline, avoiding slopes exceeding 5% for inclusivity.

2) Informational Features:

Informational Features provide users with valuable details and considerations without directly altering the algorithm's route generation. These features empower users with information to enhance their overall trip planning experience. The key Informational Features include:

- Weather Consideration: While not directly influencing paths, weather information is sourced to aid users in planning trips around weather conditions.
- Dark Avoidance: Addressing the lack of accessible street lighting data to enhance safety and comfort.
- Winter Obstacle Avoidance: Recommending ice-free routes to enhance safety and comfort.
- Amenities Inclusion: Essential amenities along walking routes, including toilets, benches, and bus shelters are needed for convenience and accessibility.
- Time Autonomy: Granting users, the flexibility to travel at their preferred times. Therefore, allow users to set a departure or arrival time whenever they want.
- Support Affordance: Catering to the need for support during journeys, including assistance with bags and vehicle entry and exit.
- Taxi Driver's Information: Offering details about taxi drivers to instill reassurance and comfort.

B. Experimentation: Co-creating the One-Stop Platform Prototype

Creating a specialized trip planner catering to the unique needs and preferences of older adults (based on the results of our Exploration phase) involves three essential layers: the Data Layer, the User Interface Layer, and the Mobilaînés Engine Layer. As shown in Figure 1.

1) Data Layer

The Data Layer encompasses the collection of information from various sources to address the specific requirements of older adults (mainly from open data of smart cities). In Mobilaînés we use a) OpenStreetMap [19]data for geographical data, to collect street data, city data about public toilets, benches, etc., b) GTFS [20] data for transit, including trip updates, service alerts and vehicle positions, supplied by the transit company of the city of Sherbrooke. c) Geotiff [21] for elevation data. d) OpenWeather [22] for weather condition data. These sources contribute to the creation of a comprehensive routing engine that considers safety, accessibility, and individual preferences.

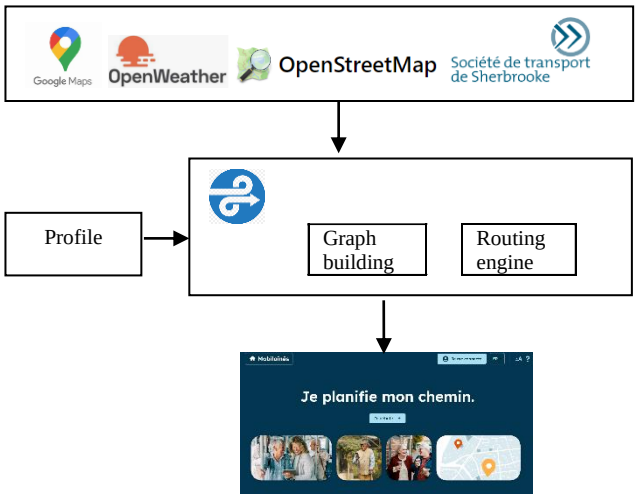

Figure 1. Mobilaînés architecture

2) User Interface Layer

Recognizing the challenges older adults face with technology, the design of the User Interface Layer focuses on various design principles. Firstly, four pioneering general usage guidelines have been selected, including Nielsen [23], Shneiderman [24], Gerhardt-Powals [25], and Weinschenk et Barker [26]. These guidelines were considered the basis for identifying existing evidence regarding age-friendly design principles and guidelines. Then via a rapid review method,10 design principles were identified. Each of these principles includes diverse age-related usability design guidelines.

- Minimizing Memory Load: Aims to reduce repetitive actions and provide recognition support by reducing options and avoiding multitasking operations.
- Visual Clarity: Focuses on improving readability by considering font characteristics, color contrast, simple background, and accompanying text and images.
- Structure and Navigability: this principle includes guidelines for presenting information hierarchically, using different types of menus, and providing visual and textual assistance.
- Ease of Use: Encompasses the smooth insertion of information and seamless navigation other pages.
- Accessibility: Involves adapting to the needs and preferences of different user profiles, as well as guidelines for affordability and planning for future trips.
- Feedback: Ensures that users receive confirmation of successful actions.

- Control: Includes guidelines for adjusting the size of elements and controlling requests by undoing, redoing, and exiting.
- Simplicity: Involves designing layouts, using easy-to-understand graphics and terminology.
- Consistency: Entails the use of familiar icons, colors, and menu hierarchy.
- Information: Provides comprehensive travel-related information, including real-time updates on travel and traffic conditions.

3) Mobilaînés Engine Layer

The Engine Layer is a server application comprising two key components: Profiling and Planification Engine.

a) Profiling

Recognizing the diversity in mobility needs and preferences among older adults, a profiling component is integrated into the Mobilaînés trip planner. This captures information on user characteristics, physical capacities, mobility behavior, saved paths and favorite addresses. The goal is to provide personalized and adapted trip suggestions while learning from user behavior to enhance future versions.

b) Planing engine

In the purpose of developing a specialized trip planner tailored to the needs of older adults, OpenTripPlanner (OTP) [27] emerges as the preferred routing engine due to its citizen-centric focus and unique features. We adopted OTP for its complete open-source architecture allows for extensive customization, ensuring adaptability to the specific requirements and preferences of older adult users. Furthermore, the possibility to adapt and use of advanced routing algorithms, such as A-star and Range Raptor, enables the generation of multi-criteria route plans, precisely catering to the distinctive needs of older adults. With a strong community, comprehensive documentation, and proven scalability and performance, OTP stands out as a reliable, customizable, and inclusive solution, enabling building a more personalized and efficient trip planning experience for older adults.

C. Evaluation: Usability Tests with Older Adults

The concluding phase encompasses usability assessments involving older adults exhibiting a different level of physical conditions, along with a variety of mobility preferences. During this phase, participants actively interacted with the Mobilaînés platform, enabling a comprehensive assessment of its accessibility, functionality, and overall user experience. The findings derived from these usability tests play a pivotal role in the refinement and optimization of the platform. This iterative process ensures that Mobilaînés is continually tailored to effectively meet the unique needs of future users. Further details regarding the outcomes of these usability tests and subsequent refinements are presented in the next section.

IV. USABILITY TESTS INSIGHTS

The usability test of the Mobilaînés platform has a pivotal role in enhancing user experience and meeting the unique requirements of older adults. The usability tests were meticulously designed to comprehensively evaluate the users' experience via a combination of quantitative and qualitative methods. Two laboratory usability tests were conducted with a different group of participants (Test 1 (August 2023) and Test 2 (February 2024)) with different levels of digital competence (frequency of use), mobility profile (travel frequency), travel planning profile (travel planning habits). This deliberate inclusion aimed to provide a holistic understanding of the platform's performance across a wider range of older adults' profiles. The objective performance of participants was tested using performance metrics to assess the ***efficiency***, ***effectiveness***, and ***error tolerance*** through three following key tasks: planning a one-way trip from their home to a grocery store (Task 1), creating and personalizing a profile (Tasks 2.1 and 2.2), and planning a two-way trip from their home to a hospital with the option to save or print the itinerary (Tasks 3.1, 3.2, and 3.3). The first session included 7 older adults, the second 5.

The error rate was to be used to evaluate the Error-tolerant usability criteria. We identified four types of errors in our testing: Navigation errors, Selection errors, Insertion errors, and errors in understanding the scenario. In Test 1, we had a total of 46 errors, while in Test 2, the number of errors was reduced to 22. The number of completed tasks will evaluate effectiveness, which refers to the success rate in task completion in the way that the user expects. In Test 2, we achieved a better level of effectiveness, with only one uncompleted sub-task compared to Test 1, which had 10 uncompleted sub-tasks. Task duration will be used to measure efficiency, which refers to the quickness and productivity of the user in task completion in the manner of time. The average task duration in Task 1 and Task 2 of Test 1 was 4 minutes and 24 seconds and 10 minutes and 52 seconds, respectively. These results were more satisfactory than those of Test 2.

TABLE I. USABILITY TESTS 1 PERFORMANCE METRICS

	Test 1		
	Errors	***Completion***	***time***
Task1	Navigation error = 2 Selection error = 3	Completed without help: 4 Completed with help: 3	Mean 04:34
Task2.1	Navigation error = 3 Selection error = 1 Error in understanding the scenario = 1 Insertion error = 2	Completed without help: 5 Completed with help: 1 Not completed: 1	Mean 7:59

Task2.2	Navigation error = 3 Selection error = 4 Error in understanding the scenario = 4	Completed with help: 4 Not completed: 3	
Task3.1	Navigation error = 9 Selection error = 5 Error in understanding the scenario = 1	Completed without help: 2 Completed with help: 3 Not completed: 2	Mean 10:52
Task3.2	Navigation error = 2 Selection error = 4 Error in understanding the scenario = 1	Completed without help: 3 Completed with help: 3 Not completed: 1	
Task3.3	Error in understanding the scenario = 1	Completed without help: 5 Completed with help: 1 Not completed: 1	

This iterative approach was informed by insights gained from refining the Mobilaînés platform following Test 1. Test 2 involved five older adults, reflecting diverse needs, preferences, and transportation choices, aiming to assess the impact of refinements on the second version of the prototype. Lessons learned from Test 1 focused on addressing "Very Important" errors and critical aspects, including: the home screen menu as a safe point of return for users, addressing navigation challenges such as clicking on the next button to navigate to the next step, improving auto data-entry in selecting an address, and enhancing user guidance by improving the accessibility in selecting time and optimizing spacing.

TABLE II. USABILITY TESTS 2 PERFORMANCE METRICS

Type size (pts.)	**Test 2**		
	Errors	***Completion***	***time***
Task1	Navigation error = 3 Selection error = 1 Insertion error =2	Completed without help: 2 Completed with help: 2 Not completed: 1	Mean: 06:43
Task2.1	Navigation error = 1 Selection error = 1	Completed without help: 3 Completed with help: 1	Mean: 6:52
Task2.2	Navigation error = 3	Completed without help: 3 Completed with help:2	
Task3.1	Navigation error = 2 Error in understanding the scenario = 4	Completed without help: 1 Completed with help: 4	Mean: 12:09
Task3.2	Navigation error = 1 Selection error = 2 Error in understanding the scenario = 1	Completed without help: 3 Completed with help: 2	
Task3.3	Error in understanding the scenario = 1	Completed without help: 4 Completed with help: 1	

These insights and refinements collectively contribute to the co-development of Mobilaînés platform, that is tailored to the diverse needs of older adults, ensuring they have an intuitive and personalized trip-planning experience.

V. CONCLUSION

We presented in this paper Mobilaînés, a user-centered trip-planning tool targeting enhancing the mobility and independence of older adults, contributing to the creation of more age-friendly urban environments. Mobilaînés encompass a completed running usable software solution (successful prototype), as a result of an iterative usability tests. Mobilaînés path results are based on smart cities' open data (the transit company and the city of Sherbrooke in our case). Looking ahead, future exploration will delve into user appreciation of the proposed routes and the practical application of Mobilaînés in real-world scenarios. Understanding the extent to which users find value in the suggested paths and observing its effectiveness in actual usage contexts remains a crucial avenue for investigation. Additionally, we plan to provide a user-friendly tutorial to support older adults with limited digital literacy and to conduct real-world testing to evaluate the platform. Furthermore, the data collected by Mobilaînés holds potential for future applications in urban planning and accessibility assessment. Moreover, as part of ongoing efforts, we envision enriching the Mobilaînés with wearable IoT technologies to acquire real-time data about the user situation [28], and provide context-aware

personalized recommendations [29], and adaptive features, further enhancing the responses to older adults' needs. This ongoing work aligns with technological advancements enable Mobilaînés to be adaptive to emerging needs and contributes to a more connected and supportive transportation experience for older adults in smart cities.

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