Prototype of a Mobile Public Transport Travel Assistant

Arne Nys

universiteit hasselt

October 2015
July 2016

Prototype of a Mobile Public Transport Travel Assistant

Master Thesis

School for Transportation Sciences
Master in Transportation Sciences

Arne Nys

Promoter:
Prof. Dr. Ir. Tom Bellemans

Co-promoter:
Dr. An Neven

Supervisor:
Dr. Yves Vanrompay

Master Thesis submitted to receive the degree of Master of Transportation Sciences, specialisation Mobility Management

universiteit hasselt

Preface

As a transportation scientist, you are neither a software developer, nor a user experience designer or a wayfinding specialist. In fact, as a transportation scientist, I find myself being a bit of everything but little of something. This gives me the liberty to get involved in a project that feels very personal to me and indulge in fields of research that are very interesting despite my limited experience.

I have long been fascinated with the ways in which travellers access information. At the same time, I know that my smartphone has transformed the way in which I live and travel. Mobile real-time information has led me to plan much less in advance before starting on a trip, and often I only start planning when I am already underway.

Mobile information enables people to live ‘spatially spontaneous’ lives, even when they depend on scheduled public transport services Still, it may be that current mobile applications are not delivering the best information possible. Especially in the case of delays or disruptions, travel apps fail to redirect the traveller as smoothly as possible, while these are the exact moments when stressed passengers could use a helping hand. Furthermore, in order to induce regular car users to try public transit, we need to make public transport as accessible, understandable and trustworthy as possible, so that even inexperienced people can use it without issues. Therefore, we need an application that guides travellers door-to-door, knowing their current location and activity, providing the right information at the right time, and assisting them when things go wrong.

Creating this work has been a very exciting endeavour, and it has helped me to get an internship that will definitely be thrilling as well. I have often doubted if this thesis would fit expectations for a Master student in Transportation Sciences, but the positive feedback from everyone during the process has definitely helped to overcome that uncertainty and to give it my best.

I am extremely grateful for the opportunity I got to develop a travel assistant concept for my Master Thesis. I thank my promoter, co-promoter and supervisor for the time they took to figure out how to launch this project and to give feedback on my progress. I am also thankful to everyone who helped me during the development of my thesis: my mother, who had much more valuable feedback than I could have imagined; my father, who did not have any valuable feedback because he hates smartphones, but who was supportive anyway; all the other test users in my individual interviews: Okky, Karlien, Evelien, Adel, Michaël, Mathijs, and Kimberly; all my focus group participants who were supportive yet critical; all the respondents that took the time to give feedback via the survey and who were so encouraging; Pascal and Nick who were so kind to give their professional view on my work; Laura who did a great job proofreading the whole thing; and probably a lot more people that I forgot to mention.

Arne

Abstract

Good travel information is essential in public transport. The last decade has seen a revolution in the way we bring mobile real-time information to travellers. Nevertheless, there is of yet no real equivalent for the car's GPS system for public transport users. We envision a context-aware, door-to-door travel assistant that would guide the user during their complete journey and provide instant alternative suggestions in case of delays or other disruptions. Up to now, only a few commercial examples of this concept exist, and they are not complete.

In this thesis, a prototype of a mobile travel assistant for public transport is developed and evaluated in an iterative cycle. The concept is based on scientific literature concerning traveller information needs, context-awareness and early travel assistant research, together with a best-practise evaluation. The first prototype is developed and evaluated through the means of eight individual test user interviews and two focus group sessions with nine participants in total. The System Usability Scale (SUS) is used to quantitatively assess the participant's satisfaction with the prototype.

Afterwards, actions for improvement are listed and a second prototype is created that differs significantly from the first version. This time, an evaluation with 134 test users is performed through an online survey. The results are positive, with an average SUS score of 80,1 out of 100 and 77 out of 134 respondents who indicate they are very satisfied with the application in general. Additional improvement actions are taken to finalise the prototype.

The research shows that the proof-of-concept has a high usability and that test users are mostly satisfied. Some limitations should be taken into account for the prototypes' evaluations, concerning the type of test users and possible non-response error for the survey, among other things. Practical implications are listed for the technical aspects of such an application and its further development, and ideas for future research and development are mentioned to expand the concept further.

Content

List of figures

1 Introduction

Information is key. In public transportation, information is essential to get from point A to point B. Without information, you would not know when or where to take a bus, let alone which bus you need to take at all. Because of the scheduled nature of public transportation, transit companies need to provide the best information possible to travellers. Although huge improvements have been made in the last decades with real-time passenger information systems, travellers can still be frustrated with the lack or bad reliability of information (Caulfield & O'Mahony, 2007).

What are the consequences of frustration information for travellers? Nyblom (2014) states that "travellers use information to cope with uncertainty and variability in the performance of the transport system." Trust, or the lack thereof, is a primary issue for passenger information (Beul-Leusmann, Jakobs, & Ziefle, 2013). This can have very negative effects on passenger satisfaction: Chorus, Arentze, & Timmermans (2007) recognised that "[i]nformation unreliability appears to have a double negative effect on choice quality: it induces lower levels of information search, and information that is acquired has a lower potential to reduce uncertainty and increase choice-quality." Eventually, these frustrations can have a negative impact on public transport use, which is detrimental for the development of sustainable mobility patterns.

As multimodal urban transport networks become more complex, it becomes close to impossible for travellers to gain complete knowledge of all factors relevant to their trips. Already in the beginning of this century, G. D. Lyons (2001) acknowledged the need for integrated multimodal traveller information services. Better information can give car drivers the necessary stimulus to try public transport (Kramers, 2014), while it can also reduce travel time by providing the fastest travel alternatives and by letting travellers minimise their waiting times using real-time information (Grotenhuis, Wiegmans, & Rietveld, 2007). Although it is not expected that multimodal traveller information will bring enormous shifts to public transport, it can definitely help to improve passenger satisfaction and comfort (Beul-Leusmann et al., 2013; G. Lyons, 2006).

With the dawn of mobile communications, lots of new possibilities have sprung up to provide real-time multimodal travel information. Smartphones have become one of the main ways to do this, and they have led Dal Fiore, Mokhtarian, Salomon, & Singer (2014) to believe that "mobile users may adopt a spatial behaviour that is less planned in advance and more emergent from contingencies (by means of just-in- time decision making)." This leads to a self-sustaining cycle: the more people will use smartphones, the less they will plan their journeys in advance, and the more people will live 'spatially spontaneous' lives, the more they will rely on their smartphones to get around.

Currently, there are lots of mobile applications that provide detailed travel information for specific services (e.g. DB Navigator[1], NS Reisplanner[2], De Lijn[3]), as well as multi- and even intermodal travel advice in regions all over the world (e.g. Google Maps[4], Citymapper[5], TripGo[6], Ally[7]). Nevertheless, most of these applications only provide detailed 'action plans' that explain every step in the journey in combination with real-time information. In order to provide the user with the best door-to-door guidance, efforts should be made to develop travel assistants that are aware of the user's activity and context. This has also been recognised by the European Commission, which states that "regarding *seamless multimodal travel*, research and innovation activities should aim at conceiving and prototyping an on-line, mobile, suite of integrated facilities providing a whole new traveller experience throughout the journey […], [including] en-route assistance including re-accommodation." (European Commission, 2014)

2 Towards an integral travel assistance

The idea of a door-to-door context-aware travel assistant is not only to guide a traveller during the whole journey, but also to provide instant alternatives in case of delays or disruptions. This would not only be helpful for people that are inexperienced with public transportation, but also for regular travellers and commuters that need to get the fastest alternative on their normal journey. In essence, such an assistant is to public transport users what the GPS has been to car drivers for years now.

The first basic concepts of public transport assistants emerged in the beginning of the 2000s. They envisioned mobile systems to assist the user while finding routes, buying tickets and travelling (Goto & Kambayashi, 2002; Hannikainen, Laitinen, Hamalainen, Kaisto, & Leskinen, 2001). Nevertheless, they remained concepts until mobile phones became mature enough to carry such applications. New attempts were made by Biagioni, Agresta, Gerlich, & Eriksson (2009), Garcia, Candela, Ginory, Quesada-Arencibia, & Alayon (2012) and Vieira et al. (2012), but their concepts remained rather limited or were more focused on the technical details than the overall application. An interesting research project has been the travel assistant by Beul-Leusmann et al. (2014), also described by Wirtz, Jakobs, & Beul (2010) and Samsel et al. (2014). This thesis partially builds on the results of their research, which will be covered in detail in later sections.

The first steps towards an integral travel assistance in commercial applications are currently being made. For example, the Flemish bus company De Lijn released their Halteaankondiging ('Stop Announcement') application in 2014 and recently incorporated the functionality in their main route

[1] http://www.bahn.de/p/view/buchung/mobil/db-navigator.shtml
[2] http://www.ns.nl/reisplanner-v2/index.shtml
[3] http://www.delijn.be/nl/routeplanner/
[4] http://maps.google.com
[5] http://citymapper.com
[6] http://us.tripgo.skedgo.com
[7] http://www.allyapp.com

planner app. Qixxit[8], an intermodal route planner by the Deutsche Bahn, has a guidance feature that tells the user when to leave, how long they still have to wait for the vehicle and how much time they have before arrival. Citymapper, a multimodal travel app with support for cities all over the world, introduced an assistance feature that guides the user during his journey. Nevertheless, improvements can still be made: a brief evaluation can be found in section 6.1.

In this thesis, scientific literature will be used to develop a travel assistant prototype that will be improved in iterations based on feedback by test users.

3 Research plan

In this section, the research plan will be explained by describing the research goals and questions, assumptions and limitations, and the general research strategy.

3.1 Research goals

The goal of a public transport travel assistant is twofold:

1. To assist the user with every step in their journey: getting through the door, going to the station, taking the right vehicle, getting off at the right location, changing to the right vehicle if needed and finally arriving at the final destination.
2. To provide real-time information about the public transportation system, but more importantly, to notify the user when needed and to give alternatives in case of disruptions of the initial plan.

For this thesis, the goal is not to actually make a working travel assistant, as this would require major programming skills, but mainly to conceptualise how such an application should function and what it could look like. Therefore, the main goal of this research is as follows:

"To create a prototype of a mobile public transport travel assistant, and to improve it with the means of evaluations by test users"

3.2 Research questions

In order to carry out a successful conceptualisation of the prototype, a number of research questions must be answered:

1. What kind of functionalities does a mobile travel assistant need?
2. How do these functionalities rely on applications of context-awareness?
3. How can these functionalities be conceptualised in a user-friendly and intuitive way?
4. How do people evaluate the usability of such a concept?
5. Based on these evaluations and on users' needs, how can the concept be improved?

[8] http://www.qixxit.de

3.3 Assumptions, limitations and boundaries

The development of mobile applications can run into a variety of (technical) uncertainties. To avoid any of these uncertainties, some clear assumptions are made:

1. The necessary data for the application (schedules, real-time information, public transit facility information, …) is openly available and accessible.
2. Real-time information is functional and reliable, without failures or interruptions and with high accuracy.
3. The focus in this application will be in assisting the user with a specific travel alternative, not with providing travel alternatives in the first place.

The essence of this application is to assist the user with a certain travel alternative. Finding and choosing an alternative is a first and very important step in the travel planning process, but the research and evaluation will be focused on the travel assistance once an alternative has been chosen. Finding and providing travel alternatives has already received a great deal of attention in previous research and has been implemented in commercial applications with success, and will thus not be elaborated on in this thesis.

The scope of this travel assistant will be limited to public transportation, including walking directions. In the future, the concept could be easily expanded to other modes like biking, car-driving and sharing services.

3.4 Research strategy

To answer the first three research questions, a study of scientific literature will cover the necessary functionalities of a travel assistant, the relevant applications of context-awareness and the conceptualisation of the application. For the remaining two research questions, the literature study will give an insight into what usability comprises and how it can be evaluated by test users.

The application prototype will first be designed using pen and paper and an application called POP[9] that transforms these drawings into a working prototype. The 'real' mock-ups that will be evaluated by the test persons will be made with Proto.io[10], a tool dedicated to making application prototypes that look and feel like real applications.

The evaluation of the prototype will take place as an iterative process in which improvements are made based on test user feedback. The first test iteration will be done via individual interviews and small focus groups, after which the prototype will be improved based on their remarks. The second iteration will be evaluated through the means of an online survey on a wider scale. Then, a third and final version of the prototype can be made. This type of evaluation process was also used by Beul-Leusmann et al. (2014) and has its foundations in the theories of Nielsen & Landauer (1993). More details on the usability testing and focus groups are provided in section 7.

[9] http://popapp.in

[10] http://proto.io

4 Functionalities

The aim of this section is to identify all relevant functionalities the travel assistant needs, and to integrate these functionalities in a workflow that forms the basis for the development of the application.

Using public transportation is far from a fixed activity. As the user passes through a series of highly dynamical and fast-evolving environments, it is logical to assume that an accompanying application needs to adapt quickly and intuitively to these different situations. As stated by Baus, Kray, Krüger, & Wahlster (2001), "[s]ince several different means of transportation typically have to be combined in order to reach a destination, it must be ensured that the user interface reacts to the user's changing situation." This is not only because of the number of travel stages a passenger goes through, but also because of uncertainties inherent to the journey (possible delays, reroutings, cancellations, …).

In order to define the required functionalities, it is important to derive which information a passenger needs at which moment. Travelling by public transport can be divided into three main phases: pre-trip, on-trip and post-trip (Kramers, 2014). For the purpose of the assistant, the focus lies with the on-trip phase, as it guides the user while they are underway. The pre-trip phase includes finding a travel alternative, while the post-trip phase covers the user's satisfaction with the guidance and starting a new or return trip.

The on-trip phase can itself be divided into two subphases: at-stop/wayside and on-board (Caulfield & O'Mahony, 2007; Grotenhuis et al., 2007). These phases have different information requirements: for instance, in the at-stop phase, the user wants to know the line number and direction of the vehicle and when it will arrive; while during the on-board phase, it is important to know at which stop they need to exit and how much time is left. Nevertheless, not all of the required information fits within these two phases. Before the at-stop phase, the user needs to know where the stop is located and how they can get there in time. After the on-board phase, the user needs directions to their destination. Therefore, the at-stop and on-board subphases are preceded and followed by walking directions.

Not only are different types of information needed at different stages of the travel process, but different persons may also require different types of information. Keller, Korzetz, Kühn, & Schlegel (2011) divided public transport users into 5 categories: Power User, Commuter, Occasional User, Tourist, and Ad-hoc User. In general, more experienced users like the Power User and Commuter need less information about which vehicle to take and where, but pay high attention to reliable and real-time information about the position of these vehicles and the impact on their journey. Less experienced users (Occasional User, Tourist, Ad-hoc User) also value this information, but first and foremost want to know how they can get somewhere and which steps they need to undertake to achieve this. Designing a travel assistant that suits the needs of all these different types of users is a challenge, while keeping the application simple and easy to use.

Grotenhuis et al. (2007) researched the different types of Integrated Multimodal Travel Information (IMTI) users need in specific stages of travel using stated-preference web surveys (Figure 1 and Figure 2). They found that, during the at-stop phase, travellers mainly want to know how they could get to the right vehicle (signage, platform information) and when their vehicle would be there (scheduled and real-time arrival and departure times). Additionally, information to avoid disruptions was highly appreciated (delay and disruption information and route advice to avoid delays). In the on-board phase, real-time delay and disruption information remained important, not only for the current vehicle, but also for the connecting vehicles in the rest of the journey. Therefore, one of the key aspects of the travel assistant should be real-time provision of travel alternatives in case of delays or disruptions. This was also acknowledged in the research by Wirtz et al. (2010) for the development of their travel assistant.

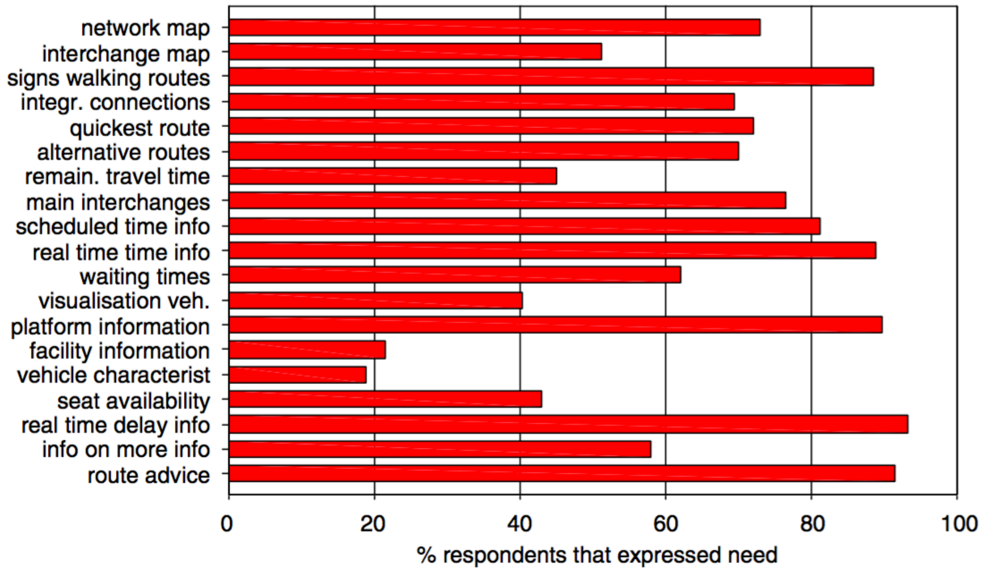


Figure 1. Most desired wayside IMTI types (Grotenhuis et al., 2007)

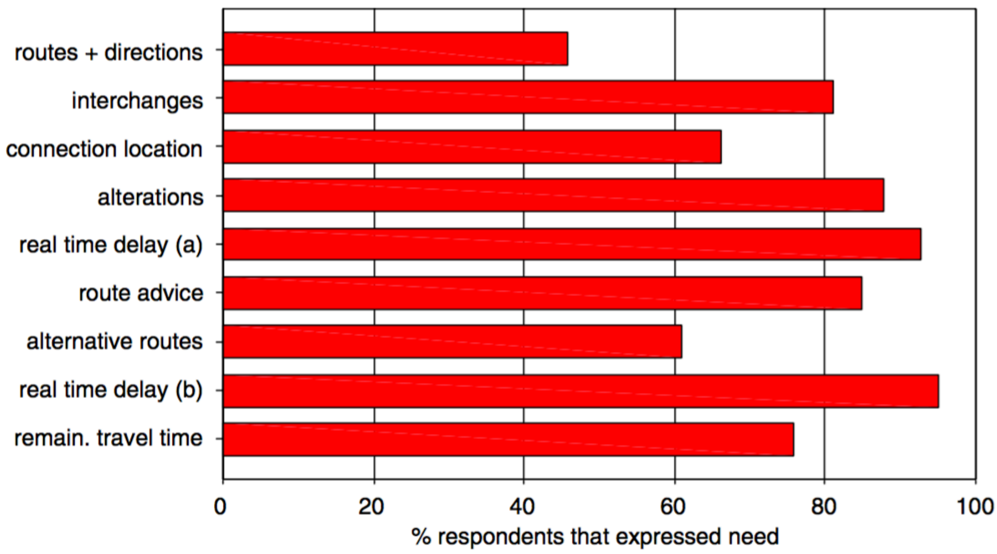


Figure 2. Most desired on-board IMTI types (Grotenhuis et al., 2007)

With this in mind, a flowchart (Figure 3) is composed that starts with the user having chosen a travel alternative, and ends with him arriving at his destination.

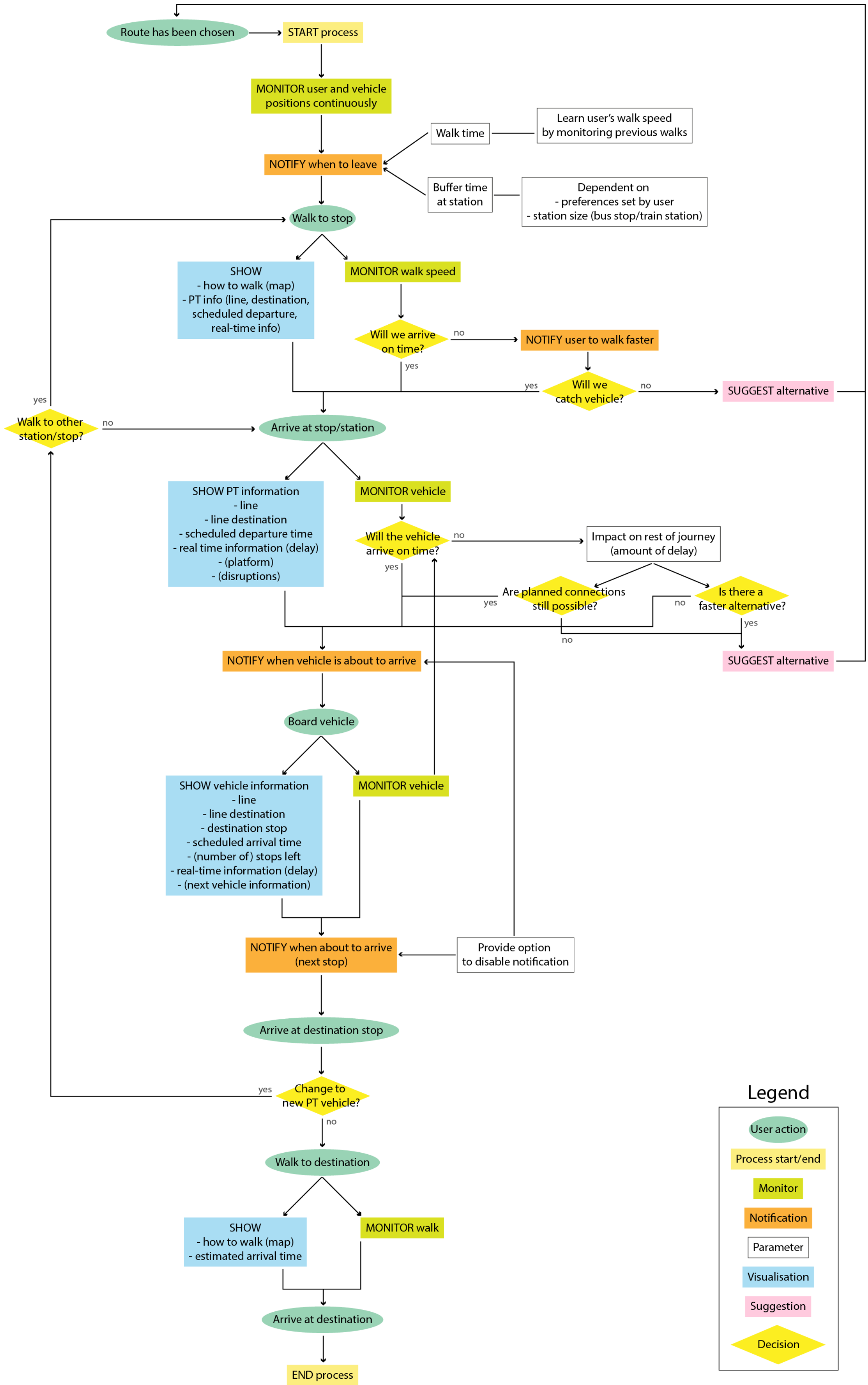


Figure 3. Assistant functionalities flowchart

In order to instantly provide the user with alternatives in case of delays or disruptions, the application needs to monitor the user's position, as well as the real-time positions of the vehicles involved in the journey. Continuously updating this information is fundamental, as traffic situations can change very quickly. For example, your connecting train may still be on time when you have just boarded your first train, but once you are well underway it may be delayed by 20 minutes, in which case it might be better to stay on board and take another train at another station. In case the user chooses a second alternative, the application would still monitor the vehicles of the first alternative in order to signal when everything returns to normal, enabling the user to still catch their connection.

As described in the flowchart, the application has four main phases, defined earlier in this section: walking to the stop, at-stop, on-board and walking to the destination. Each phase has different information needs, listed in the flowchart in the blue 'SHOW' boxes. In the first walking phase, the user needs to know how to reach the stop and which vehicle they will take once there. Therefore, it is important to know when the vehicle will arrive and if the traveller can still catch it. If it appears that the vehicle is running earlier than expected, or if the user is walking slower than expected, a notification will be given that the vehicle might not be caught, thus urging the user to walk faster. If this first step fails, alternatives will be provided. The application can also integrate the traveller's walking speed and adapt further travel suggestions: thus, in the case of a slow walker, walking times will be provisionally increased.

At the stop (or station), the user needs to know at which platform to wait for their vehicle and when it will depart, together with the basic characteristics of line identification and destination. While on-board, the most important information is when to get off, and the next vehicle information in case the user needs to change. During the at-stop and on-board phases, the application keeps checking if the current and next vehicles are on time, and provides alternatives in case the current journey cannot be performed. The user would also be able to let the application notify them when their vehicle is about to reach the destination and they need to exit.

The final part of the journey consists of walking to the destination. As there are no more vehicles to monitor, this process can be stopped, and the only relevant information the user needs are walking directions and estimated time of arrival.

In the next part, it will be explained how these functionalities rely on applications of context-awareness. Subsequently, the flowchart will be translated into a first concept of what the application needs to look like, and a method to evaluate this concept will be developed.

5 Context-awareness

As stated earlier, the travel assistant is used in different stages of the journey and therefore needs to adapt swiftly to changing circumstances. In Human-Computer Interaction (HCI), context-awareness has been a field of research that gained a lot of attention in the last two decades. With the surge of mobile internet and smartphones, context-aware applications have become ubiquitous, and the amount of possibilities for these applications has increased exponentially.

Dey, Abowd, & Salber (2001) define context awareness as "any information that can be used to characterize the situation of entities (*i.e.* whether a person, place or object) that are considered relevant to the interaction between a user and an application, including the user and the application themselves. Context is typically the location, identity and state of people, groups and computational and physical objects." In this case, a 'person' is the respective user of the travel assistant, a 'place' can be an origin, destination, bus stop, train station or any other geographical place that is relevant for the journey, and 'objects' are the respective vehicles the user will take.

As stated by Baldauf, Dustdar, & Rosenberg (2007), "[c]ontext-aware systems are able to adapt their operations to the current context without explicit user intervention and thus aim at increasing usability and effectiveness by taking environmental context into account." The different characteristics of the context thus define what the application shows and when. Dey et al. (2001) defined different types of context (application examples between brackets):

- Identity (of the user)
- Location (of the user, of the places they are going to, of the vehicles)
- Status/activity (user: walking, on-board, waiting, …; vehicle: arriving, in the station, delayed, …)
- Time (general time, scheduled vehicle times, estimated vehicle times)

Consequently, context-aware applications can have different functions (Dey et al. 2001):

- Presenting information and services (information about vehicles, walking directions, …)
- Automatically executing a service (checking real-time information, changing visuals when the user arrives at a station, …)
- Attaching context information for later retrieval (monitoring walk speed and using this as a standard, …)

5.1 In practice: how to gather context?

In essence, there are two main context areas the application should reckon with: the vehicle context which describes where which vehicles are at any given time, and the user context, that covers the current location and activity of the user. For each area, the general methods to gather this information will be explained.

5.1.1 Vehicle context

Real-time positions of public transport vehicles have been used in Real Time Passenger Information (RTPI) for over two decades now, and their use has proven positive for traveller satisfaction (Brakewood, Barbeau, & Watkins, 2014; Politis, Papaioannou, Basbas, & Dimitriadis, 2010), and having an impact on path choice (Hickman & Wilson, 1995), ridership (Brakewood, Macfarlane, & Watkins, 2015; Tang & Thakuriah, 2012) and passenger travel time (Dziekan & Kottenhoff, 2007; Watkins, Ferris, Borning, Rutherford, & Layton, 2011).

The most common way of determining the location of a certain vehicle is GPS, which has a good reliability and reasonable precision. Some systems (mostly rail-based) opt to use trackside positioning systems with beacons. This can be more precise, especially if the beacon density is high. Both technologies can complement each other to give increased precision, which is sometimes done for bus networks. The information is shared with a central database via dedicated trackside or mobile communication systems. Subsequently, the positions are used to estimate the time left to the next stop and to check if the vehicle is on time. For this application, it is assumed that real-time data about vehicles is always accessible, reliable and precise.

5.1.2 User context

In an age of constant improvement in mobile telecommunication, finding a user's location has never been easier. Smartphones generally have a built-in GPS antenna, and the GPS positioning information is complemented by mobile network antennas and Wi-Fi stations. In order for the travel assistant to work properly, the user's position needs to be monitored continuously. This might have an impact on the battery level of the device. De Pessemier, Dooms, & Martens (2014) found that using periodic GPS data every 30 seconds instead of continuously, battery life increases with over 50%. This is however not sufficient to provide walking directions because it would give low precision. That said, smartphone manufacturers and software developers are constantly striving to obtain more efficient energy use, and meanwhile the application should be optimised to use as little energy as possible.

Deriving the activity of the user (walking, waiting, on-board) is a less straightforward process, but this aspect has recently attracted notable attention from the research community. Not only is it possible to sense what the user is currently doing (walking, standing, sitting in a vehicle), but this activity can also be matched to a particular vehicle and trajectory (Biagioni et al., 2009). As stated by Samsel et al. (2014), "[b]y using the context data, […] the application is enabled to ascertain whether a user has entered the vehicle she was headed for on her itinerary."

Until now, two main technologies have been used to ascertain the activity of the travelling user: GPS and the accelerometer. With GPS, the activity of the user is derived from their location and the relationship to his journey, like the locations of stops and real-time position of vehicles. Researchers who used this method obtain accuracies of 71% (Zheng, Chen, Li, Xie, & Ma, 2010) to 93.5% (Stenneth, Wolfson, Yu, & Xu, 2011).

The accelerometer method uses a sensor placed in most smartphones that senses the acceleration of the device in all three spatial axes. These patterns are compared with known patterns for each travel mode, and an assumption is made on the respective similarity. The accuracy of this method has been proven to range from 80% (Hemminki, Nurmi, & Tarkoma, 2013) (Figure 4), over 88% (Zhang & Poslad, 2013) to 93% (Nham, Siangliulue, & Yeung, 2008).

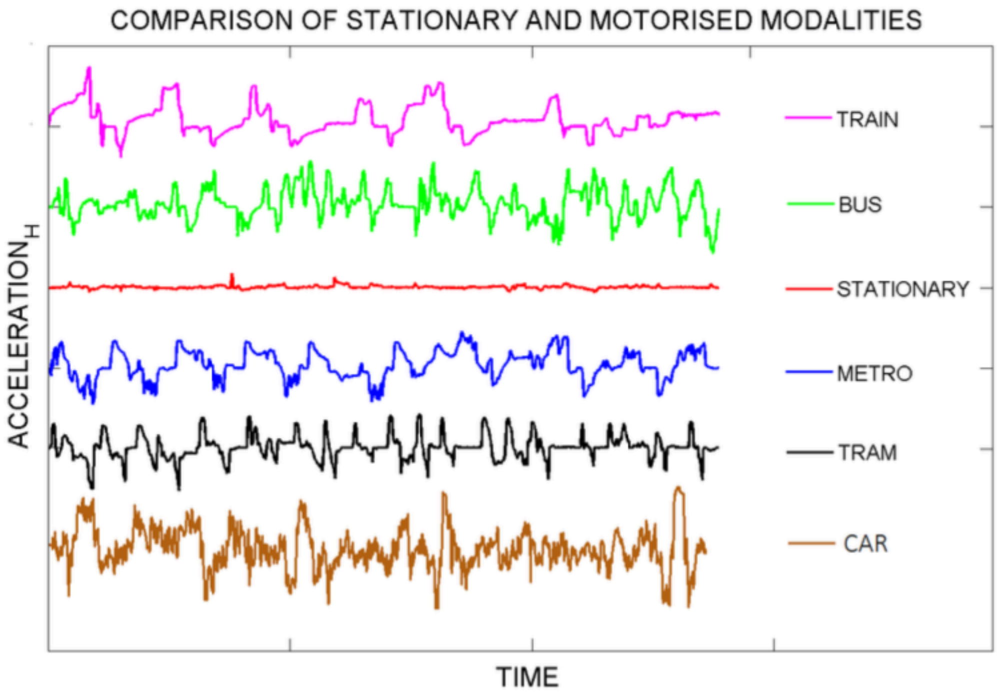


Figure 4. Comparison of horizontal acceleration profiles for different motorised transportation modes (Hemminki et al., 2013)

Combining both technologies has been proven to provide the best results, with accuracies ranging from 91.7% (Feng & Timmermans, 2013) over 93.6% (Reddy et al., 2010) to 96.31% (Xia, Qiao, Jian, & Chang, 2014). Further research and technology improvements are likely to give even better results. For example, Hemminki et al. (2013) mentioned that for “applications which require quick detection of correct transportation modality, the latency can be significantly reduced by fusing in measurements from additional sensors, e.g., changes in GSM or Wi-Fi signal environment, GPS speed or changes in magnetic field.”

As the travel assistant already knows what travel modes will be used during the journey, sensing the user’s activity is less an issue of ‘guess the vehicle’, but rather of confirming that the user has transitioned to the correct following stage, using GPS as the main source of position information and accelerometer as an assisting source of activity information.

In the next section, the literature that explores how to visualise travel information will be covered, in particular for guiding the user during his journey.

6 Conceptualisation

Designing an application is never an easy task, especially when you want to give a lot of information on a limited screen area. In transportation, mobile applications need to convey relevant information in a very clear way, so that travellers immediately get a sense of what they should do. Samsel et al. (2014) stated that "most current mobile applications for public transport are flawed in terms of usability under cognitive stress. Current applications […] shine with a fancy Graphical User Interface (GUI), many configuration options and a high amount of information. Such applications perform well in situations where the traveller can direct all of her cognitive capacity to the application, but fall back in terms of usability in stressful situations."

Therefore, the highly dynamic and sometimes stressful situations of public transportation require an easy-to-use application that provides the right information at the right time, without any interaction. According to Walsh (2012), travellers on the move seek types of information that "are often factual, small elements of information. […] There is likely to be limited evaluation of the information they find, and little opportunity to take detailed information away and derive new knowledge from it. Detailed information is to be avoided as it is hard to read on the small screens, or too time consuming to look at in this context."

Wirtz et al. (2010) investigated the communicative abilities of passenger information applications and which characteristics were important for the development of such an application. One of their findings was that "[u]nexpected patterns irritate users and cause interaction difficulties, whether they occur on a terminological, structural, or visual level." According to the researchers, an application should be intuitive and predictable, through avoiding unreasonably structured information, unclear naming, vague instructions and missing feedback. Additionally, "[d]esigners of new formats should consider that users expect to find familiar patterns that they know from the usage of their respective reference objects." The application should thus function and behave in a fashion that is recognisable by the user, so that they do not need to exert mental effort in learning to work with it.

Samsel et al. (2014) explored the so-called 'Cascading Information Theory', taken from gamification theories, and its use in travel information. Cascading information means that information is broken down in as small amounts as possible and only shown at the right moment, in order to keep the user focused on the current objective and to prevent confusion. Applying this to a travel assistant, it means that the complete journey gets broken down into separate steps, e.g. 'walk to bus stop', 'wait for bus', 'take bus to stop X', and 'walk to destination'. In each step, the user is focused on the current sub-goal, namely reaching the bus stop, taking the right bus, or getting off at the right stop. Information for the next step is only shown at the moment the user enters said stage. By completing all sub-goals, the main goal of reaching the destination is completed as well.

In order to try this out, Beul-Leusmann et al. (2014) applied the principle of Cascading Information in their travel assistant, and had test users give feedback about the application. Although the users clearly appreciated the effort to break down information into manageable pieces, they also mentioned the need for an overview of the complete journey, so that they could monitor their progress and know which steps they still had to make. Most test users were in favour of a progress bar, but it needs to be clear what kind of progress it would show (number of steps, progress in time, progress in distance, …). Based on those results, it is derived that the travel assistant should present two separate 'fields' of information: a main part that covers the current step and the information the user needs at that instant, and a secondary part that shows the user's progress and where he or she can find an overview of the journey.

The travel assistant needs to be able to offer travel alternatives in case the current journey cannot be performed as planned. Keller et al. (2011) explored different kinds of visualisation types for travel alternatives, of which the 'time bar' principle is used nowadays by applications like Qixxit and Moovel[11]. Travel alternatives are represented by coloured bars per mode with differing lengths according to their departure and end times. In this way, users can visually comprehend how much time a given alternative requires and how this compares to other alternatives. This can be especially valuable in situations of stress, where journey length is an issue.

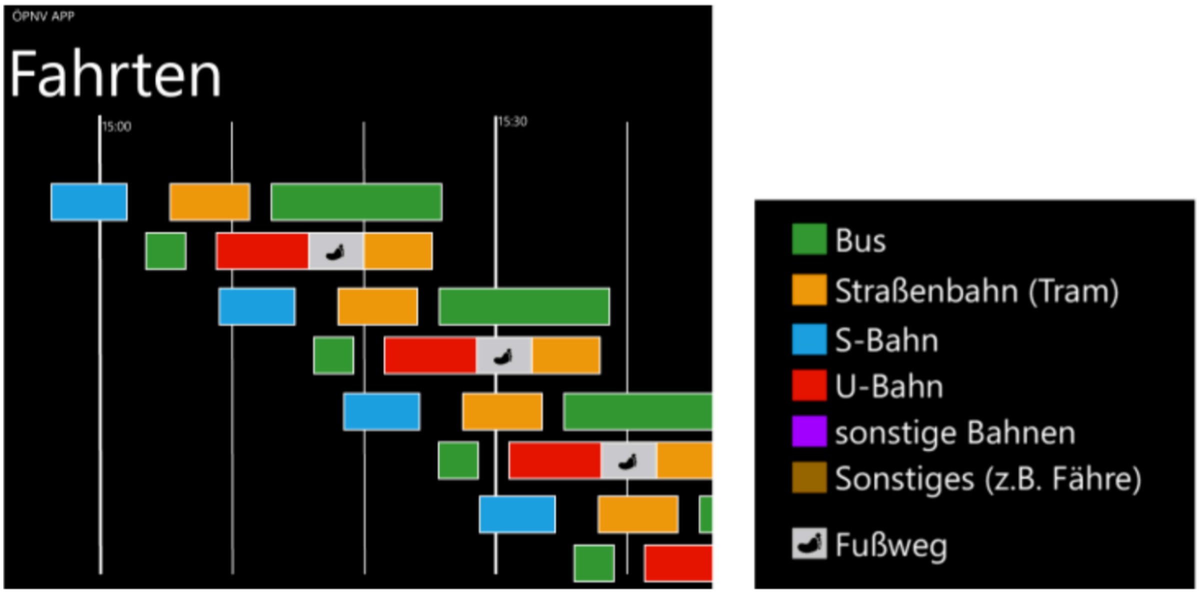


Figure 5. Travel alternative visualisation with time bars (Keller et al., 2011)

6.1 Best practices

6.1.1 Qixxit

Qixxit is a German online intermodal journey planner developed by the Deutsche Bahn that gives travel alternatives for all kinds of different modes, including car sharing, long-distance bus and trains, and even airplanes. Its mobile application includes a so-called 'Begleitung' ('Guidance') functionality that keeps track of the user's location and gives directions for each step. The basic interface consists of a vertical progress tracker that keeps track of the user's position in each leg of the journey, and a circular counter that informs the user how much time remains until the next step (Figure 6). In this way, the application provides a minimalistic and orderly view of the information the user needs at the current moment, as well as an overview of the steps that still need to be taken.

[11] https://www.moovel.com

Nevertheless, the amount of information provided is not always enough for inexperienced travellers. For example, the map view does not provide a detailed trajectory for walking. Another issue is that it does not show the final destination of public transport vehicles, which could confuse passengers who quickly need to decide on the right vehicle to board. The main drawback of the Qixxit assistant is that it does not keep track of the actual position of the user and is, therefore, not context-aware: instead, it assumes the user is following the instructions with success. This means that the assistant cannot intervene when the user seems lost or the initial plan is disrupted. Overall, however, the application sets a good example for user interface, and these aspects will be taken into account for the design of our own application.

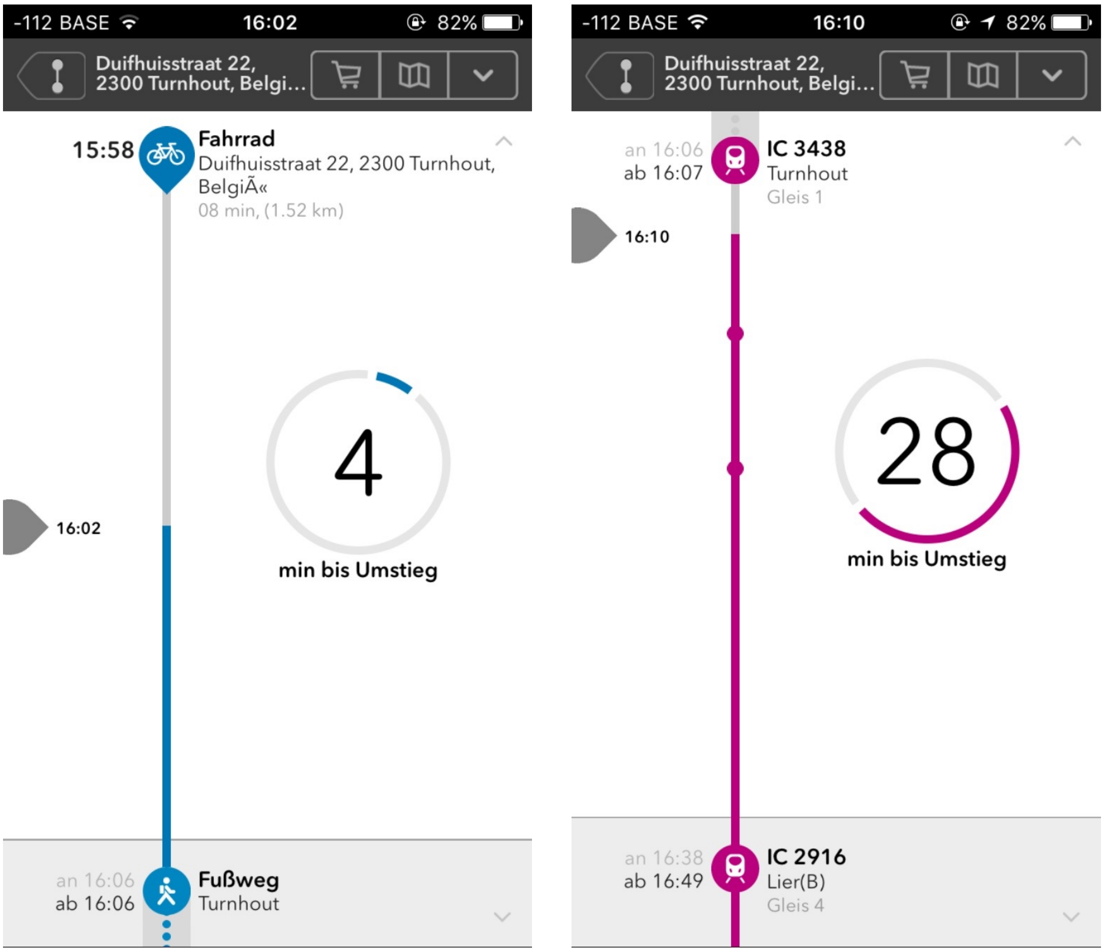


Figure 6. Qixxit travel assistant.

6.1.2 Citymapper

Citymapper is a browser- and mobile-compatible multimodal journey planner that can be used in cities all over the world. It has gained a large user base, and recently introduced an assistance feature to guide users during their journey. In contrast with the clean interface of Qixxit, the Citymapper assistant interface is based on a map of the journey with extra information overlaid on top (Figure 7). The journey is broken down into more steps, so that 'waiting at the stop' becomes a distinct leg that deserves its own screen. Also, walking routes are shown on the map so that the user knows how to reach their stop or station.

Although Citymapper is devoted to guiding the user step by step, a number of significant remarks can be made about the way this is done. To start with, overlaying relevant information on a map view at all times is not the best way to give the user the clearest instructions, as it feels cluttered and chaotic at times. Furthermore, progress is shown as a number of dots standing for the number of steps performed, as well as time left until arrival; but these are only proxies for the user to estimate how much of the journey has been completed. Finally, no indications are provided about the next step of the journey until the users look for it themselves. Overall, it feels like improvements can still be made to make the assistance feature feel more seamless and less cluttered.

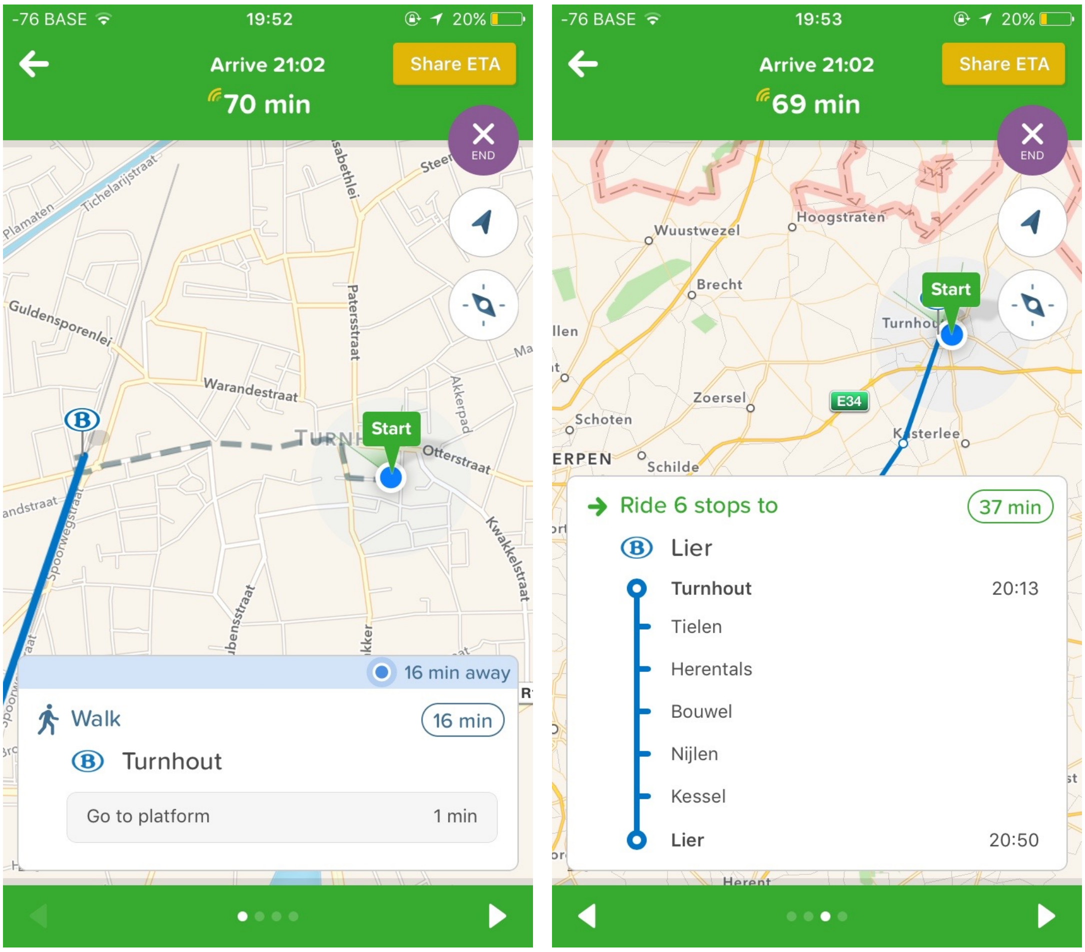


Figure 7. Citymapper travel assistant

6.2 First concept

Taking into account our earlier literature study and the teachings of best practices, a first paper prototype is developed to give a general idea of what the application will look like (in Dutch). Later in the process, these paper mock-ups will be transformed into a functional prototype.

The assistance view comprises two distinct fields: a 'current step' field that shows the user what they need to do at this particular moment, and a 'progress' field that shows both the user's progress in time (using a horizontal bar) and the next step in the journey, in order to prepare the user. During the walking steps, the current step field shows a map with walking directions and the estimated arrival time. In the other steps, a circular counter is shown that indicates the remaining time until the next step, along with basic information the user needs.

The top of the screen shows the name of the current step (for example 'Walk to X', 'Station X' or 'Vehicle Y'). Beneath that, the goal of that step is shown ('Get off at X', 'Wait for vehicle Y'), along with a counter that states how much time is left before the goal is reached. At the bottom of the current step field, relevant details are shown for the goal ('Z many stops left for X, arrival at this time', 'Vehicle Y leaves at that time'). The list of remaining stops is hidden at first to prevent too much information being shown simultaneously, but the user can choose to have a look at the names of the remaining stops if they wish to do so.

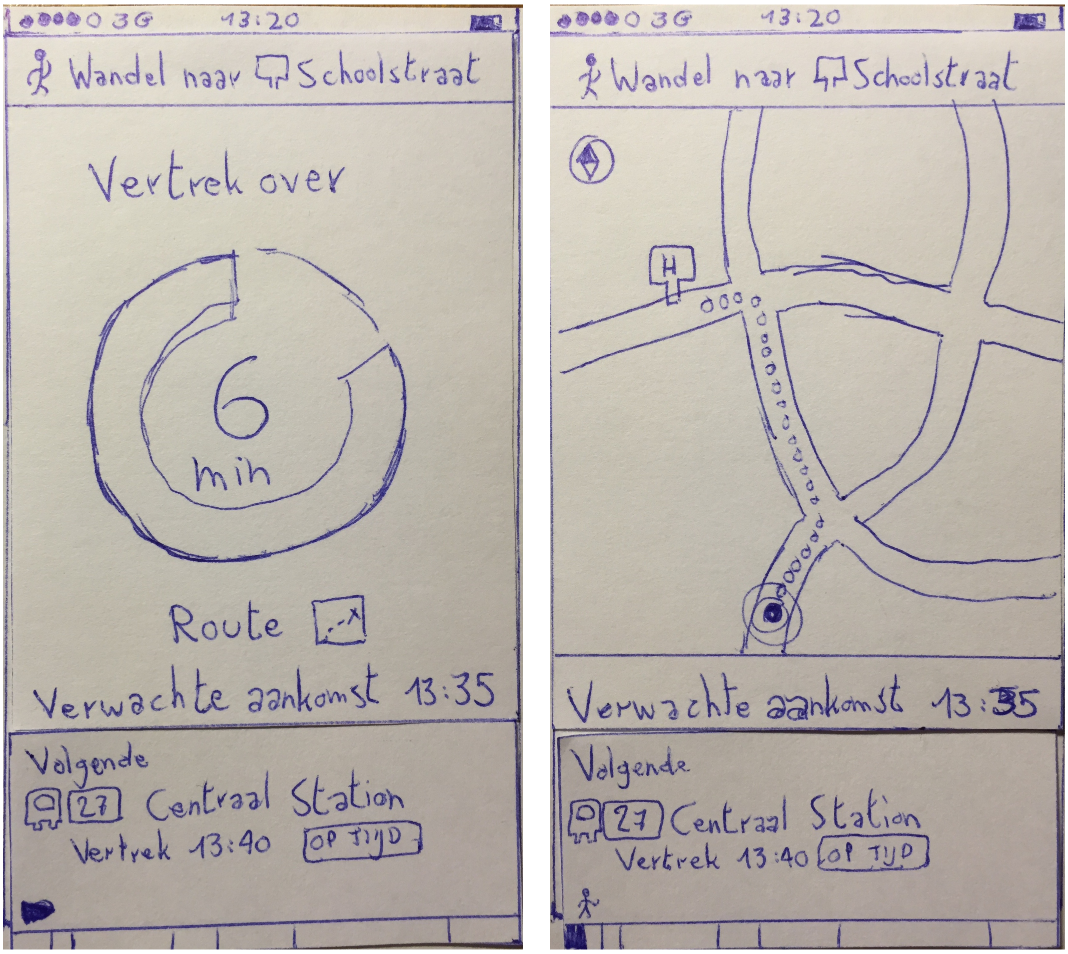


Figure 8. Paper concept: walking instructions

Time indications are shown in both 'absolute' ('xx:xx') and 'relative' ('x min') ways to give the user enough certainty. This is also the case for scheduled time and real-time indications ('on-time'/'+x min'), in order to clear any doubts and to establish the user's trust in the assistant's information. For high-frequency lines, e.g. subways with less than 5 minute headways, scheduled time information is not as relevant as these times are often not shown in subway stations themselves. For many other kinds of public transit, however, scheduled time is shown in stations even if vehicles are delayed, and the schedule functions as an identifier for the vehicle (for example, 'the IC train of 12:37'). Additionally, delays are highly unpredictable and can change very quickly, so that an 'estimated arrival time' is not a reassurance by itself. As such, it is recommended to provide both scheduled time and delay information for most vehicles.

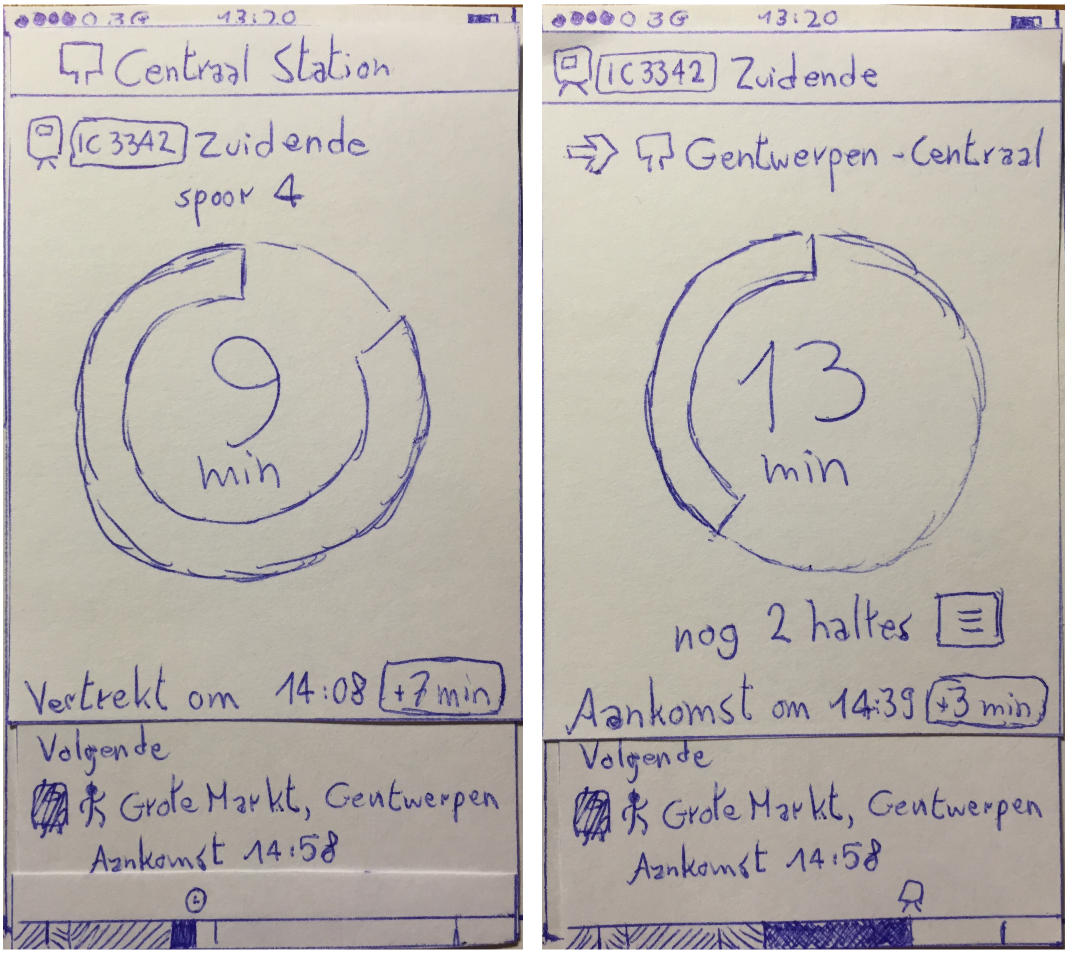


Figure 9. Paper concept: station and vehicle information

In the progress field, the next step of the journey is shown at all times so the user is aware of what they will need to do next. For example, during the walking stage it will show the identification of the vehicle they need to take ('Bus X to Y') and its expected departure both in scheduled time and real-time, so that the user knows what they need to do on arrival and how much waiting time they will have. This can have an impact on how fast the user will walk. On-board, the application shows whether the next step is walking to the destination or changing to another vehicle. In the latter case, users can prepare themselves to get out of the vehicle quickly so that they will not miss the connection. If the user wants more information on the rest of the journey, tapping on the progress field brings up an overview of all the steps ahead.

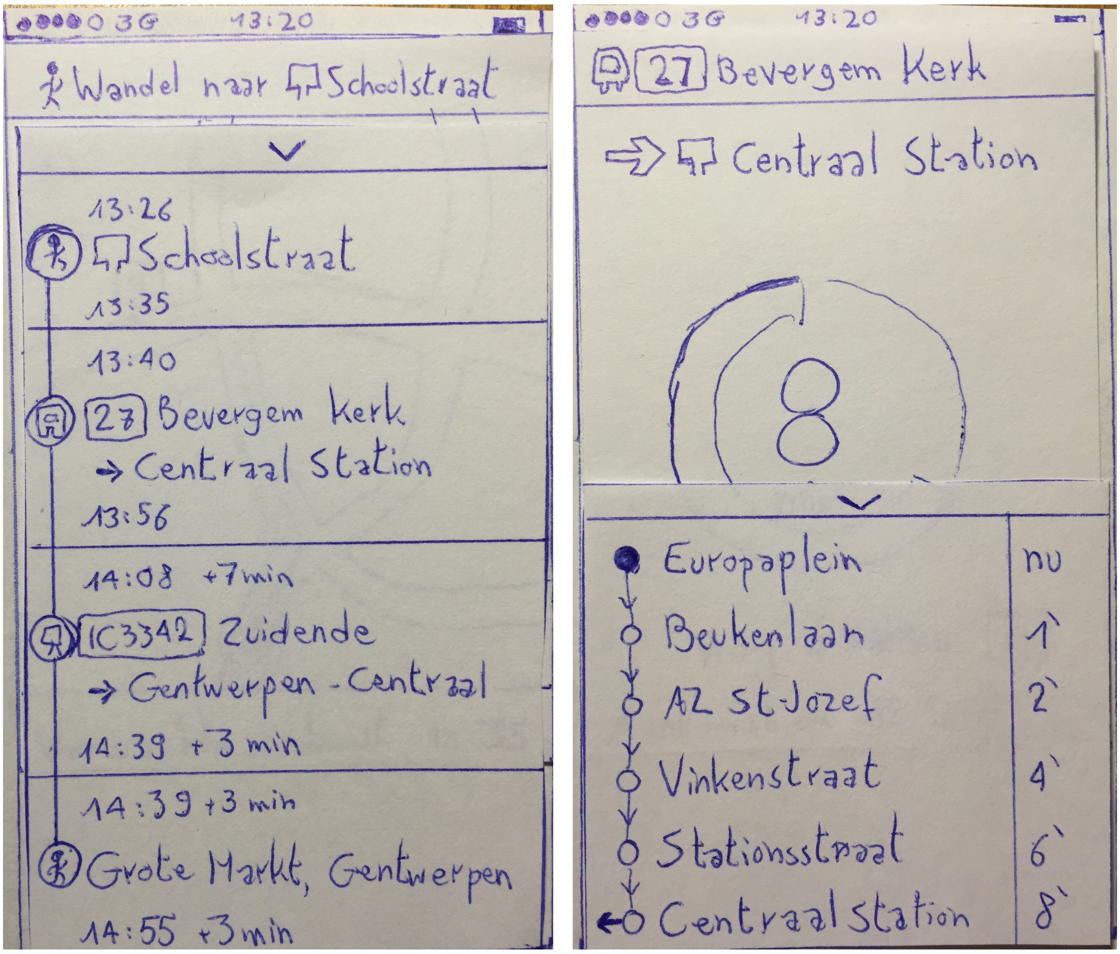


Figure 10. Paper concept: journey overview and next stops list

Finally, a key aspect of the application is its automatic intervention in case of disruptions. During the journey, the assistant regularly checks if the route can still be completed according to plan. If this is not the case, the application will notify the user and provide alternative travel plans. The user can then choose one of the alternatives, after which the assistance resumes with the new route.

There are different grades of possible disruption for a user's journey. The least disruptive grade is a minor delay while there is no faster alternative: in this case, the user should not be asked to intervene. The delay is instead shown in the regular assistance view of the application. In case of a more serious delay (generally more than 5-10 minutes), the application needs to check if there are faster alternatives to get to the destination. For example, the user could board a train that takes another route, or they could exit at the next station and switch to a bus. These alternatives will be suggested to the user, but they can also choose to stick with the current alternative.

The most serious grade of disruption occurs when the current journey is impossible to complete, either because of cancellations or because none of the connections can be caught. When this happens, the user is only able to choose out of one or more alternatives to the current journey. These alternatives most likely have a longer travel time than the initial plan, so a comparison in travel time is indicated for each alternative. Both types of disruption assistance are shown in Figure 11.

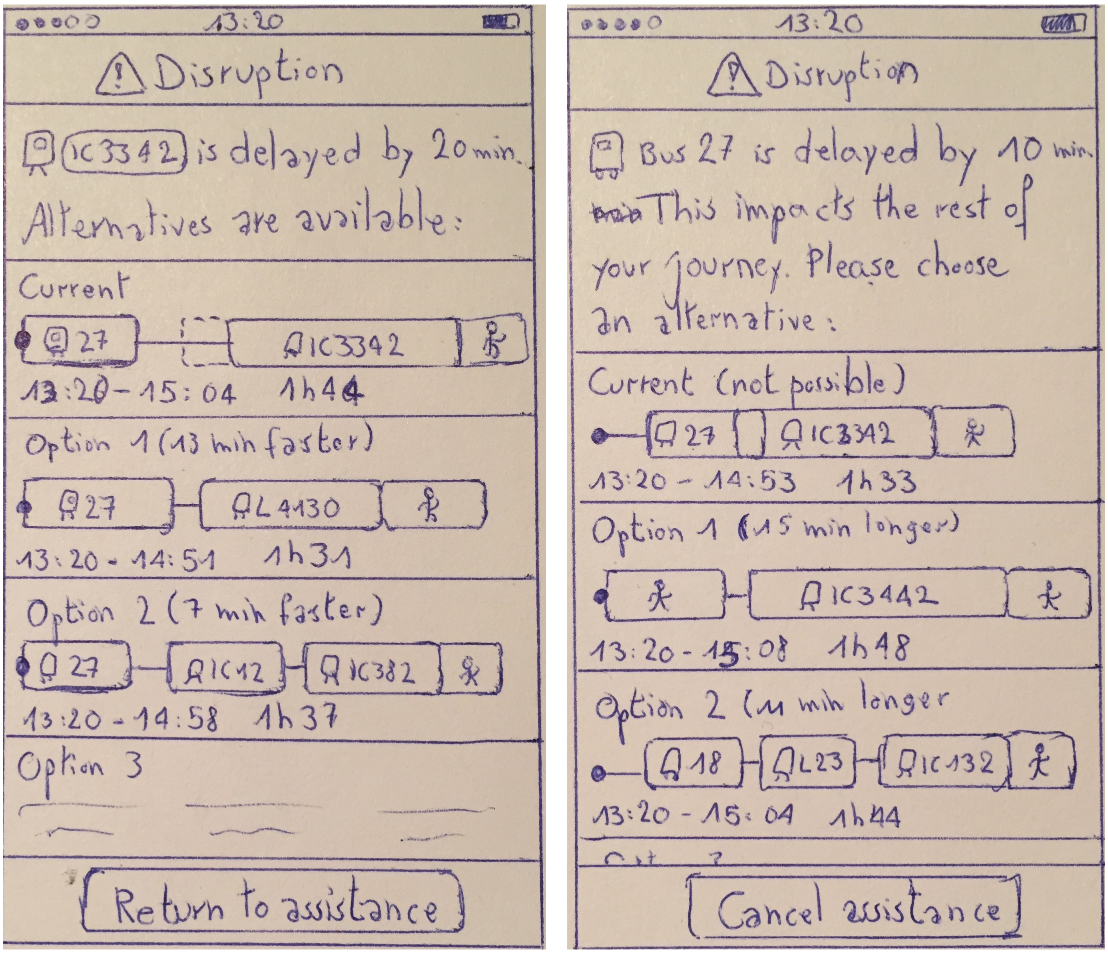


Figure 11. Paper concept: travel alternative suggestions for medium and serious disruption

Travel alternatives are visualised with the time bars developed by Keller et al. (2011). Each leg of the journey is represented by a coloured bar with a length corresponding to its duration. Aspects like total travel time, in-vehicle time, wait time and walk times can easily be deduced and compared between alternatives by observing the time bars, and they are accompanied by the actual start, end, and travel times. The user's current position on the trajectory is represented at the left edge by a coloured dot that suggests real-time location, like in maps applications. If the user is currently in a vehicle, the route alternatives are automatically based on possibilities with this vehicle, in order to provide only useful route suggestions. Details of each alternative can be viewed by tapping on it: a step-by-step explanation folds out, which contains all relevant information for the user to make a decision (Figure 12). When an alternative is chosen, the vehicles involved in the previous choice are still monitored as long as the user has not changed to a new vehicle, in case the disturbed situation returns to normal and the old route can be resumed.

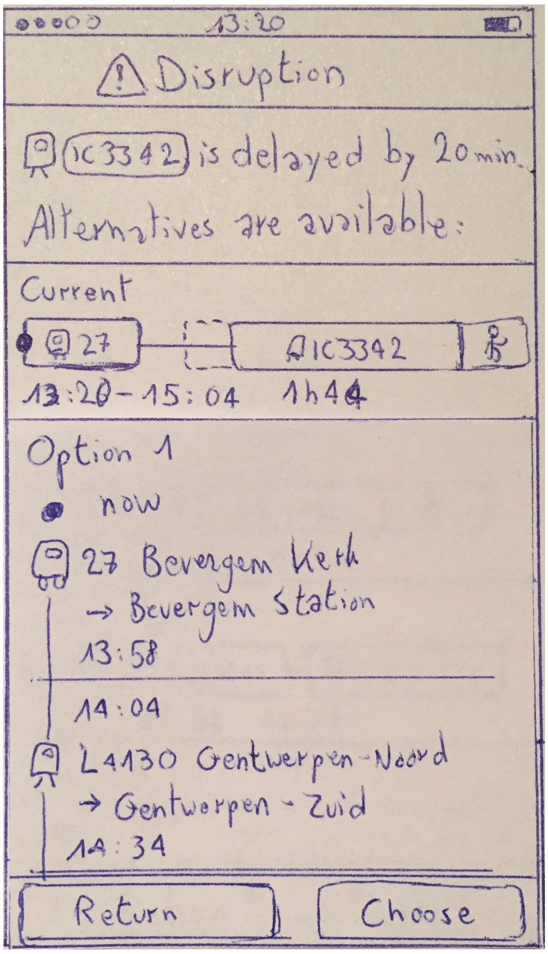


Figure 12. Paper concept: travel alternative details (scrollable)

Experienced public transport users who regularly perform the same journey, like commuting to work, would also benefit from a tool that automatically notifies the user in case of disruptions and that suggests alternatives, but they do not necessarily need the rest of the assistant's functions as they are already familiar with the steps they need to take in order to get to their destination. For this public, the application should be able to let users monitor their travel journey without activating the assistance function. The application would only notify the user in case there are faster alternatives or if the chosen journey can not be completed, and let the user choose to only monitor the new route or also give assistance during the journey. An extra functionality would be to let users set 'favourite routes' and automatically monitor them on specified days and times of the week (for example every workday to get to work). For the scope of this thesis however, the evaluation will be focused on the combination of assistance and monitoring.

Figure 13 shows a mock-up of what the prototype application might look like once it is made with Proto.io. This design can still evolve during the development process before testing, based on the capabilities of the prototyping tool and individual test user feedback, but it already gives an idea of the general look and feel of the application. In the next section, a description will be given of how the evaluation of the prototype will be performed and what it should encompass.

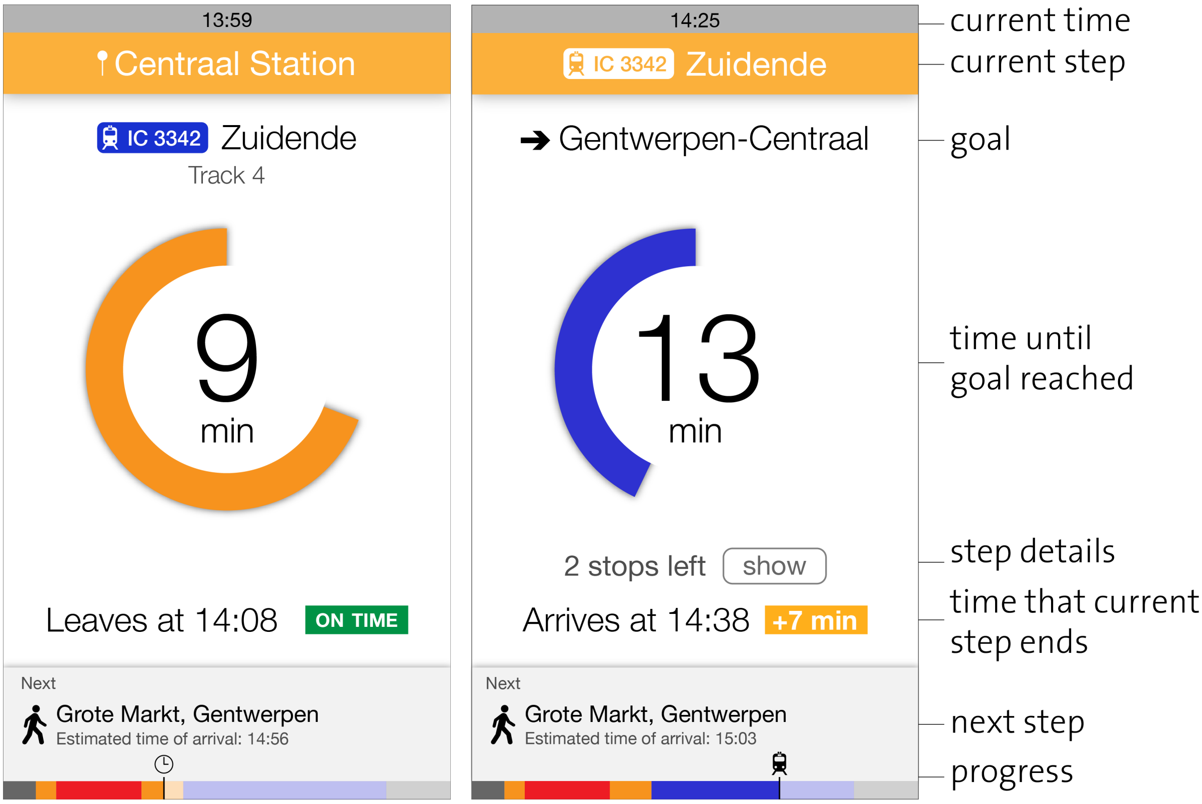


Figure 13. First application mock-up

7 Testing with users

User tests are critical for the successful development of an application, and arguably the cornerstone of this thesis. They will form the basis for evaluation and further improvement of the travel assistant prototype. The first step of the testing setup is to create an evaluation framework on which the evaluation can be built.

In 1989, the Technology Acceptance Model (TAM) was proposed by Davis (1989) to explain how users come to accept and use a specific technology. The model states that two main factors influence user acceptance, namely: perceived usefulness and perceived ease of use. Perceived usefulness is defined as “the degree to which a person believes that using a particular system would enhance his or her job performance”, while perceived ease of use describes “the degree to which a person believes that using a particular system would be free of effort”.

Davis went further to define the main evaluation clusters for both concepts:

Perceived usefulness evaluation clusters

- Job effectiveness
- Productivity and time savings
- Importance of the system to one’s job

Perceived ease-of-use evaluation clusters

- Physical effort
- Mental effort
- How easy a system is to learn

Davis’ work has been very influential for evaluating IT systems and new technologies. It has been expanded and modified by other researchers to make it more applicable to certain systems. Brooke (1996) developed a scale that measures usability, a general name for the amount in which a system is meaningful for users. According to Brooke, “[u]sability is not a quality that exists in any real or absolute sense. Perhaps it can be best summed up as being a general quality of the *appropriateness to a purpose* of any particular artefact. […] In general, it is impossible to specify the usability of a system (i.e., its fitness for purpose) without first defining who are the intended users of the system, the tasks those users will perform with it, and the characteristics of the physical, organisational and social environment in which it will be used.”

According to the International Organization for Standardization (ISO), measures of usability should cover:

1. Effectiveness (the ability of users to complete tasks using the system, and the quality of the output of those tasks),
2. Efficiency (the level of resource consumed in performing tasks),
3. Satisfaction (users’ subjective reactions to using the system).

(“ISO 9241-11:1998", 1998)

Wirtz et al. (2010), who tested the usability of their travel assistance application, expand the meaning of usability to not only cover effectiveness, efficiency and satisfaction, but also “affective and hedonic aspects (attributes emphasizing individual’s well-being, pleasure, and fun while interacting with technology) and the social value of applications.”

In short, ‘usability’ is a terminology which covers many different aspects of using technology. Nevertheless, the most important aspects to evaluate for this prototype are the degree to which users find an application easy to handle (efficiency/ease-of-use), how well they think it does its job (effectiveness), how useful they would find it in the real world (usefulness), and their general satisfaction with how the application looks and works.

The first round of user tests is, besides a few individual interviews, performed in focus groups with a small number of participants. The reason for this small number is because in an iterative development, it is more productive to have multiple test iterations with a small number of test persons than a few number of rounds with a large number of test persons (Nielsen & Landauer, 1993). According to Nielsen (1997), focus groups of 6 to 9 representative persons are ideal, and more than one focus group should be held, so that the outcome of one single session does not weigh too much on the evaluation. In the case of the application at hand, the most important factors for assembling focus groups are public transport experience and smartphone use. Test participants should be selected so that there is a fair distribution of users that have a lot/little experience with using public transport and a high/low rate of smartphone use.

Focus group sessions should be free-flowing and relatively unstructured, so that participants feel free to give spontaneous remarks during the discussion. It is important for the moderator not to assist participants in using the prototype, so that they can explore it for themselves (Nielsen, 1997). These principles were also used by Beul-Leusmann et al. (2014) and Wirtz et al. (2010), who let users ‘think aloud’ while they were using the travel assistant prototype, and recorded these comments for later analysis. After using and discussing the prototype as a group, individual responses were collected via questionnaires. More information on the focus group methodology can be found in section 9.2.

In the individual questionnaires, the prototype’s usability should be tested by asking questions about its ease-of-use, effectiveness, usefulness and the user’s satisfaction with the application. A common way to do this is the System Usability Scale (SUS) (Brooke, 1996), a ten-item scale in which users are asked to indicate their degree of (dis)agreement to several statements. These items get ranked on a 5-point Likert scale, and summed to obtain a general assessment of the system’s usability (Figure 14). Additionally, questions about certain aspects of the application can be asked, as well as the possibility to give extra comments on the prototype.

	Strongly disagree 1	2	3	4	Strongly agree 5	
1. I think that I would like to use this system frequently					▯	4
2. I found the system unnecessarily complex				▯		1
3. I thought the system was easy to use		▯				1
4. I think that I would need the support of a technical person to be able to use this system	▯					4
5. I found the various functions in this system were well integrated		▯				1
6. I thought there was too much inconsistency in this system			▯			2
7. I would imagine that most people would learn to use this system very quickly		▯				1
8. I found the system very cumbersome to use				▯		1
9. I felt very confident using the system					▯	4
10. I needed to learn a lot of things before I could get going with this system		▯				3

Total score = 22

SUS Score = 22 *22.5 = 55

Figure 14. Example of the System Usability Scale (Brooke, 1996)

Using the results from the individual interviews, focus group discussions and participants' individual assessments, the first prototype is evaluated. Improvements will then be carried out, after which a second test iteration takes place. Depending on the number of changes that need to be made and users' general satisfaction with the prototype, the second test iteration can be held in different formats. If users had a lot of remarks and were generally dissatisfied, new focus group sessions can be held. If users were generally satisfied, an online survey can be disseminated to a larger group of people. In the first case, new focus groups should be held with the first participants to make a direct comparison with the first prototype, as well as with new test users to gather fresh input. After the second test iteration, final improvements are made to the prototype.

The end product of this thesis is the prototype of a context-aware travel assistant for public transportation. This concept could function as a component of an already-existing application, or form the basis for a new application that still needs to be developed. The strength of the prototype relies on two factors. First of all, the design is based on scientific literature about essential functionalities, context-awareness and application design. Secondly, the prototype will have been tested and revised in an iterative design process with two test iterations. This ascertains that the final prototype may spawn a usable product.

8 First prototype

Based on the results from the literature study and the first mock-up designs, a functioning prototype was developed using the tool called Proto.io, with the objective to use it during individual interviews and the focus groups. To give an overview of all relevant functionalities of the travel assistant, a fictional travel scenario was prepared that included walking parts and two public transport legs with different types of vehicles. Fictional location names were used to keep test users unprejudiced, but the names were familiar-sounding to create a sense of acquaintance with the travel assistant. As users of the test prototype would mostly be Flemish, the travel scenario was designed to make it recognisable in a Flemish/Belgian context, using familiar naming for train types, etc.

The basic travel scenario looks as follows:

13:20 – Begin app use

13:26 – Start of walking trip to bus stop ‘Bevergem Schoolstraat’

13:35 – End walking trip, wait for 5 minutes at bus stop

13:40 – Board bus line 27 in direction of Bevergem Kerk

13:56 – Exit bus at stop ‘Bevergem Station’, change to train

14:08 +7’ – Board train IC 3341 in direction of Zuidende

14:39 +3’ – Exit train at station ‘Gentwerpen-Centraal’ and walk to destination

14:52 +3’ – Arrive at destination (Grote Markt, Gentwerpen)

Chronologically, the following screens were implemented in the prototype for the basic travel scenario (Figure 15 to Figure 24). The first screen shows an overview of the itinerary from the current location to the final destination (Figure 15). At the top, the total projected travel time is indicated. The basic principle of the overview is a series of locations that the user has to go to in order to get to his destination, with travel modes in between to get to those locations. Stops and stations are indicated with ‘pin’ icons. The start and end times of each travel mode are indicated above and below the respective mode. Public transport legs show vehicle identification (line number and destination) and real-time information (‘On time’ or the delay in minutes). At the bottom, the user can tap a button to start the assistance.

The first in-assistance screen shows a countdown to when the user has to leave. The countdown function actually moved in this prototype. The basic principle for all in-assistance screens are the same: at the top, the title indicates the current step. Right below, the goal of that step is indicated (in this case, ‘Bevergem Schoolstraat’ is the stop the user has to walk to). The circle timer indicates the time left before this step ends, with the absolute form of the end time underneath. The bottom part of the screen indicates the next step of the journey, in order to give the user more context and certainty. The horizontal coloured bar indicates the user’s progress in time. When the user taps on or swipes up from this ‘Next step’-zone, the full journey overview appears (see Figure 24).

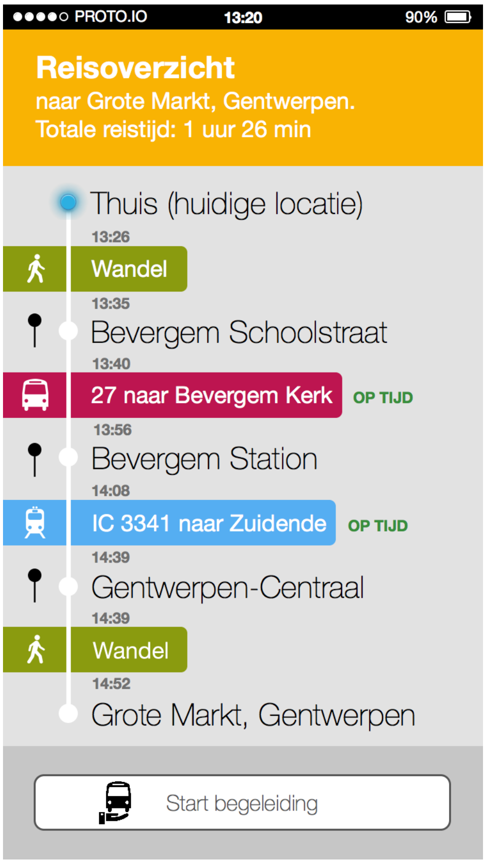


Figure 15. v1 Start screen

Figure 16. v1 Screen before walking

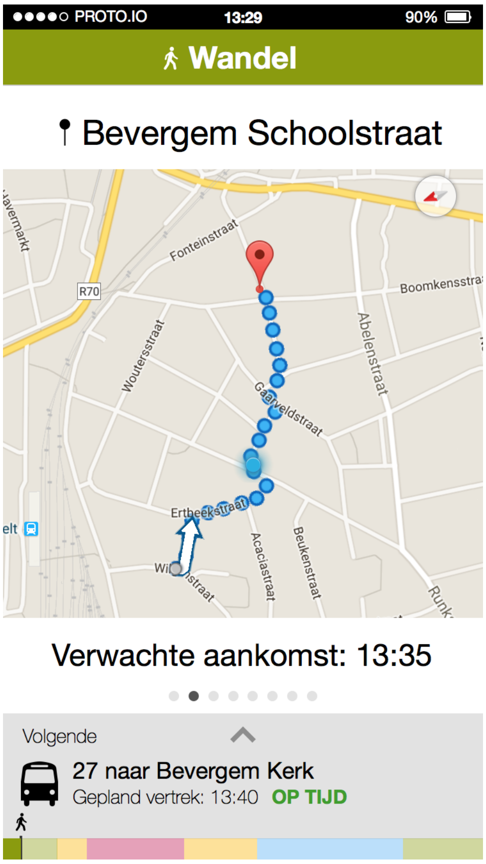


Figure 17. v1 Screen during walking

Figure 18. v1 Screen at bus stop

When the user starts walking, the assistant will show a map with the walking route and the current location (Figure 17). In the prototype, the map was static and could not move or be zoomed on, but this should be the case in the real application. The current location indicator moved along the route, so that test users would understand its function.

Figure 18 features the screen for waiting at the bus stop. Both the scheduled departure time of the bus and real-time information are shown. In this case, the bus is on time. When the user boards the bus, the number of remaining stops is shown (Figure 19). A button indicates that the names of the stops can be shown, but this functionality was not yet implemented in this prototype. When the user needs to exit at the next stop, the indicator changes to 'next stop' in the colour of the current mode, in order to catch the user's attention. In a working application, the user could also get a notification if they do not have the application currently opened.

In case of delay, the real-time indicator next to the scheduled departure/arrival time shows the delay in minutes (Figure 20). The circle time indicator shows the relative time until the effective time of departure including delay, but if the user wants to know this time in absolute form, they would have to sum the delay and the scheduled time. This is similar to the delay indications on platforms of Belgian train stations. The scheduled departure time is still shown because it serves as an identification for the right train.

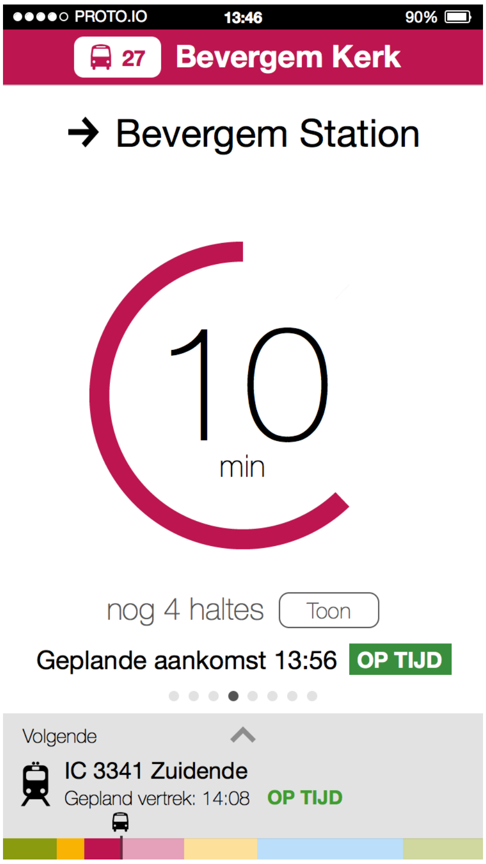


Figure 19. v1 Screen during bus ride

Figure 20. v1 Screen at train station

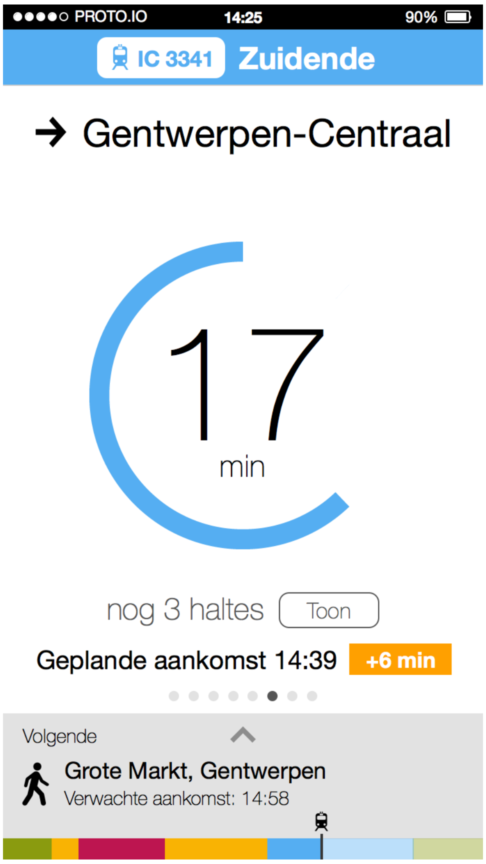


Figure 21. v1 Screen during train ride

Figure 22. v1 Screen during walk to destination

Figure 23. v1 Screen at destination

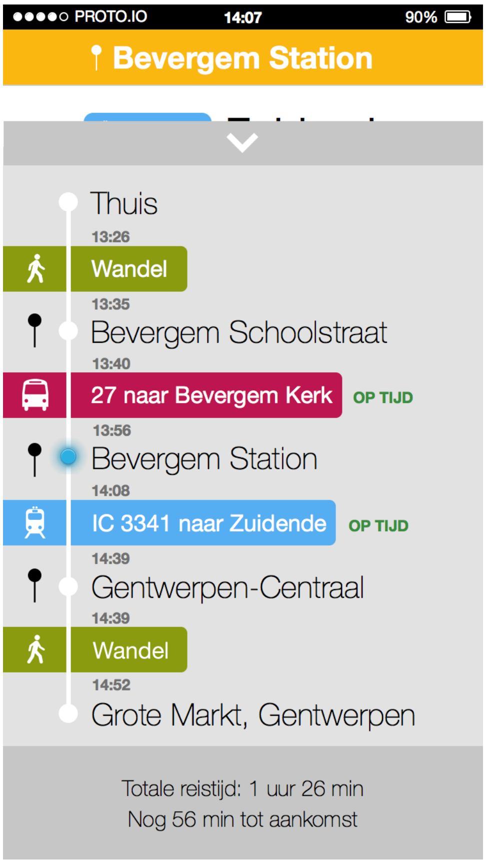


Figure 24. v1 Overview overlay screen

Afterwards, the user sees a screen for the train ride (Figure 21) and for the final walking part (Figure 22). When the user gets to their destination, a map of the immediate surroundings appears (Figure 23). The user can choose to plan a new journey from there, or to find a return trip to their point of origin.

Finally, from each in-assistance screen, the user can swipe up an overview of the entire journey, with a blue indicator for the current position (Figure 24). At the bottom, the time left until arrival is shown. The user can return to the current step assistance by swiping down the overview or by tapping the top of the screen.

Test navigation between the different assistance screens happened through swiping left for the next step. Circle indicators were used right above the 'next step' part of the screen to suggest the possibility to swipe. In the real application, these indicators would not be visible as the app automatically switches to the right screen in function of the user's context, without any interaction needed.

Separate from the first basic scenario, two additional, shorter scenarios were added to the prototype to show the capabilities of the alternative route suggestion process in case of disruptions, or the so-called 'Travel Advice'. In the first 'disrupted' scenario, the user would continue from the previous destination ('Gentwerpen') to a new destination by train. As the first train suddenly gets delayed by 20 minutes, it becomes impossible to continue the current journey because the second, connecting train cannot be caught. As a result, the assistant pops up a travel advice screen with two alternative suggestions: either the user takes another, local train, or they wait and take the same connection half an hour later.

The first disrupted scenario looks as follows:

15:03 – Begin of app use

15:10 +20' – Departure of train IC 4840 in direction of Wittenberge

15:38 +20' – Arrival in Vaarschot

15:43 – Departure of train IC 2161 in direction of Beverlee

16:04 – Arrival in Zeusden-Holder

Alternatively, the first option looks as follows:

15:18 – Departure of train L 628 in direction of Beverlee

16:26 – Arrival in Zeusden-Holder

The second option is similar to the basic scenario, but half an hour later:

15:40 – Departure of train IC 4841 in direction of Wittenberge

16:08 – Arrival in Vaarschot

17:13 – Departure of train IC 2161 in direction of Beverlee

17:34 – Arrival in Zeusden-Holder

The user would have to choose between one of these two options, as the application cannot guarantee guidance on the current disrupted journey. The following screens were visible in the prototype (Figure 25 to Figure 28), in addition to a new in-assistance screen for both available options (not shown here):

Figure 25. v1 Scenario 2 Start screen

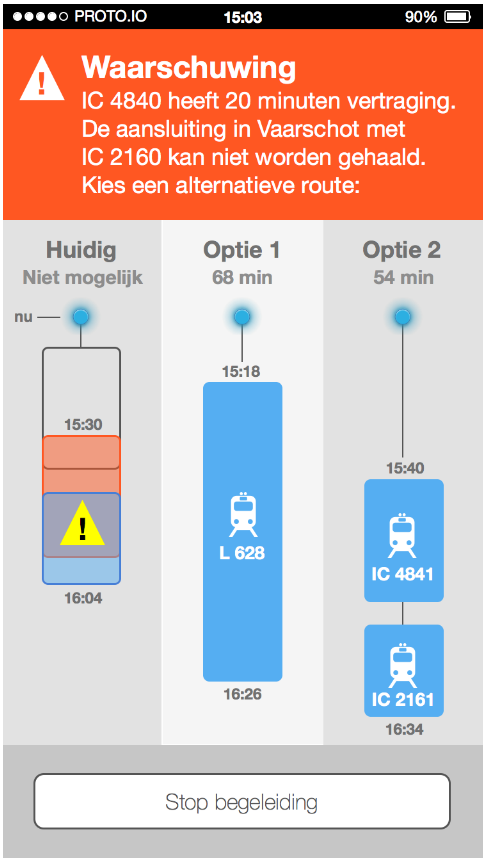


Figure 26. v1 Scenario 2 Travel advice

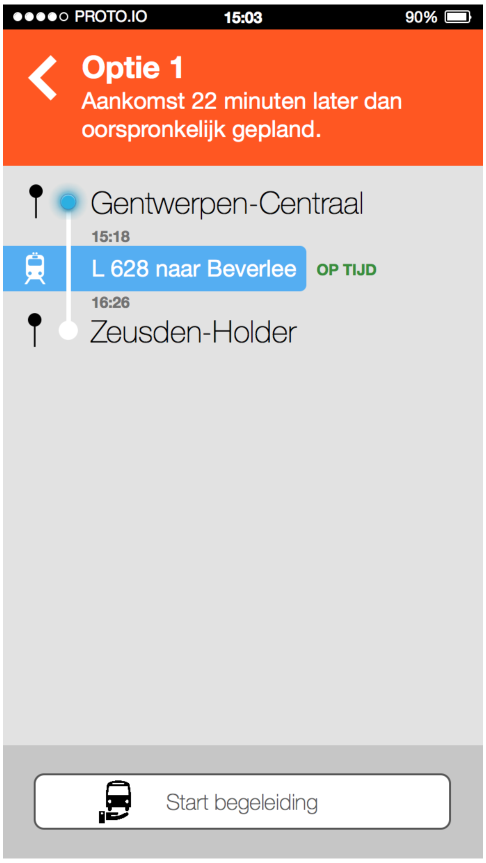


Figure 27. v1 Scenario 2 Option 1 details

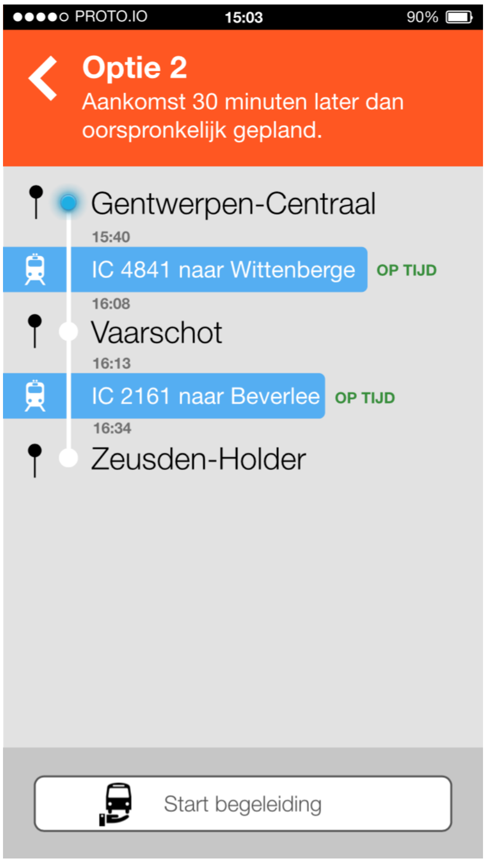


Figure 28. v1 Scenario 2 Option 2 details

In the test version, the alternative overview screen (Figure 26) would automatically slide up after 5 seconds. At the top, the screen explains that the first train in the journey has a 20 minutes delay, which means that the connecting train in Vaarschot cannot be caught. The user is then asked to pick an alternative journey. The current journey and both alternatives are expressed via the vertical time bars described earlier. A blue indicator is used to show the user's current position on these journeys. The delayed train is shown in red, together with a warning sign, to show that this option is not possible. The travel time of both other options is indicated above each time line, counting only the travel time from departure of the train. At the bottom, the user can choose to stop the assistance. In the prototype however, this would return the user to the first screen (Figure 25).

When the user taps one of the alternative timelines, the app offers more details in the style of a schematic journey overview (Figure 27 and Figure 28). At the top, the additional travel time compared to the original arrival time is shown. At the bottom, the user can choose to start guidance on this option.

Finally, a second 'disrupted' scenario was implemented (Scenario 3), in which the user would be on a bus that gets severely delayed. The application suggests a travel alternative in which the user could get off at an intermediate stop and continue to his destination by train. The user could also choose to stay on the current, delayed bus-only journey.

The principles of this scenario are the same as in the first disrupted scenario. After five seconds, the alternative suggestion (Figure 30) would slide up from the in-assistance screen (Figure 29). In this case, the user does not have to choose an alternative: it is possible to continue with the current journey. To imply lower 'urgency' in the notification, another colour is used for the title bar. The details of both travel options are shown in Figure 31 and Figure 32.

During the development of this first prototype, a number of individual interviews were held with test persons to get initial feedback, so that the application could be fine-tuned for the focus group sessions. In these interviews, the test persons were invited to use the prototype, without much explanation in the beginning, and to give remarks (both positive and negative, whatever notion came to them) on it. The methodology and results of these interviews will be dealt with in in section 9. The following adjustments were made to the first prototype based on these interviews before the focus groups were held:

- An upward facing arrow was added to the 'Next vehicle' section to indicate the possibility to swipe up this part of the screen to show the journey overview.
- Certain pieces of text were made larger to make them more legible, e.g. the time indications in the journey overview and option details of the travel advice.
- The start screen (Figure 15) was added to give some context, because test persons had troubles with understanding what the application was about in the first screens.

With these adjustments, the prototype was found to be ready for testing by more individual persons and test users in focus groups. The setup of these evaluations and their results will be discussed in the next section.

Figure 29. v1 Scenario 3 Start screen

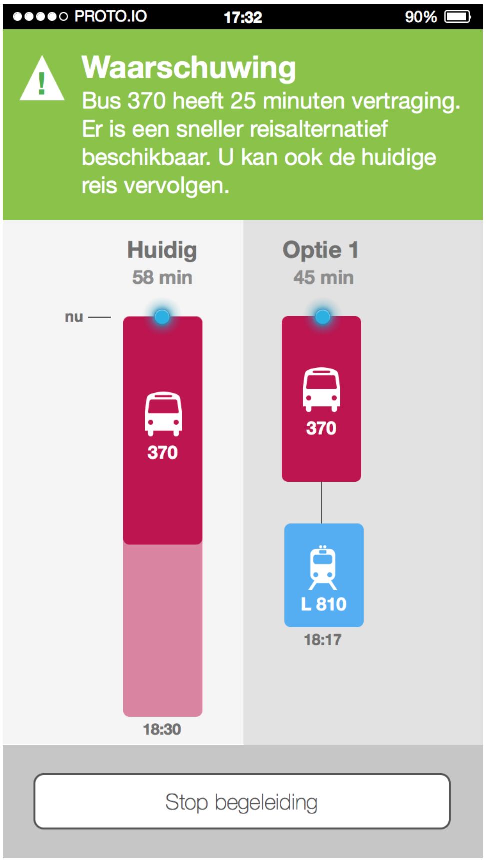


Figure 30. v1 Scenario 3 Travel advice

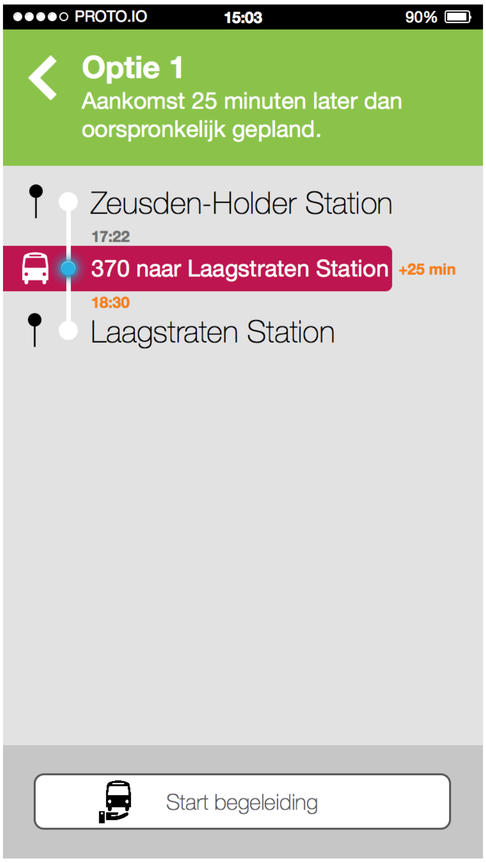


Figure 31. v1 Scenario 3 Current option details

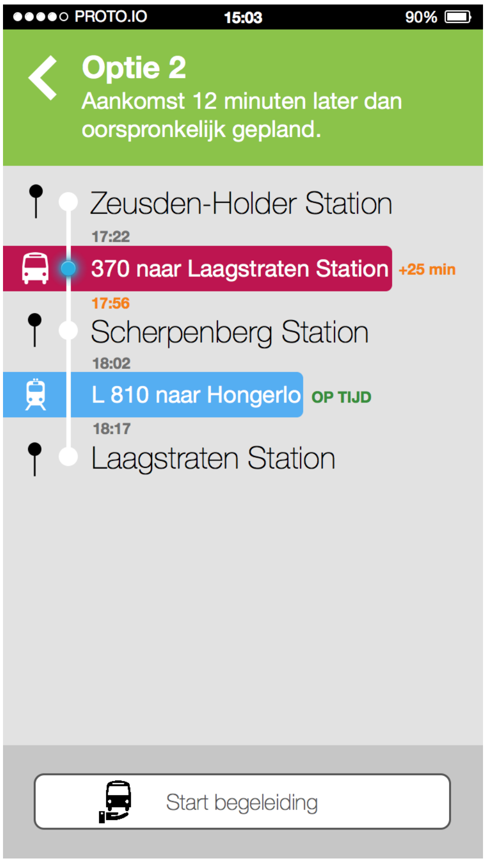


Figure 32. v1 Scenario 3 Option 2 details

9 Interviews and focus groups

After the creation of the first prototype, the evaluation of this proof-of-concept by test users was done in two ways:

1. Individual semi-structured interviews with a small number of participants who could give an extensive and personal view on the prototype.
2. Focus group sessions with a small number of participants per session for an optimal discussion between them.

First, the methodologies of these two strategies will be explained. Afterwards, the results of both evaluations and the main improvement areas will be described.

9.1 Individual interviews

Before the focus group sessions were held, individual interviews with various participants were held to evaluate the prototype. The main advantage of this strategy is the personal nature of such interviews, in which the test users could use the application at their own pace and give spontaneous remarks. This provided a rapid accumulation of feedback: as a result, a relatively low number of interviews already provided a large amount of opportunities for improvement. This is in accordance with Nielsen & Landauer (1993), who state that it is more productive to have multiple test iterations with a small number of testers than a fewer rounds with a larger number of testers.

The interviews were structured as follows: participants were told that they would get to see a certain application, without much explanation about what kind of application and how it worked. They were invited to try and use the application and to interact with it as much as possible. During this time, they were free to give any comments on it, which they could also write down. Questions about the application were not answered until after the user had gone through the full application. Assistance was only given if the test user appeared to be stuck or did not understand a vital part of the application in order to continue. After a brief discussion about the first scenario, the participants were shown the two disrupted scenarios. Afterwards, all of the interviewee's questions were answered and a more general discussion was held. Additional questions were asked, like 'What do you think the purpose of this application is?', 'When would you use this application?' and 'In general, how do you like the application?'. If necessary, additional questions could be asked or items could be discussed further.

In total, 8 individual interviews were held with different types of people. The eight persons were equally split between male and female. 6 of them were in the 20-25 age range, while the two other persons were in the 55-65 range. All participants were relatives, friends or acquaintances. This could pose a risk for bias, as they would possibly be more positive towards the interviewer. Nevertheless, participants were asked to be critical, and the results of these interviews made clear a number of opportunities for improvement. Therefore, this bias did not pose a serious threat.

9.2 Focus groups

As discussed earlier, some of the remarks that came out of the individual interviews were already used for modifications to the prototype, so that the application would be completely ready for testing in focus groups. These focus group sessions were the main evaluation method for the first prototype. Originally, only one focus group session was envisioned in the beginning of the afternoon, which was decided to be an easier time slot for a lot of university employees than later in the evening. Participants were invited through an e-mail to all employees of Hasselt University, with a link to an online questionnaire in which the following things were asked:

- How often do you travel by public transport?
    - Less than once a month
    - A few times per month
    - A few times per week
    - (Almost) every day
- Do you have a smartphone?
    - Yes
    - No
- Which kind of smartphone do you have?
    - Android
    - iPhone
    - I don't know
- Do you sometimes use travel applications? Examples of these applications are the De Lijn-app [regional bus operator], NMBS-app [national rail operator], Google Maps, Citymapper, …
    - Yes, I do
    - No, I never use those applications
- What is your year of birth?
- What is your gender?
    - Male
    - Female
- What is your email address, so I can reach you?

The questions about participants' travel behaviour, smartphone use, travel app use and socio-demographics were asked to get a rough idea of the composition of the focus groups and to gather feedback from persons of different backgrounds. For example, having only 20 to 25 year-olds with high smartphone experience would deliver non-transferable results for the rest of the population. The question about which type of smartphone the participant had aimed to check for compatibility with the prototype. The prototype could be opened on any type of smartphone with a web browser, but during pre-tests some Android phones had troubles running the application. Once it was known how many participants used an Android device, extra iPhones could be brought to the focus group as a backup.

In total, 13 people signed up for the focus group session. The design planned for 6 to 9 people per focus group, so it was decided to have two sessions with roughly the same number of people in each session. Participants could choose on which day they preferred to come. Two participants dropped out because they could not attend any of those days. Before the start of the focus groups, two extra participants dropped out, so that in the end there were two focus group sessions with 4 and 5 participants respectively. Although these are smaller numbers for the focus groups than originally planned for, this could not be changed at the last minute. The numbers also did not appear to be problematically low during the sessions. The composition of these groups was as follows:

- Focus group 1: 2 female and 2 male participants between 29 and 45 years old. All of them use public transportation a few times per month or less. 3 out of 4 have a smartphone, of which 2 use travel applications.
- Focus group 2: 4 female and 1 male participants between 30 and 58 years old. One person uses public transport almost every day, two use it a few times per week and two use it a few times per month. All of them have a smartphone and 4 out of 5 use travel applications.

Overall, the composition of both focus groups was differentiated enough to obtain a certain response variety in the evaluation. One thing that should be taken into account is that all participants were either current or former university employees (researchers, administrative employees, lecturers, …), of which three are active at the Institute for Mobility for which this thesis is written. This might introduce a bias in the results, since university employees are generally better educated than the overall population and could react differently to the prototype than random users, especially in the case of the three Institute for Mobility employees. In this stage of the prototype evaluation however, this is not an important limitation, since more diverse participants are reached later in the evaluation.

The focus group sessions were set in the early afternoon and were meant to last for a maximum of two hours. Sandwiches and drinks were provided to make the participants comfortable. At the start, the researcher introduced himself and a brief explanation about the project was given without too much information about the application itself. The session was audio-recorded. The first question to the participants was to describe what they saw in two screenshots of the application (Figure 18 p.26 and Figure 19 p.27). This was done to check how participants reacted to the application without any context and to see how they read the screens. Afterwards, participants were invited to load the prototype in a full-screen browser on their own smartphones or on one of the smartphones brought as backup devices.

Participants could then interact with the prototype for the first, full scenario. A bundle of papers with screenshots of the application were handed out to each person, so that they could write down their remarks for each specific screen. Afterwards, a brief discussion about the first scenario was held and questions were answered. The same method was used for the two disrupted scenarios. Before a more general discussion, participants were asked to fill out the SUS questionnaire. The Dutch translation of the SUS scale was used ("System Usability Scale - Dutch", 2012), with the word 'systeem' (system) changed to 'applicatie' (application) to make it better suited to the context. Additionally, a more general evaluation question was asked, which looks as follows (translated to English):

"In general, how (un)satisfied are you with this application?"

- *Very dissatisfied*
- *Rather dissatisfied*
- *Neither satisfied nor dissatisfied*
- *Rather satisfied*
- *Very satisfied*

Furthermore, participants could write any kind of remark, suggestion or question in a text box. Afterwards, a more general discussion was held where the interviewer asked questions like '*What do* *you think the purpose of this application is?*', '*When would you use this application?*' and '*In general, how do you like the application?*', like in the individual interviews. A more thorough explanation about the project and the prototype was given, and the next steps in its development were discussed. Finally, participants were thanked for their time and the focus group session ended.

9.3 Results

Using all the input from individual interviews, focus group recordings and filled-in paper bundles of focus group participants, 20 main areas of concern and their corresponding actions for improvement are discussed here. Afterwards, the results from the SUS evaluation and the general satisfaction will be reviewed.

9.3.1 Qualitative evaluation

1. **Circle counter and minutes remaining**

Evaluation: some participants found that the circle counter with the remaining number of minutes until the end of the current step was too prominent and distracted the user from other, more relevant information, like the number of remaining stops or the actual time of arrival (e.g. Figure 19 p.27). They found that the number of remaining minutes is not always as important, and that for example in the in-vehicle screen this could be replaced by the number of remaining stops inside the circle counter.

Action for improvement: *it should be checked if decreasing the size of the circle counter can make room for other information while not degrading the legibility of the application. For the in-vehicle screen, the remaining minutes can be replaced by the number of remaining stops, but it should be evaluated in the next version if this does not degrade the continuity and predictability of the application.*

2. **Screen before walking**

Evaluation: in general, many participants had trouble understanding the 'before walking' screen that indicated the remaining time before the user should start walking to the bus stop (Figure 16 p.26). Often, it was mistakenly understood to mean the user was already walking or they were already waiting at the bus stop. Some participants suggested making the 'urgency' of leaving the house more visible, for example by adjusting the colour of the circle counter.

Action for improvement: *it should be clearer that the user is not yet underway in the first screen but that it merely functions as a suggestion to leave in time. A way to do this might be to integrate this screen better with the next screen ('during walking'). The walking route could already be shown instead of the circle counter, and the urgency to leave could be represented both textually ('Leave in … min') and visually by adjusting the colour of the text.*

3. **Screen during walking**

Evaluation: participants were generally pleased with the walking instructions and the availability of a route map (Figure 17 p.26). The suggestion was made to include a Street View functionality that would make navigation even clearer and simpler. Other participants suggested including a more textual approach to navigation.

Action for improvement: *implementing a Street View functionality is a good suggestion that would further reduce confusion during walking, as it can show the environment like in 'real life'. Smartphone sensors like an accelerometer and gyroscope can ensure that the user is always looking in the right direction. Textual navigation, on the other hand, dates from a time when navigation websites did not have high quality maps yet and when walking directions were very basic. Textual navigation would still require an extra 'translation' to the real world, while Street View navigation skips this translation and would probably be easier to use.*

4. Clarity issues with the at-stop and in-vehicle screens

Evaluation: certain participants had trouble differentiating the at-stop screen (Figure 18 p.26) from the in-vehicle screen (Figure 19 p.27), perceiving 'waiting for the bus' as 'in the bus'. Furthermore, some users got confused by the different location names with different purposes ('Bevergem Schoolstraat' as the bus stop where the user got on, 'Bevergem Kerk' as the destination of the bus and 'Bevergem Station' as the stop where the user had to exit). The yellow colour for 'waiting' in the title bar, circle counter and progress bar confused some participants, because it was different from the colour of the respective travel mode they were waiting for.

Action for improvement: *there should be a clearer distinction between waiting and in-vehicle time. This could be done through better use of symbols, extra text, and/or differentiated colour use. For example, bus and train stops could get a clearer symbol than the current 'pin'. Text could make the destination clearer by adding 'to', and the exit stop could be made clearer by changing the current arrow to a textual 'get off at'. The colour of the at-stop phase could be adjusted so that it is clearer in the progress bar that waiting is not a mode on its own but a preparation for another travel mode. These adjustments should not be made at the expense of legibility or recognisability.*

5. Platform indications for buses

Evaluation: in analogy to train station platform indications, some participants felt this should also be added for buses, especially for larger bus stations.

Action for improvement: *a clear platform indication should be present for any type of public transportation used in the application, insofar as the data is available. For De Lijn, the Flemish regional bus operator, platform numbers are used for larger bus stations, so they could be implemented in the prototype. However, for small bus stops with one platform on either side of the street, there are no specific indications except for the stop number (which is hard to find) and the direction of the bus line(s), which the user does not always know. This could partly be remedied by providing very precise walking directions in the walking phase, so that the user is certain they arrived at the bus stop on the correct side of the street.*

6. Identification of vehicles

Evaluation: some participants find that the inclusion of train numbers is not relevant information as they never use these numbers to find the right train (e.g. Figure 20 p.27). They would rather see the train destination indicated in the vertical time bars of the travel advice.

Action for improvement: *except for the recent introduction of the so-called S-trains in and around Brussels, it is true that the train numbers are rarely used by Belgian train passengers for identification.*

Instead, the departure time and destination are used, and train numbers are not shown on digital screens in the station. However, they are shown in the official mobile application and in the paper schedules. Leaving them out of the application would not reduce its functionality, but it would not be possible to indicate the train's destination in the vertical bars instead as there is only little space available. In this prototype, the train numbers will remain as they do not degrade the clarity of the application, but in an eventual implementation, the inclusion of this indication should be decided for each individual public transport service that is featured.

7. Overview screen

Evaluation: the overview screen (Figure 24 p.28) got a very positive review by almost all participants. So positive even, that some participants indicated that they would only use this for their navigation, instead of the context-aware travel assistant. They also would have liked extra information, like platform numbers and intermediate stops, to be included in this screen. The screen was found to be well-ordered and clear, possibly because of familiarity (the De Lijn- and NMBS-apps use a similar approach). Even so, some participants remarked that they did not find the time indications above and below the travel modes very clear, and that they did not realise that the intermediate stops meant that they should change vehicles.

Action for improvement: *from these remarks, it became clear that many participants were more familiar with a schematic, list-like form of travel information that kept an overview of the whole journey. Depending on the context, relevant information could be added to each step and viewed whenever desired. Without doing away with the complete concept, it is clear that there should be a better integration between the overview and in-assistance screens, so that there is less of a 'bridge' to gap between these two forms of travel information. A more integrated concept should be designed, so far as the prototyping tool allows this. Furthermore, it should be clearer when the user is expected to change vehicles, and the time indications should have a better relation to the steps that the user needs to take.*

8. Function of the progress bar

Evaluation: the opinions on the progress tracker were mixed (e.g. Figure 18 at the bottom of the screen, p.26). Some people enjoyed it (even referring to it as 'cute') and found it a good addition to the concept. Others did not perceive its advantage and rather used the overview screen. Some participants indicated that they had not even seen the progress bar before others made them aware of it.

Action for improvement: *the progress bar should get a more prominent place in the application, perhaps between the assistance section and the 'next step' section. At the same time, the progress bar could play a role in making the distinction between overview and assistance less harsh.*

9. 'Next step' section

Evaluation: during the focus group sessions, no comments were made on the 'next step' section (e.g. Figure 18 at the bottom of the screen, p.26), but during the individual interviews it became clear that not everyone understood its function, confusing it with the current step. This was especially the case when the user was in the at-stop screen, where logically the next step would be ride in the vehicle they are waiting for, but instead the step afterwards was shown because otherwise information would be repeated in the same screen.

Action for improvement: *adjusting the wording from 'Volgende' ('Next') to something like 'Hierna' or 'Daarna' ('Afterwards') could make it more clear that this section shows information for when the current step is done. This could also reduce confusion in the at-stop phase.*

10. General clarity issues with assistance

Evaluation: in general, some participants (especially in the older age range) found the assistance to be confusing and lacking in consistency. They did not always understand the difference between screens, and found some information to be incomplete or vague.

Action for improvement: *it is difficult to ascertain if this clarity issue arises from the user interface or from a lack of context during testing (see no. 20). Nevertheless, every screen should be critically reviewed in order to improve clarity. The addition of short items of text, and better symbol and colour use, could help make information more understandable, together with a complete overhaul of the user interface.*

11. Visual value

Evaluation: some participants indicated that they found the application good-looking and visually attractive.

Action for improvement: *there is no real action for improvement here, though it is clear that visual attractiveness of any user interface is a very important but hard to quantify aspect of application design. As such, this should be taken into account when improving the prototype.*

12. Time indication naming

Evaluation: some participants had trouble distinguishing between time indications like 'gepland' ('planned'/'scheduled'), 'geschat' ('estimated') and 'verwacht' ('expected').

Action for improvement: *there should be a clear distinction between theoretical and expected time indications. The distinction between 'estimated' and 'expected' is too vague to keep in this application, so they should be called the same. There should also be a clear distinction between scheduled and real-time indications. This can be emphasised by adding colour and text for real-time indications ('On time', green or orange), and by clearly stating that scheduled times are theoretical.*

13. Time indications for delays

Evaluation: Some participants got confused by the different time indications that were present in the application, like the relative remaining time inside the circle counter, the theoretical times from the schedules, the delay information and the estimated arrival times for walking. Some persons saw the 'On time' indication as a confirmation that the information was real-time, which had a positive effect on their confidence, while others did not see the purpose of adding 'On time' if there was no delay and would rather not see this. There was no definite conclusion about the issue if times should be indicated in relative terms ('in 5 minutes') or in absolute terms ('15:23'), and if delays should be incorporated into these times or added next to them ('15:23 +5 min'). It was remarked that this should foremost correspond with the way that respective transport authorities show this information.

Action for improvement: *there are different ways in which to show a time indication. There is no 'correct' way to do this, but it can change depending on the context: in a frequent metro service, scheduled times* *are irrelevant and the delay information should not be separate from the remaining time. In an hourly train service, however, where scheduled departure time is more important (and often contributes to identification of the service), the delay time is usually separated, while the remaining amount of time until departure is less relevant. The application should theoretically be able to change the type of time indication for different transport modes, as long as this does not impede the continuity and clarity of the assistance during a multimodal journey.*

A possible solution would be to use three types of time indications in case of delay, like at general departure screens in Belgian train stations: [scheduled time]+[delay]->[actual departure/arrival time], with the circle counter always counting down to the actual time. In that case, the word 'scheduled' can be left out, and colour coding could improve the recognisability of the information. Leaving out the 'On time' indication would maybe not degrade the application's value, but it would also not improve it. Some participants clearly stated they appreciated this feature. A possible compromise would be to just show the time indication in green if the vehicle is on time.

14. Travel time indications for alternatives

Evaluation: some participants found the travel time indications above the vertical time bars in the travel advice screen (Figure 26 p.30) to be confusing, as it seemed that the travel time was longer even though they would arrive earlier than the other alternative. This is because only the 'underway' travel time is shown, excluding the wait time before first step, like in any other travel application. However, as the user is already underway here with the application giving advice to continue the journey, this creates confusion.

Action for improvement: *to reduce confusion, the travel times should indicate the total time until arrival, including any wait time before taking another vehicle. However, this could create confusion with indications in the application before starting the assistance, where only the actual travel time is counted. This distinction should be made clear.*

15. Time bars of alternatives

Evaluation: many participants indicated that they wanted to know the transfer time between vehicles in the vertical time bars of the travel advice screen (Figure 26 p.30), because this could influence the choice of alternative. Currently, this transfer time can only be deduced from the arrival and departure time indications in the details of each alternative.

Action for improvement: *it should be checked if transfer time information can easily be added to the vertical time bars without cluttering the interface.*

16. Delay indications of alternatives

Evaluation: one participant found that there should be separate delay indications in the vertical time bars (Figure 26 p.30). Currently, only the actual times are shown, coloured in orange in case of delay.

Action for improvement: *it should be checked if separate delay information (+x') can easily be added to the vertical time bars without cluttering the interface.*

17. Clarity of non-urgent travel advice

Evaluation: some participants found that the green colour of the non-urgent alternative suggestion was confusing (Figure 30 p.32) and that the title name 'Waarschuwing' ('Warning') did not indicate that the suggestion was optional.

Action for improvement: *the colour could be changed to another colour like orange. The naming could be adjusted to 'Suggestion' or 'Travel advice' instead.*

18. Notification method for travel advice

Evaluation: in general, participants indicated that they would not find it annoying if travel advice popped up automatically, even if the suggestion is not urgent. It is however not strange to imagine that future users want to decide for themselves in which way to receive notifications.

Action for improvement: *suppose that users can set their notification preferences, depending on the urgency of the notification. Another notification method would be to indicate that there are alternative journeys available in the travel assistant, but that the user has to interact with the application first before the alternatives can be viewed.*

19. Tariff structure context

Evaluation: some participants mentioned that they would not choose an alternative in which a train trip was included if they were originally only supposed to take a bus (Figure 32 p.32). This has to do with the fact that tariffs in Belgium are not unified, which means that bus passengers cannot suddenly switch to a train without buying an extra ticket.

Action for improvement: *because tariff structures can be different over various transport services in a country or region, users should be able to indicate which modes they want to be included in the travel advice for specific modes. In this proof-of-concept however, this kind of settings is beyond of the scope of research.*

20. Context and learning effect

Evaluation: Finally, many participants indicated that they understood the application better as they used it and got to know the concept. Some also mentioned that previous comments became irrelevant as they progressed further in the prototype. At the same time, a few suggested that it would be easier to understand the application when it was actually used in a journey, with immediate and obvious context. That would clarify the relationship between the different screens and the corresponding steps in the journey.

Action for improvement: *the lack of context in these evaluations must definitely be taken into account in further developing the prototype. Certain contextual factors cannot be simulated, and therefore the feedback from these evaluations is by definition limited. Before a full release of such an application, it should be properly tested in real life situations. Nevertheless, much of the feedback can be used to improve the concept before it turns into a functioning application.*

9.3.2 Quantitative evaluation (SUS)

Besides the qualitative input from the individual interviews and the focus groups, there is also quantitative feedback from the SUS questionnaires filled in by the focus group participants. The results of these questionnaires can be found in Figure 33. The values for negatively phrased questions have been switched so that a high score corresponds with a positive evaluation.

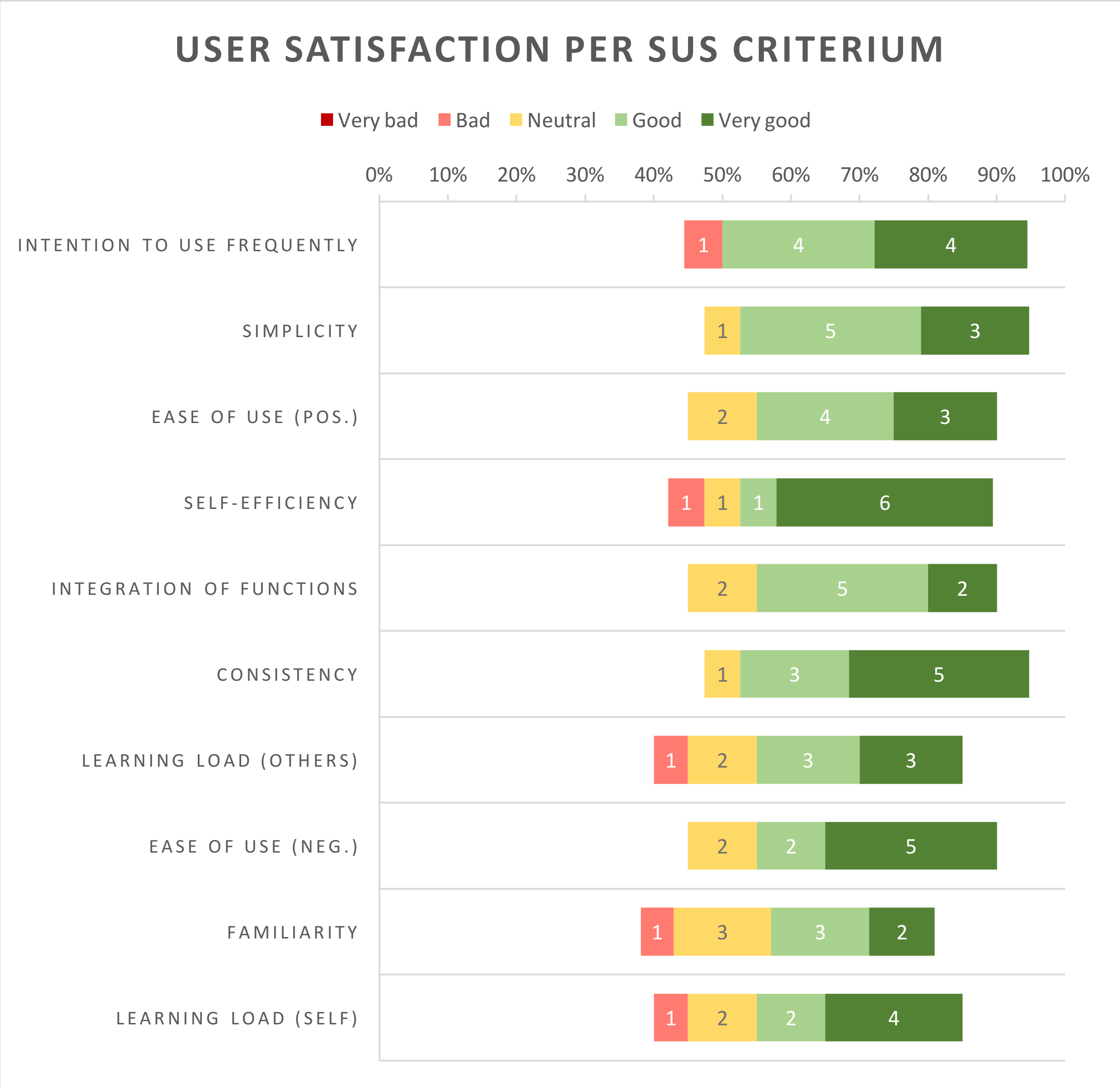


Figure 33. SUS evaluation by focus group participants

The 10 different statements and their evaluation will be separately discussed here.

1. **Intention to use frequently**

"I think I would like to use this application frequently"

Positively phrased statement: a high score ('Strongly agree') corresponds with a positive evaluation ('Very good'). 4 out of 9 participants indicated that they strongly agreed. One participant did not agree. Compared with the other questions, participants are overall positive.

2. Simplicity

“I found the application unnecessarily complex”

Negatively phrased statement: a high score (‘Strongly agree’) corresponds with a negative evaluation (‘Very bad’). 5 out of 9 participants rather disagreed. One participant was neutral. Overall, the participants found the application to be not unnecessarily complex, but they were rather modest in their evaluation (only three strongly agreed).

3. Ease of use (positively phrased)

“I thought the application was easy to use”

Positively phrased statement. Although most participants agreed or strongly agreed (7 out of 9), they were rather modest in their evaluation, and two participants were neutral.

4. Self-efficiency

“I think I would need help from someone else to use this application”

Negatively phrased statement. This statement got the most positive evaluation with 6 out of 9 participants strongly disagreeing. This is not surprising, as mobile applications are usually intended to be used without any external help or education. Still, one person rather agreed with the statement (that same user would not use the app frequently) and one person was neutral.

5. Integration of functions

“I found the various functions in the application well integrated”

Positively phrased statement. Most participants agreed or strongly agreed (7 out of 9), while 2 participants remained neutral. In comparison with other evaluations, this is rather modest.

6. Consistency

“I thought there was too much inconsistency in this application”

Negatively phrased statement. With 5 out of 9 participants strongly disagreeing with this statement, the general evaluation is very positive.

7. Learning load (others)

“I imagine that most people would learn to use this application very quickly”

Positively phrased statement. Participants’ evaluations were a bit mixed, with 1 person rather disagreeing, 2 persons remaining neutral and the rest evenly split over rather and strongly agreeing.

8. Ease of use (negatively phrased)

“I found the application very cumbersome to use”

Negatively phrased statement. 5 out of 9 participants strongly disagreed with this statement, giving it an overall positive evaluation. The evaluation for this statement is also better than for the positively phrased ease-of-use statement, which means that participants are more reluctant to call it cumbersome than to call it easy to use.

9. Familiarity

"I felt very familiar with the application"*

Positively phrased statement. This statement got the most negative evaluation, with 1 person rather disagreeing and 3 persons remaining neutral. This is in line with some participants' remarks that they had trouble with immediately understanding the application.

*In the official SUS questionnaire, 'confident' is used instead of 'familiar'. In the translated Dutch SUS questionnaire however, the word 'vertrouwd' is used, which translates better to 'familiar' than to 'confident', which would be translated as 'zelfverzekerd'. This might have an impact on the overall SUS score when compared to other scores, but as the two words are somewhat related and the other statements are well translated, this should not pose a serious threat for result interpretation.

10. Learning load (self)

"I needed to learn a lot of things before I could get going with this system"

Negatively phrased statement. Participants' opinions were almost as mixed as for the Learning Load (Others)-statement, with one participant strongly agreeing instead of rather agreeing.

Overall, general evaluation of the different statements by focus group participants is rather positive, with the worst scores going to familiarity and learning load, which corresponds with the participants' remarks. The reason why the results for familiarity and learning load could be so mixed might be because people in older age groups have more trouble immediately understanding the application, feeling that they would need to learn a lot in order to get used to it.

Using the total scoring system for the SUS questionnaire designed by Brooke (1996), the total score for the first prototype is a 78,1 out of 100 points, which is a higher-than-average grade. According to Sauro (2011), the average SUS score is 68 out of 100, based on more than 5000 SUS observations. This means that this prototype gets a rather good evaluation. However, it should be noted that only 9 participants filled in the SUS questionnaire, which is not statistically significant to draw large conclusions from. In the survey that will be sent out for the second prototype, the SUS evaluation will be more trustworthy.

Finally, participants rated a general evaluation question: "In general, how (un)satisfied are you with this application?". 2 participants indicated they were very satisfied, 6 participants indicated they were rather satisfied, and 1 participant remained neutral. Overall, this is a rather positive evaluation.

The results from these qualitative and quantitative evaluations are used for the development of a second prototype, described in the next section.

10 Second prototype

Based on test user remarks gathered during the individual interviews and the focus groups, a new prototype was developed that was meant to resolve most of the issues found. To keep the application uncluttered and streamlined, it was decided not to improve on the first prototype but instead to start from scratch and to develop a whole new concept. This was deemed necessary because there were too many remarks on the clarity and 'flow' of the information in the prototype. A new approach was thus appropriate.

Concerning the basic structure of the application, a less harsh divide between the in-assistance screens and the journey overview was needed, in order to better integrate both functionalities in a single concept. The progress tracker needed a more prominent position inside the application and could be a way to unite both functionalities. If the progress tracker became a vertical interface element, the overview list could be hooked on to it, and specific information for each assisted step could also be referred to in the vertical tracker. The 'next step' below the in-assistance section would be linked closer to the progress tracker (in which the next step is always below the current step). This led to a new concept that is shown in Figure 34 and Figure 35:

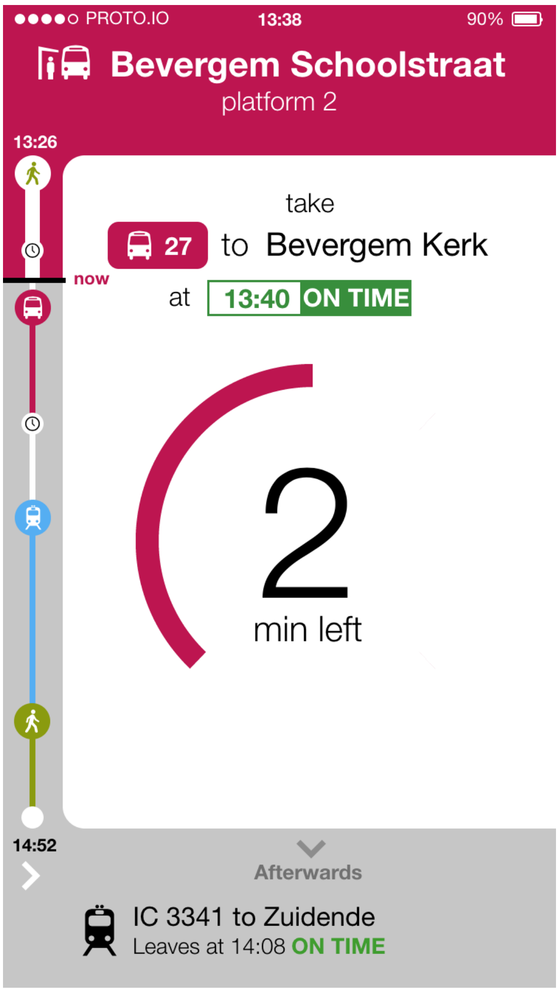


Figure 34. v2 Screen at bus stop

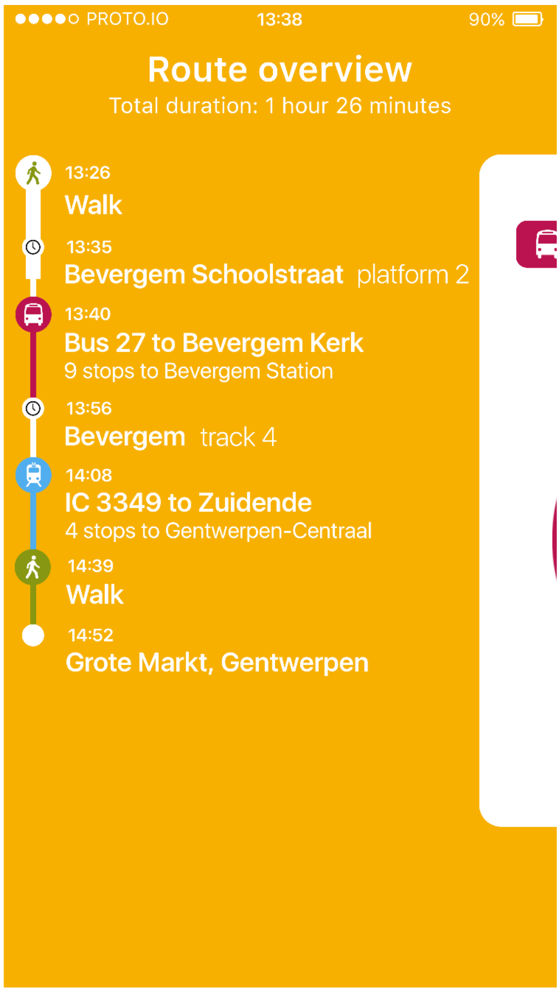


Figure 35. v2 Overview screen at bus stop

Switching from the assistance screen to the overview is done by swiping the white in-assistance section to the right or by tapping the vertical progress tracker. Going back is done by tapping the in-assistance section or swiping it back. A smooth animation changes progress tracker elements from their proportional length during assistance to a length that fits the overview list. The background colour changes to orange to signify an overview of the complete journey. In the overview, time indications are always placed next to icons for the corresponding steps, which answers former concerns of some test users about the unclarity about these indications. Below, the title of that step and possible extra information is shown. It was decided to add platform information and the number of stops to the overview, because several test users indicated that they would appreciate this. It should also be possible to view the list with intermediate stops when the user taps this information, but this was not yet implemented in this prototype.

All the prototype's screens will be shown here and discussed in more detail. Like in the first prototype, the user first saw a journey overview where they could start the assistance (Figure 36), similar to the overview screen in Figure 35. Afterwards, the walking information is shown before the user leaves the starting location (Figure 37). To solve many users' confusion about this screen, a full route map was included with the circle counter replaced by a text stating when the user should leave. The colour of this text indicates the urgency of the message.

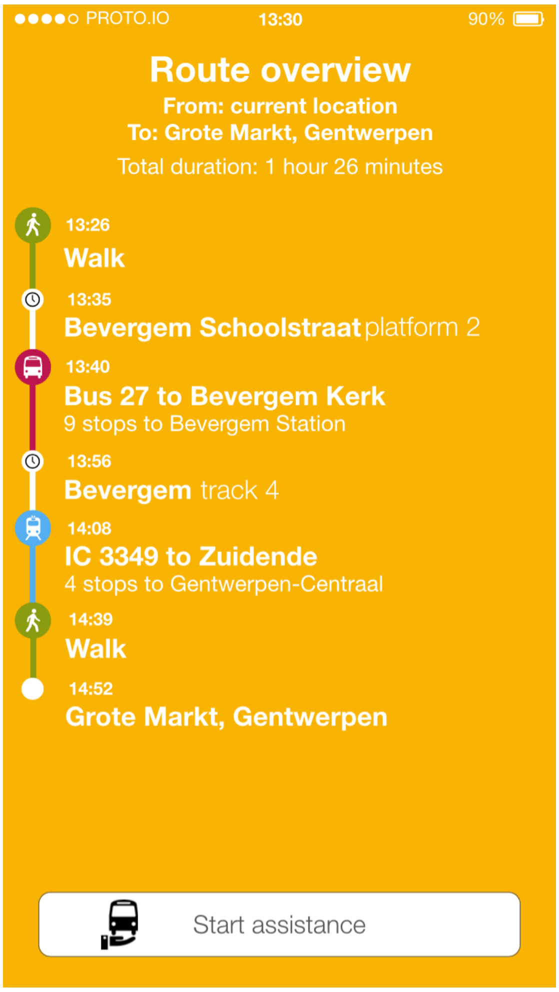


Figure 36. v2 Start screen

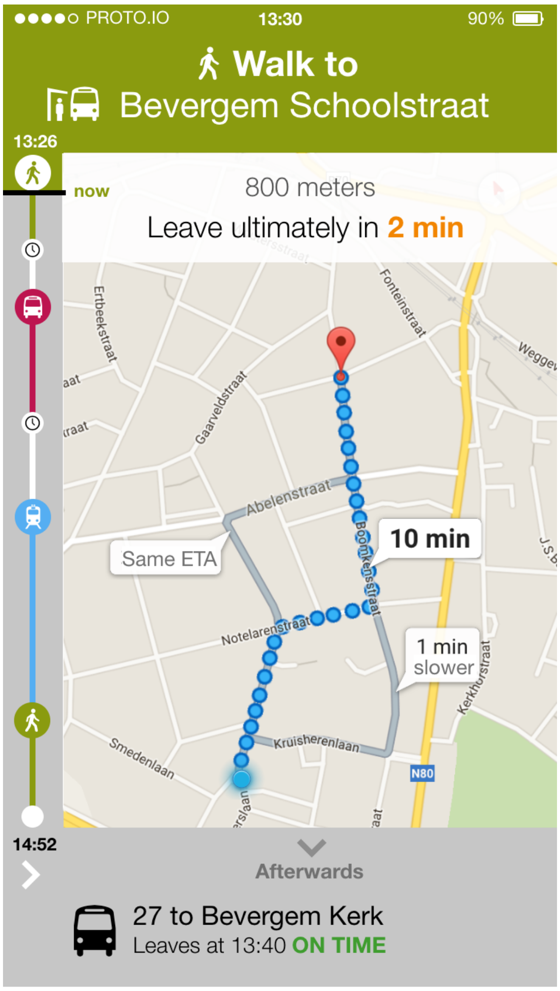


Figure 37. v2 Screen before walking

The distance is also added to give the user an idea of the walking time. A horizontal bar in the vertical progress tracker, together with the word 'now', indicates the user's current position in the journey. When the user starts to walk, the walking navigation is shown (Figure 38). Users can choose between a Street View interface or the 'classic' map navigation. In the Street View interface, the walking route is virtually reproduced in the environment. Depending on the walk speed of the user, the wait time at the bus stop is computed, with a colour code to indicate if there is enough time left or if the user should walk faster.

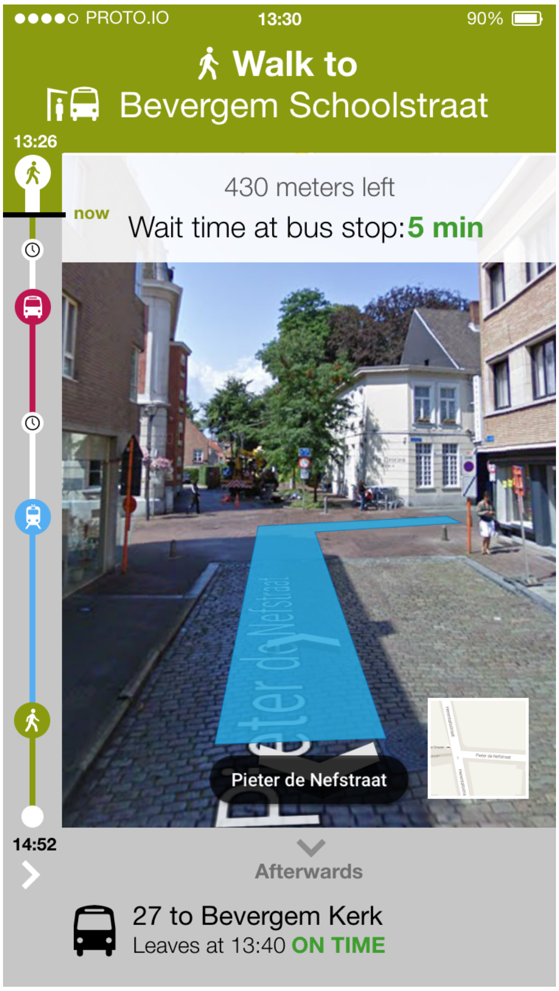


Figure 38. v2 Screen during walking

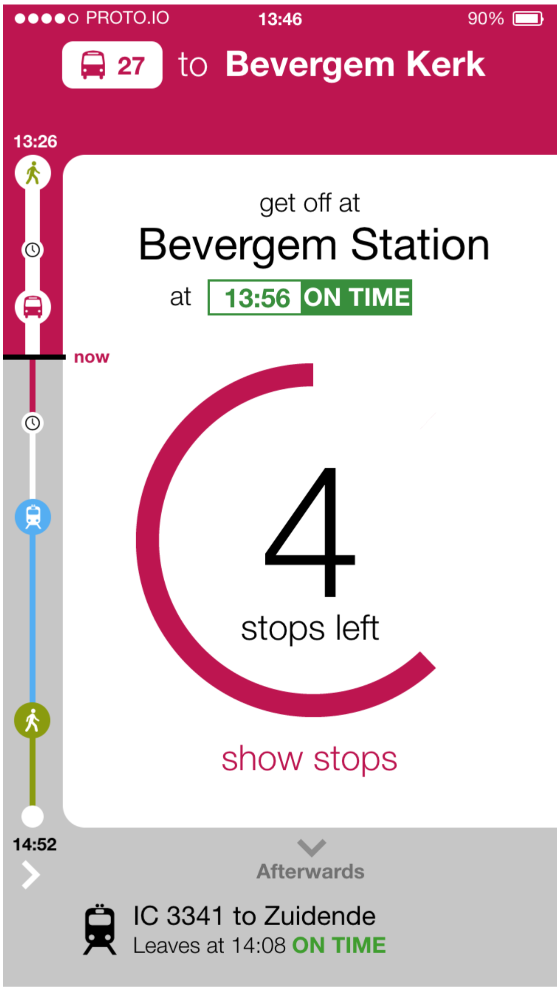


Figure 39. v2 Screen in bus

The screen for the at-stop phase can be seen in Figure 34. It is the same colour as the in-vehicle screen (Figure 39), answering test users' confusion about the colour of the waiting phases. This strengthens the connection between waiting for a vehicle and actually riding the vehicle. Small pieces of text are also added to make the information clearer: 'to' before the vehicle's destination, and 'get off at' to underline the distinction between line destination and exit stop. The time indications are transformed so that there is no need to keep the words 'planned' or 'scheduled' and 'arrival' or 'departure' anymore: this now follows from the wording ('take', 'get off at') and the times themselves. If the vehicle is on time, this is shown right next to the scheduled time in green. If there is a delay, the scheduled, delay and actual time will be shown like in Figure 40. This is a result from some test users' confusion about the different types of time indications. A more standardised approach is an answer to this confusion.

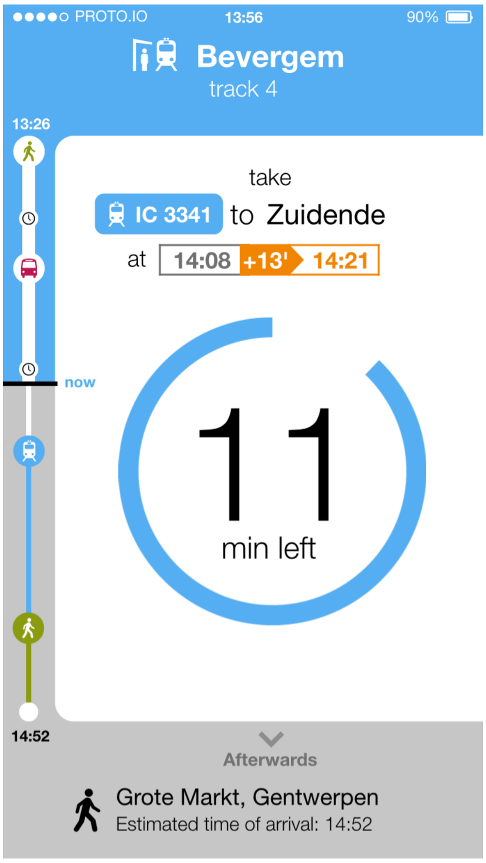


Figure 40. v2 Screen at train station (delayed)

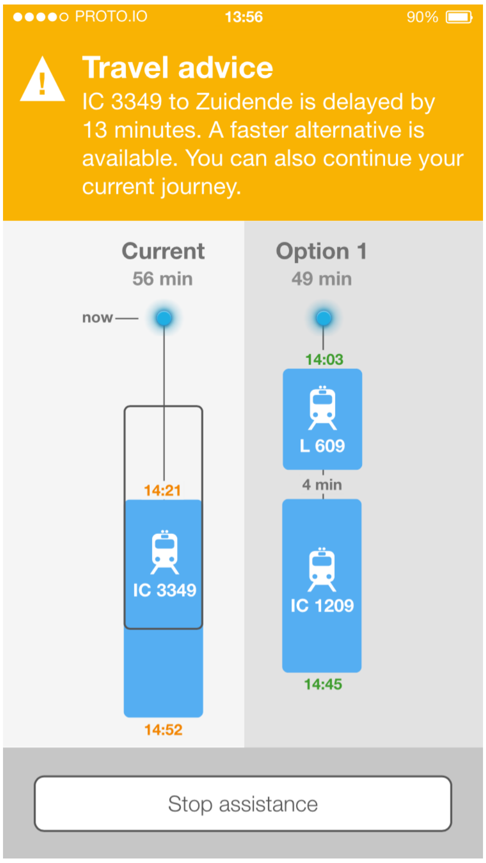


Figure 41. v2 Travel advice

Figure 42. v2 Current journey option details

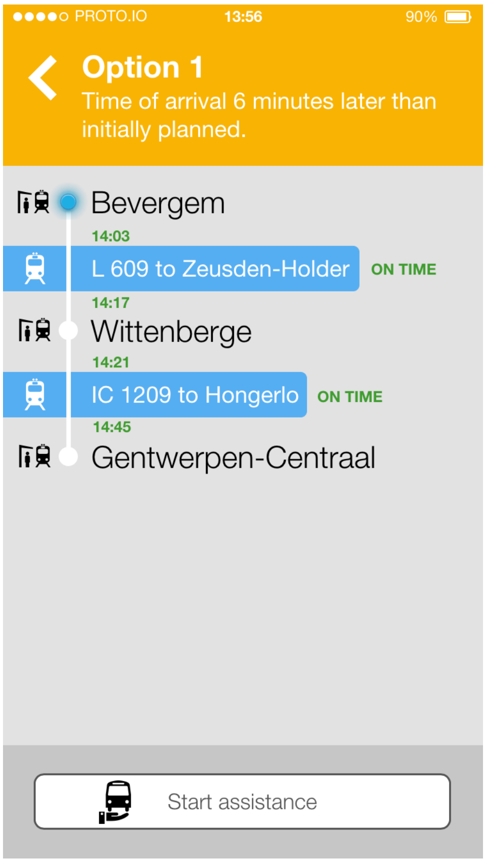


Figure 43. v2 Option 1 details

In the prototype, a travel advice screen (Figure 41) would pop up five seconds after the user viewed the in-station screen where the train has a 13 minute delay. In this travel advice screen, numerous alterations have been made, based on the test users' remarks. The colour of this non-urgent travel advice has been changed from green to orange. The indicated travel times include the waiting time from present, as the user is already underway. Inside the vertical time bars, transfer time is indicated, and time indications for on-time vehicles are coloured in green. The delay time is not separately added to the orange time indications, as this would create confusion (time indications should correspond with their positions on the vertical scale).

In the option details (Figure 42 and Figure 43), not much has changed except for the green colouring of on-time indications and the addition of more specific symbols for train stations and bus stops, which are also used in the other screens. Ideally, these screens should be visually similar to the overview screens in this prototype, but due to time constraints this was not yet implemented.

In this prototype, it was chosen to have only one scenario in which the user was notified with travel advice once, in order to keep survey respondent fatigue to a minimum. The user could choose between either continuing the current, delayed journey, or opting for an alternative in which the user would arrive earlier but would have to change trains once.

After choosing an alternative, users could continue their journey to destination. An in-vehicle screen from both alternatives is shown in Figure 44 and Figure 45.

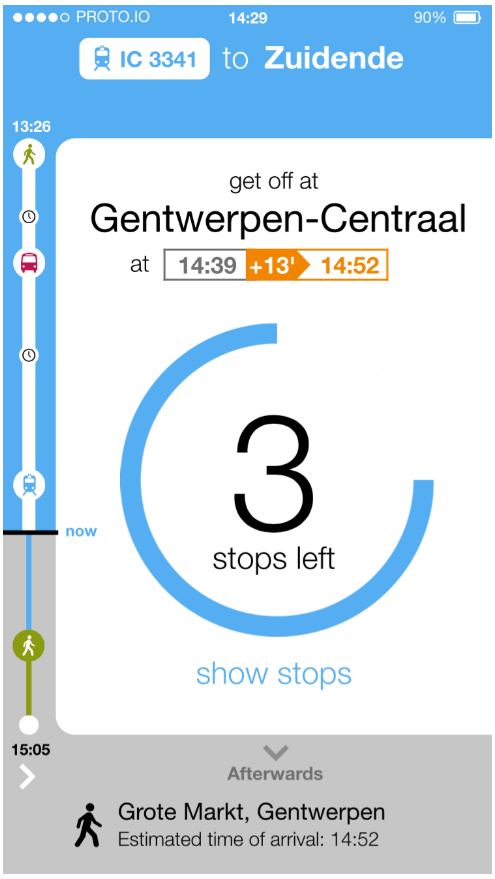


Figure 44. v2 Current journey in-train screen

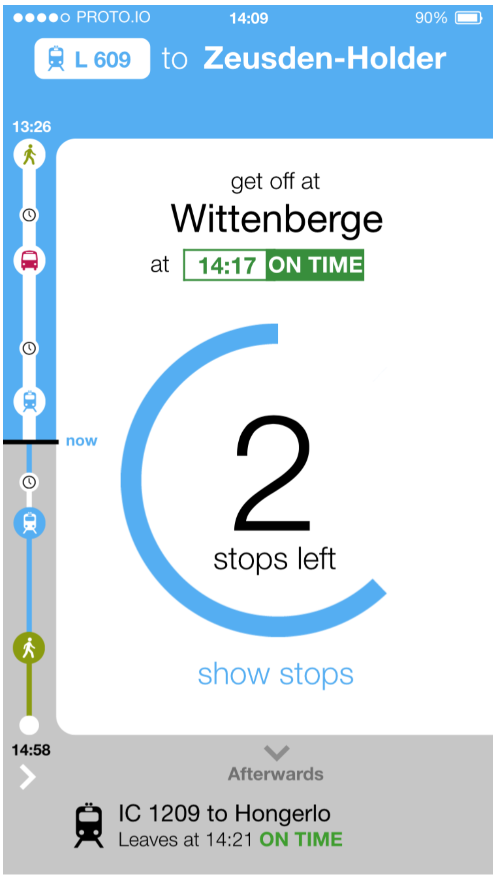


Figure 45. v2 Option 1 in-train screen

In this prototype, the 'show stops' functionality was not yet implemented.

Afterwards, the user saw the final walking screen, with this time the maps navigation version shown in Figure 46. Finally, users would reach their destination. A short review of the journey was added, with the total journey time and the additional travel time shown at the bottom of the screen.

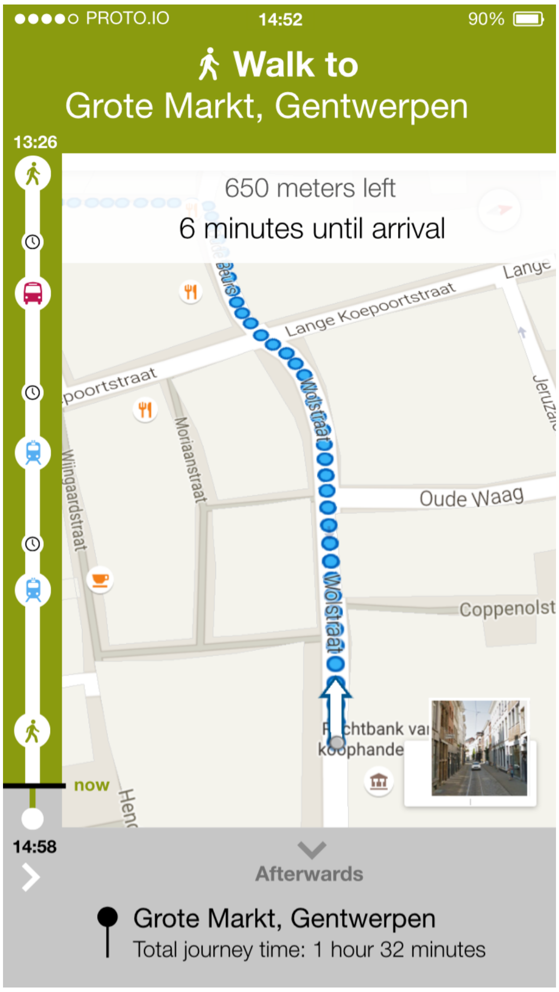


Figure 46. v2 Screen during walk to destination (Option 1)

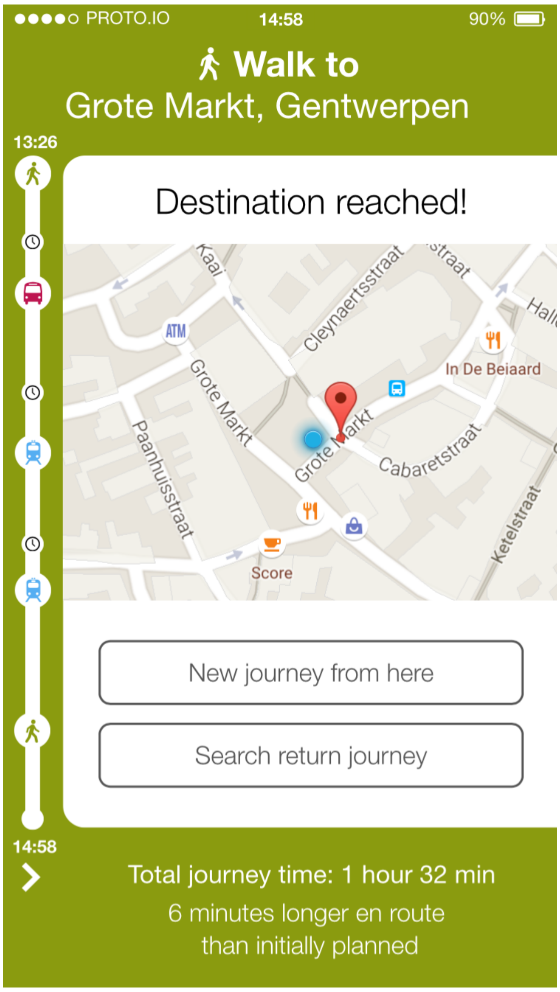


Figure 47. v2 Screen at destination (Option 1)

The evaluation of this prototype version was primarily done through an online survey. The methodology and results of this survey evaluation will be described in the next section.

11 Survey

To evaluate the second prototype, it was decided to create a survey for two reasons. First, it was assumed that the second prototype would generate fewer remarks because it was already an improvement on the first version. In that sense, it was ready to get tested by more people, and an online survey is an efficient way to do this. Second, having an extra type of evaluation could add to the quality of the research, not only for the extra results it would bring but also for the experience gained via creation and analysis of the survey. A short evaluation of the different evaluation methods (a meta-evaluation) takes place at the end of this thesis.

Although there are clear advantages to an online survey, namely the rapid and efficient collection of feedback from a lot of different people, there are also drawbacks that should be taken into account while analysing the results. The major drawback is probably the lack of personal interaction between the interviewer and the participant. In the course of the survey, the respondent cannot ask questions or react at things the interviewer says or does. This lack of interaction could produce a less thorough evaluation of the prototype, worsened by the relatively short time respondents will take to evaluate the application (compared to the focus groups). As a long and detailed survey creates fatigue with survey respondents, resulting in a relatively large dropout ratio, an online survey may not deliver the same level of detail as individual interviews and focus groups. Although this is something that should definitely be taken into account during analysis and further improvement, the online survey retains great value for rapid collection of feedback from a significant number of respondents.

Before discussing the results of this survey, the methodology and response information will be described.

11.1 Methodology

The first goal of the online survey was that it should, on average, take no longer than 15 minutes to complete. Otherwise, the amount of respondents dropping out of the survey could grow too high, which would have a negative impact on the number of complete responses. In order to keep survey time low, some screens of the application would have to be evaluated together. For instance, the at-stop and in-vehicle screens of the bus and train phases could be evaluated together, as those screens have the same composition of information elements.

The full survey can be found in the annexes (in Dutch). First, a short introduction to the project was given. Afterwards, the same socio-demographic and travel behaviour questions as in the focus group invitations were asked, excluding the one about type of smartphone, irrelevant for the survey. More information about the prototype was given, so that respondents would understand the goal of the application. This was done to compensate for the lack of interaction with the interviewer, who had been able to intervene during the focus groups and interviews whenever necessary. Afterwards, the respondent had the chance to walk through the scenario of the prototype via a link to a Proto.io-viewer that could also be opened on mobile devices. Two tooltips (small information guides) were shown in the screen before walking (Figure 37 p.46) that indicated where the user should tap to continue to the next step and how the overview screen could be opened.

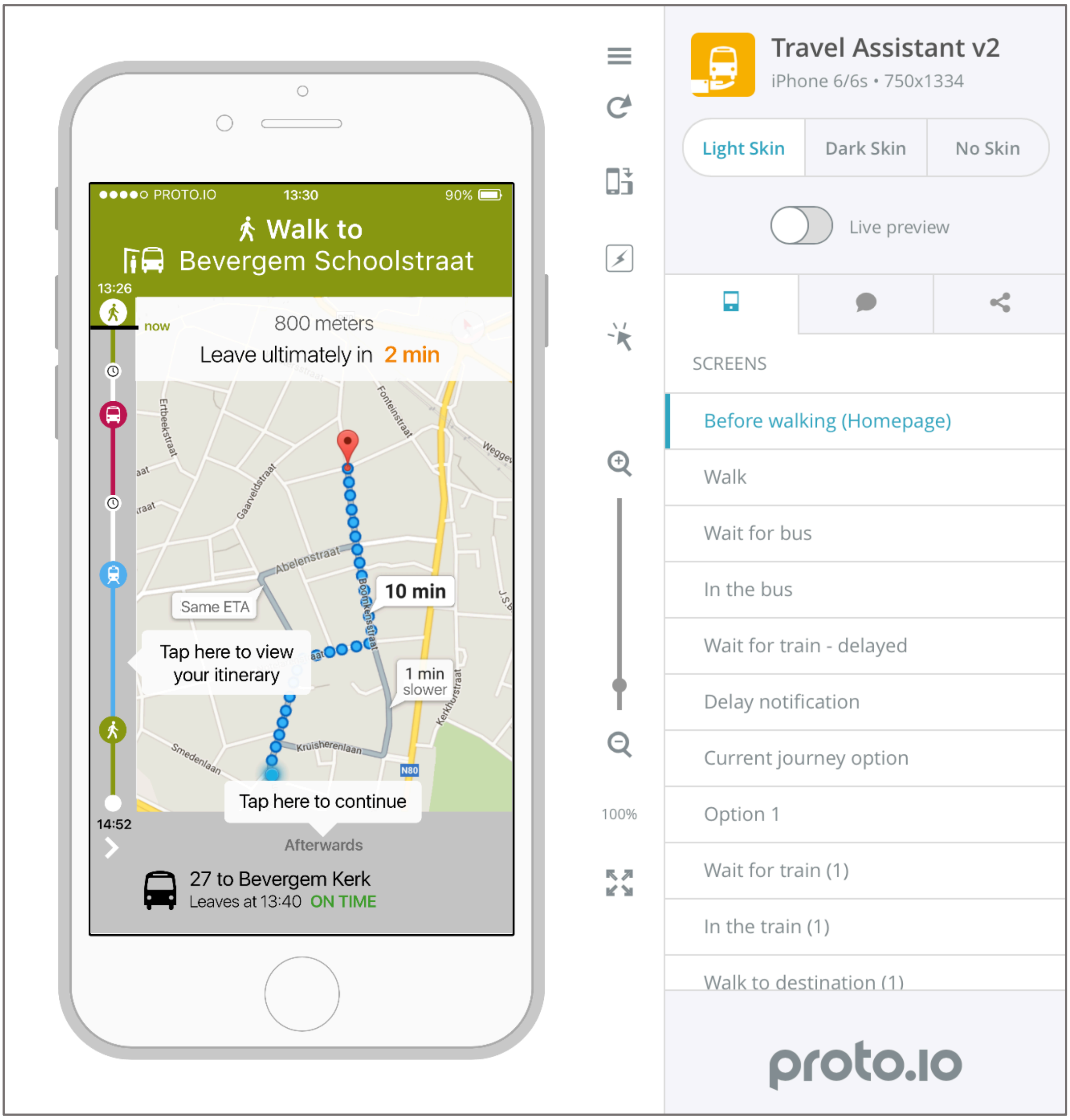


Figure 48. Proto.io viewer and the screen before walking with tooltips

In the last screen of the prototype, a message was shown that stated that the user had come to the end of the scenario, and that they could return to the survey.

Then, the survey showed screenshots of all relevant screens of the prototype and asked respondents to rate their satisfaction with the screen and to add any comments, suggestions or questions that they deemed relevant. On every page, a hyperlink was provided so the respondents could return to the Proto.io viewer whenever they wanted.

The following screens were evaluated separately:

1. Start screen (Figure 36 p.46)
2. Screen before walking (Figure 37 p.46)
3. Screen during walking (Figure 38 p.47)

4. Screen at bus stop (Figure 34 p.45) and screen in station (Figure 40 p.48)
5. Screen during bus ride (Figure 39 p.47) and screen during train ride (Figure 44 p.49)
6. Travel advice (Figure 41 p.48) and option details (Figure 43 p.48)
7. Overview screen (Figure 35 p.45)

The satisfaction question for each set of screens was as follows:

"How satisfied are you with this screen? (consider legibility, clarity, overview, relevance of the information at the right time, etc…)"

- *Very dissatisfied*
- *Rather dissatisfied*
- *Neither satisfied nor dissatisfied*
- *Rather satisfied*
- *Very satisfied*

If the respondent chose one of the two 'dissatisfied' options, an extra question appeared in which the respondent was asked why they were dissatisfied with the screen. This looked as follows:

"If you are dissatisfied with this screen, why is that?"

- *Legibility of the text*
- *Clarity of the information*
- *Overview of the interface*
- *Relevance of the information*
- *Other: [text box]*

The respondent could choose one or more options. If the respondent was neutral or satisfied with the screen, an open question with a text box would show up instead. The question was phrased as follows:

"Do you have questions, comments or suggestions for this screen? You can leave them here:"

After the individual screen assessment, a SUS questionnaire was shown to the respondent with the same questions and phrasing as for focus groups. Afterwards, general satisfaction with the prototype was gauged by showing 5 stages of a smiley face: very sad, sad, neutral, happy, and very happy.

Finally, respondents were given the opportunity to give general feedback or suggestions or ask questions in an open text box. Respondents could also leave their email addresses if they wanted to be kept informed about the further development of the thesis, but this was optional.

11.2 Response

The survey was first sent out to the test users from the individual interviews for the first prototype. This was done to check if there were no issues with the survey. If respondents found issues, these could be dealt with before diffusion to a wider audience. The next day, participants from the focus groups were invited by e-mail to fill in the survey. Afterwards, the survey was spread via Facebook and Twitter. A few days later, it was also diffused via the e-mailing system of the university to all employees. It was decided not to e-mail all university students, because this would greatly impact the age distribution of the respondents and create a bias towards a younger age group.

Between April 27 and May 6, 2016, 224 people opened the survey. 134 respondents filled it in completely, which gives a completion rate of 59,8%. In comparison, Hoerger (2010) found completion rates between 70,9% and 94,4% in six different studies. He states that “[a]pproximately 10% of participants can be expected to drop out almost immediately, with an unremarkable 2% dropping out for every 100 items of survey content.” Although the number of ‘items’ in this survey is relatively low, the complete survey asks for a lot of energy because the prototype has to be used and evaluated. Similarly, SurveyMonkey found that the dropout rate (the inverse of completion rate) rises as the number of questions in a survey rises, but this relationship is not linear. From their results, it can be derived that for a survey of about 30 questions (this survey has 31), the dropout rate would be about 8% (“Does Adding One More Question Impact Survey Completion Rate?", 2010). This is however based on 2000 random surveys with different characteristics, so it is difficult to translate this to an evaluation of this survey’s dropout rate.

Why is the dropout rate relevant? It introduces the risk of non-response error, which occurs when respondents to a survey differ from the population from which they are drawn (LaRose & Tsai, 2014). When convenience samples are used, like in this survey, there is a risk that people who did not fill in the survey might have a different opinion on the prototype than when a random sample from the population is taken and respondents have to fill in the survey. The risks of this non-response error should be taken into account for the analysis and evaluation of the results of this survey.

Only the completed surveys will be further analysed. To check the socio-demographics and travel behaviour aspects of the survey sample for validity purposes, their results will be discussed first. 53% of the respondents were male and 47% were female, which is a fairly even split. When looking at age, it is clear that a large part of the respondents is between 18 and 34 years old (70,8%), which may introduce a bias towards younger people in the prototype evaluation (Figure 49).

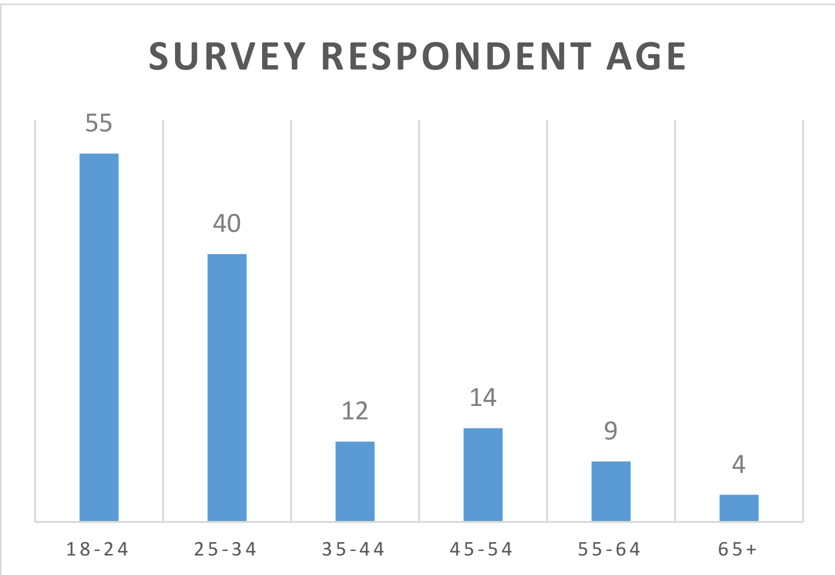


Figure 49. Respondent age distribution

Considering the public transport use of the respondents, there is a fairly equal distribution between frequent and occasional public transport users. Respondents who use public transport at least a few times per week make out 50% of the sample, with the other half consisting of respondents who use public transport a few times per month or less (Figure 50).

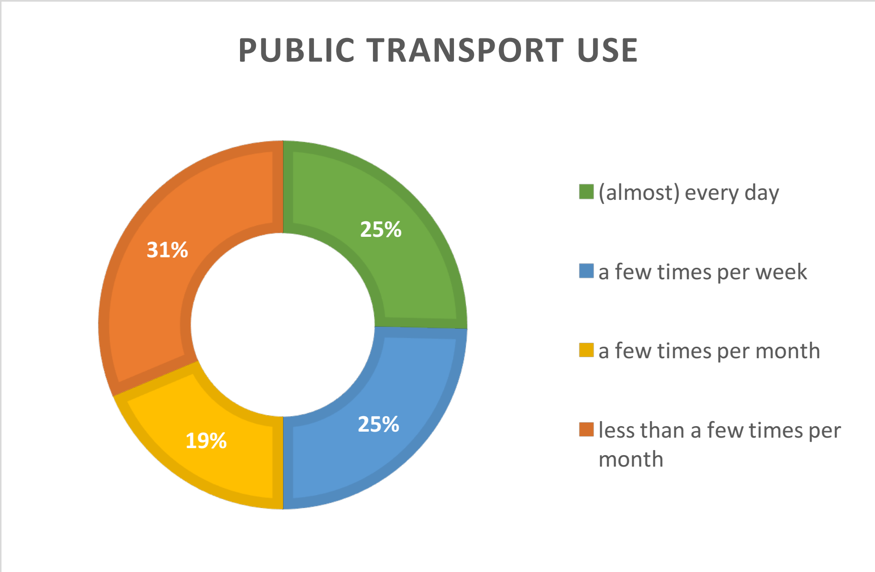


Figure 50. Public transport use among respondents

90% of respondents own a smartphone. This is higher than the 68,5% in Belgium, found by Vanhaelewyn, Pauwels, De Wolf, Accou, & De Marez (2015), which is probably due to the relatively young demographic in this survey. However, the report indicates that smartphone ownership rises by around 10 percent points every year, so by the time that the survey was diffused, the difference between sample and population smartphone ownership may have been lower. Out of the smartphone owners, 71% respondents use travel apps. Most of them use the De Lijn- and NMBS-apps (77 respondents each, or 80% of respondents that use travel applications) and Google Maps (76 respondents, or 79%). 19 of them, or 20%, use other travel applications (Figure 51).

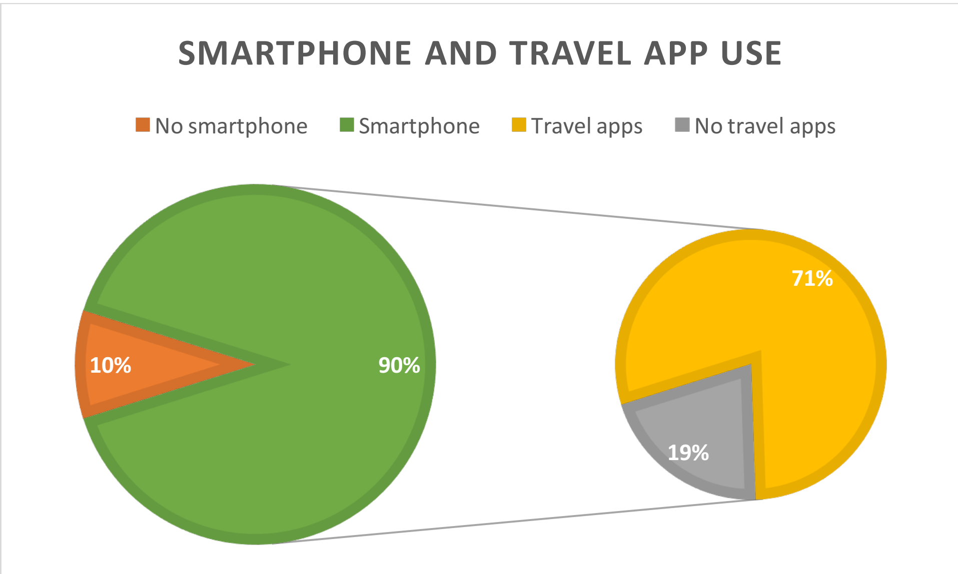


Figure 51. Smartphone ownership and travel app use

Finally, a short analysis about the survey completion times is relevant. The survey was intended to be completed in 15 minutes, in order to keep respondent fatigue as low as possible. Out of the 134 respondents, 91 completed the survey in under fifteen minutes (68%), of which 23 did it in even less than five minutes (17%). The minimum completion time is 2 minutes and 27 seconds. Completing the survey in less than five minutes would mean that the respondent could not have taken a lot of time to test the prototype, which could be problematic for giving critical feedback. This should be taken into account during the result analysis. Furthermore, 27 respondents completed the survey in between fifteen and thirty minutes (20%), eight respondents did it in between thirty minutes and an hour (6%), and eight respondents did it in over an hour (6%)[12]. It is possible that these respondents decided to leave the survey for some time and return later. This is however not possible to derive from the survey data.

Next, the results of the survey will be discussed.

[12] The average completion time for all respondents is exactly 20 minutes, but with a standard deviation of 42 minutes and 44 seconds. If all completion times over an hour are considered as outliers, the average time becomes 12 minutes and 5 seconds, with a standard deviation of 9 minutes and 36 seconds.

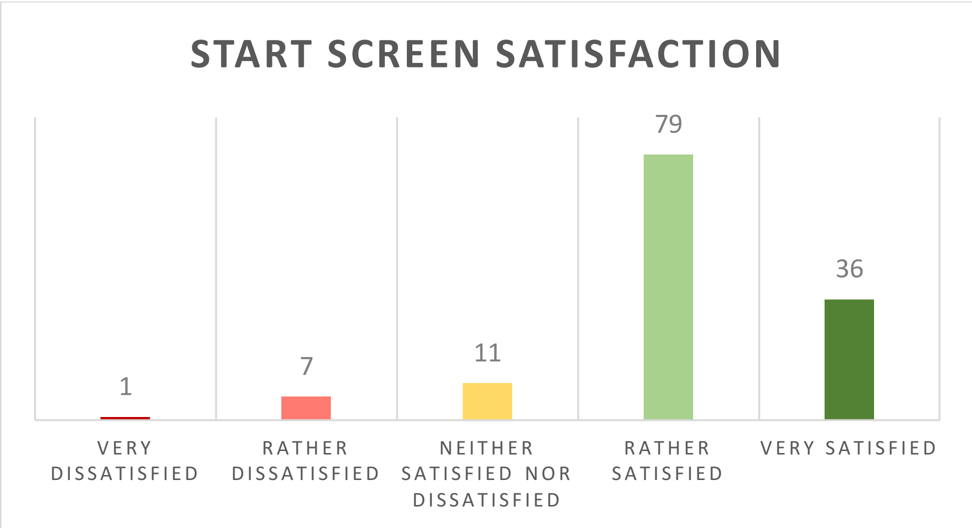
11.3 Results

First, the satisfaction and remarks of each set of screens will be discussed. Afterwards, a more quantitative analysis will be made through the SUS questionnaire.

11.3.1 Satisfaction and remarks

For every set of screens, the satisfaction distribution of the respondents will be analysed. Then, the main groups of remarks will be discussed.

1. **Start screen**

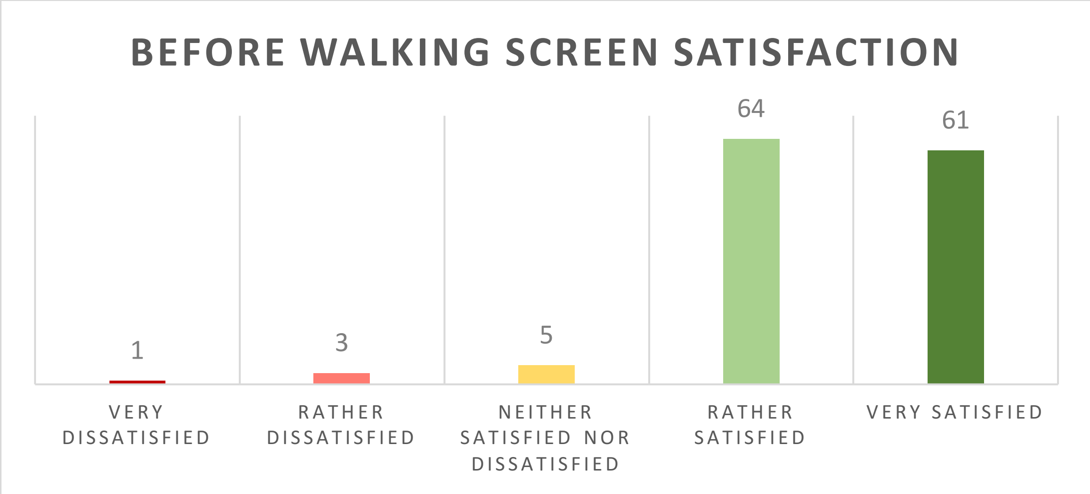


Most respondents (59%) were rather satisfied with the start screen (Figure 36 p.46). For those who were rather or very dissatisfied, 5 respondents indicated that this was because of the text legibility, 2 found the clarity of the information insufficient, and 2 found that they lost overview. More than one reason for the lack of satisfaction could be indicated.

Looking at the remarks that respondents gave, the biggest concern was about the orange background of the start screen. 25 respondents found this to be too bright, making the text illegible (two respondents, however, indicated that they enjoyed the orange background and did not find it disturbing). Seven respondents indicated that they would like to see the walking distance for each walking part. Six respondents suggested that the duration of each step should be included in the overview. In contrast with the two last comments, five respondents found that there was already too much information on the screen and that it should be reduced. Other respondents asked if this screen also showed delays, if an integration with ticket purchasing could be implemented, and if the number of transfers could be shown at the top.

Action for improvement: *the biggest concern is the orange background of the screen, which would create legibility issues. This should change so that the contrast is better. This will also make it possible to show delayed time indications in orange, in line with the rest of the application. Including the walking distance is possible, as an analogy with the number of intermediate stops for the public transport trips. Indicating the duration for each step would, however, greatly increase the amount of information on the screen, which is already found overwhelming by some.*

2. Screen before walking

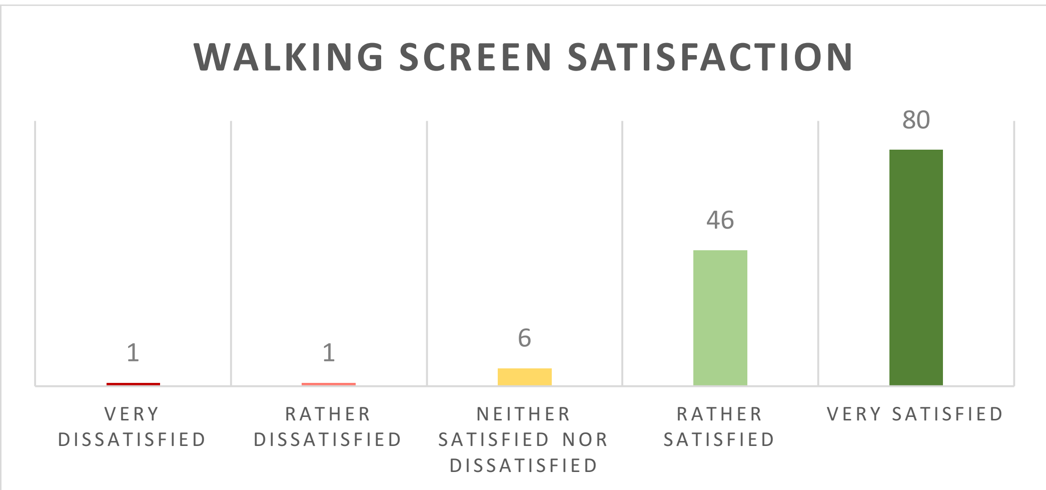


Satisfaction for this screen (Figure 37 p.46) was higher than for the previous screen, with 93% of respondents indicating they are rather or very satisfied with this screen. Dissatisfied respondents indicated that they had issues with information clarity (1 person), overview (2 persons) and information relevance (1 person).

Most remarks were about the Google Maps interface, with six respondents saying that the interface was not always very legible and clear, that they do not want several walking route alternatives, that they did not understand 'ETA', that they found the blue circle for the current position to be badly visible, or that they generally did not like the Google Maps interface. Six respondents indicated that they found the whole screen to be clear and well-arranged, appreciating the functionality that states when to leave. Another respondent asked if it was possible to have directions for bicycles.

Action for improvement: *although the Google Maps interface cannot be changed very easily, it should be noted that users demand a clear and easy to use walking navigation. More research should go into how digital maps can be optimised for pedestrians, but this is beyond the scope of this research. Adding bicycle navigation should certainly be possible for this kind of application, but this has been left out of the concept so far because it would not significantly add to the evaluation of this prototype.*

3. Screen during walking

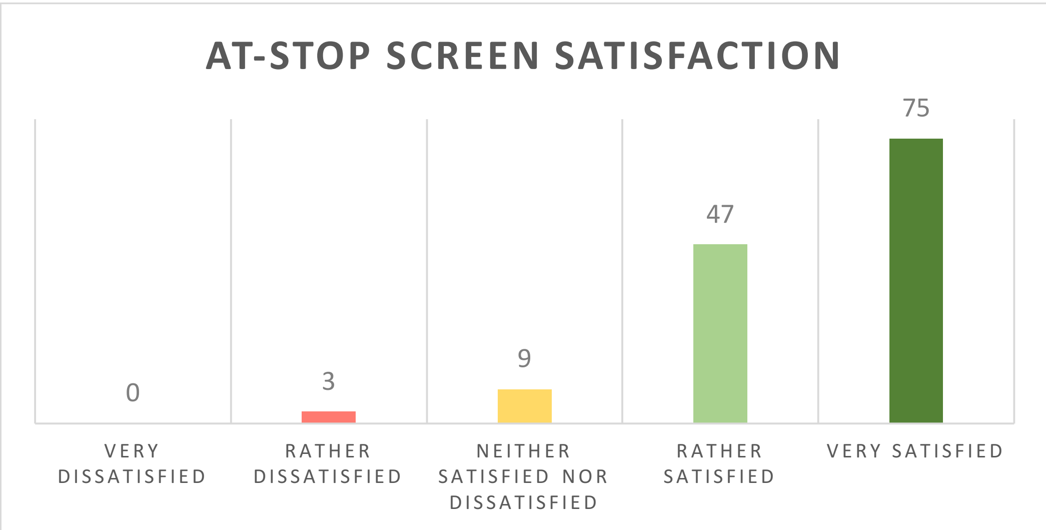


With 80 out of 134 respondents very satisfied with this screen (Figure 38 p.47), this is the best-evaluated portion of this prototype. Dissatisfied respondents did not tick any reasons for their dissatisfaction, but indicated that Street View would demand a lot of data communication, and that they did not need Street View navigation but would be content with maps.

Ten respondents indicated they were very happy with the Street View functionality. Three respondents had concerns about the battery usage, while two other respondents wanted to know what would happen if Street View was not available. Another respondent asked what would happen if the bus could not be caught anymore.

Action for improvement: *a Street View functionality would probably use more battery and bandwidth than normal maps navigation. However, there is always the possibility to switch to maps navigation, which is standard if there is no Street View available. In case the bus cannot be caught, the application will automatically show travel alternatives.*

4. At-stop screen

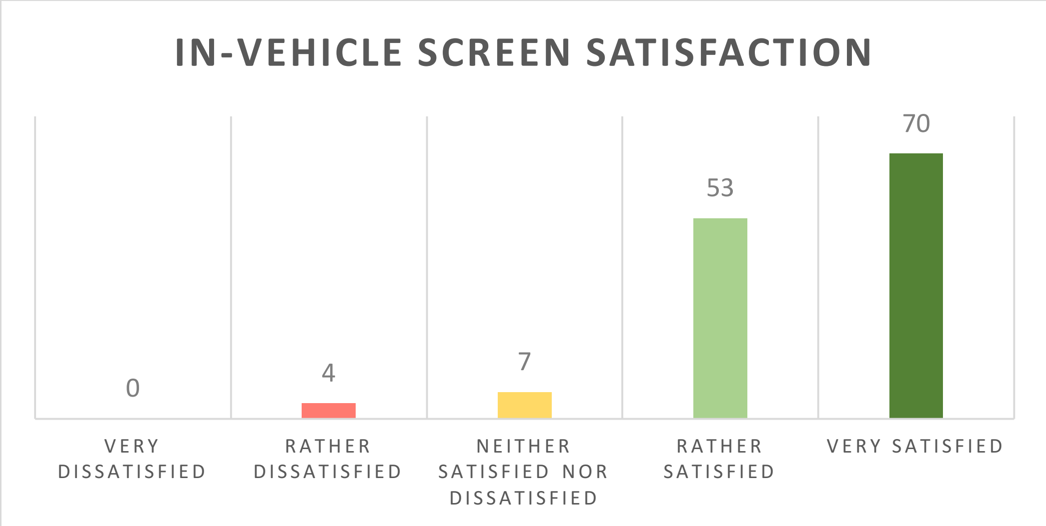


Most respondents (75 out of 134) were very satisfied with this screen (Figure 34 p.45 and Figure 40 p.48). Dissatisfied respondents expressed concern about information clarity and overview.

Five respondents asked if it would be possible to show the delay part in the circle counter. Other respondents asked if the application gave notifications and what happened if the track or platform got changed at the last minute. Four respondents explicitly stated that they liked this screen. One other person stated that they did not see the added value of the circle counter, but that it was not disturbing.

Action for improvement: *it is a good idea to show the delay part in the circle counter through a different colour. Notifications should be activated in the settings. In case of a last-minute track or platform change, this should be made clear visually and/or through a notification.*

5. In-vehicle screen

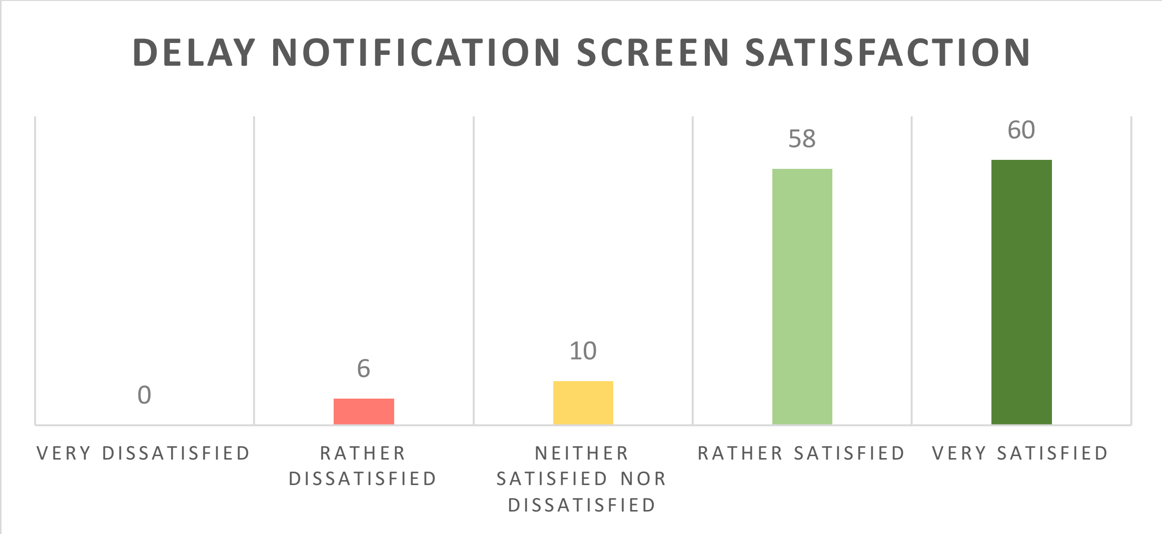


Respondents were approximately as satisfied with this screen (Figure 39 p.47 and Figure 44 p.49) as with the at-stop screen, with 92% indicating they were rather or very satisfied. Dissatisfied respondents indicated that they had issues with information clarity (2 respondents), overview (2 respondents) and information relevance (1 respondent).

While the focus group participants indicated that the number of remaining stops was more important than the number of remaining minutes, five survey respondents indicated that they would prefer to see the remaining time. Some of the respondents also indicated that they found the number of remaining stops to be a bad indicator of progress, because buses do not halt at every stop. Three respondents suggested to give a push notification when the user is nearing their exit stop. One respondent asked if the number of remaining stops was calculated with the GPS position or if it was linked to the real-time information. In the latter case, he would not trust this information. Another respondent indicated that the delay time indication was very clear.

Action for improvement: *as users clearly have different opinions on whether to show the remaining time or the remaining stops, it might be an option to let the user switch between the two by tapping the circle. As mentioned earlier, notifications can be customized in the application settings. The current location through GPS is the most accurate way to calculate the number of remaining stops, but when the signal is bad the application should be able to revert to real-time information from a server.*

6. Delay notification screen

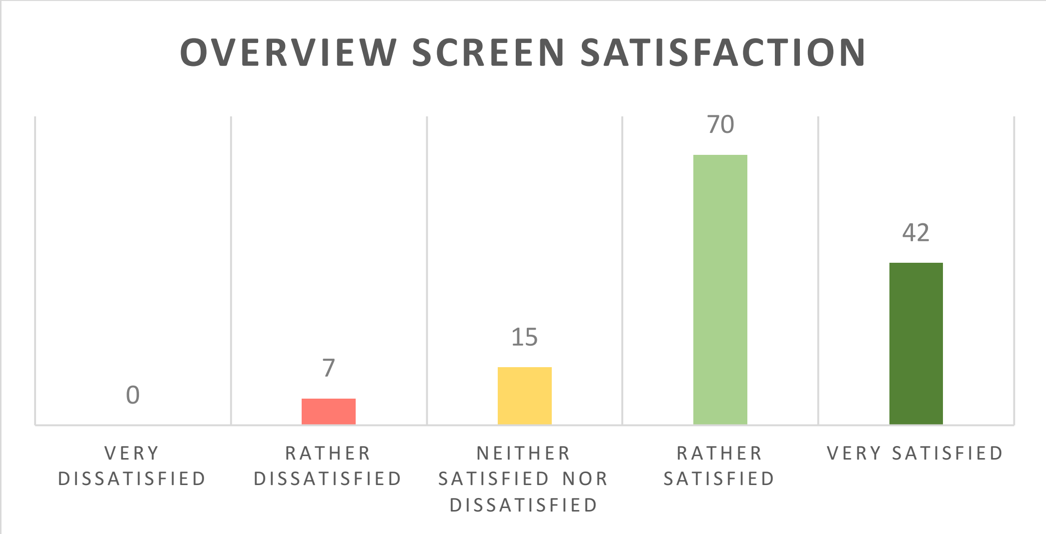


Respondents were overall quite satisfied with the delay notification screen (Figure 41 p.48) and the option detail screens (Figure 42 p.48), although the proportion of very satisfied respondents is lower compared to the three previous screen evaluations. Dissatisfied respondents indicated that they had issues with text legibility (1 person), information clarity (4 persons) and overview (4 persons).

Seven respondents indicated that they had trouble with the presented information, stating that they found the information unclear and that it was not clear that they had to choose an option. Some respondents also found the different route overview type in the option details to be unclear. Four other respondents stated that they found these screens very straightforward. Two respondents indicated that they did not like the orange background colour at the top. One person suggested to let the introductory text end with a question, as this would incite user action. This time, there were no comments on the travel time indication above the vertical time bars, which might imply that the new situation is better for the respondents.

Action for improvement: *it is not completely evident why some respondents found the screens unclear. One possibility might be the different types of route overview in the option details. This should be changed to the 'normal' overview style that is used in the rest of this prototype. There were no specific comments on the vertical time bars, so they do not seem to raise much of an issue. The colour of the top sections can be adjusted to increase contrast. It is also a good suggestion to let the text end with a question, for instance "Would you like to choose a faster alternative, or continue your current journey?".*

7. Overview screen



Compared to the other screens, the overview screen (Figure 35 p.45) gets a worse evaluation, with 7 rather dissatisfied and 15 neutral respondents. Dissatisfied persons indicated that they had issues with text legibility (3 respondents), information clarity (3 respondents) and overview of the information (1 respondent).

Like in the case of the start screen, a number of respondents had issues with the orange background colour which would not provide enough contrast with the white text (seven remarks). Besides that, nine respondents indicated that they found the thicker white line not sufficient to show the user's progress in the journey; suggesting that this should be made clearer. Another respondent suggested to put the time indications besides the text instead of above it. Two respondents indicated that the screen was rather crowded, although one of them stated that it became useful once they got accustomed to it.

Action for improvement: *like in the case of the start screen, a solution should be found for the orange background colour so that the information gets more legible. A horizontal line could be added to emphasise the current progress of the user. Putting time indications next to the text, for instance on the other side of the vertical progress bar, could be a way to 'clean up' the screen and give it more structure.*

11.3.2 Quantitative evaluation (SUS)

Like the focus group participants, survey respondents were asked to fill in a SUS questionnaire. The results of this questionnaire are shown in Figure 52.

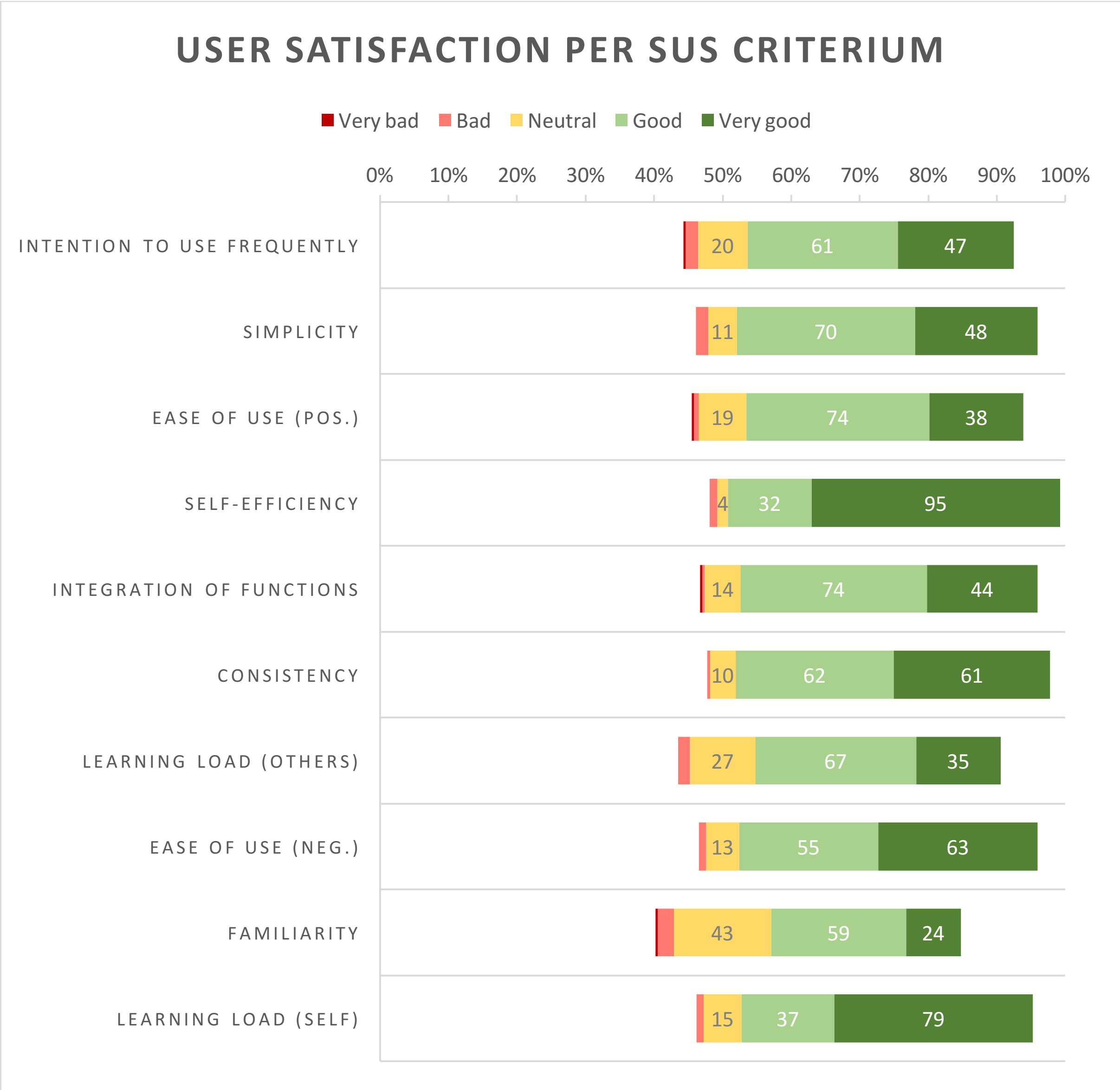


Figure 52. SUS evaluation by survey respondents

1. **Intention to use frequently**

"I think I would like to use this application frequently"

Positively phrased statement: a high score ('Strongly agree') corresponds with a positive evaluation ('Very good'). 80,6% of respondents rather or strongly agreed.

2. Simplicity

“I found the application unnecessarily complex”

Negatively phrased statement: a high score (‘Strongly agree’) corresponds with a negative evaluation (‘Very bad’). 88% of respondents rather of strongly disagreed, which is a positive score.

3. Ease of use (positively phrased)

“I thought the application was easy to use”

Positively phrased statement. Although most participants rather or strongly agreed (83,6%), they were modest in their evaluation, with 74 out of 112 respondents rather agreeing. 22 respondents disagreed or were neutral.

4. Self-efficiency

“I think I would need the help from someone else to use this application”

Negatively phrased statement. Like with the focus group participants, this statement generated the most positive evaluation with 70,9% of respondents disagreeing strongly. This should again be little surprise, as mobile applications are usually intended to be used without any external help or education.

5. Integration of functions

“I found the various functions in the application were well integrated”

Positively phrased statement. This statement got a similar evaluation to those of Simplicity and Ease of Use (Pos.): 88% of respondents rather or strongly agreed.

6. Consistency

“I thought there was too much inconsistency in this product”

Negatively phrased statement. With 45,5% of respondents disagreeing strongly and a similar percentage rather disagreeing, this is a positive evaluation, similar to that of the focus group participants.

7. Learning load (others)

“I imagine that most people would learn to use this application very quickly”

Positively phrased statement. Participants’ evaluations were a bit mixed, with 5 respondents rather disagreeing, 27 persons remaining neutral and most of the respondents rather agreeing (50%).

8. Ease of use (negatively phrased)

“I found the application very cumbersome to use”

Negatively phrased statement. Almost half of respondents (47%) strongly disagreed with this statement, giving it an overall positive evaluation. The evaluation for this statement is better than for the positively phrased ease-of-use statement, which means that participants are more reluctant to call it cumbersome than to call it easy to use.

9. Familiarity

"I felt very familiar with the application"

Positively phrased statement. This statement got the most negative evaluation, with 1 person strongly disagreeing, 7 respondents rather disagreeing and 43 respondents remaining neutral (32%). This is similar to the evaluation by the focus group participants.

10. Learning load (self)

"I needed to learn a lot of things before I could get going with this system"

Negatively phrased statement. This is the only statement where the evaluation differs noticeably from the one by the focus group participants. In this case, it is the second most positive evaluation, with 59% of respondents strongly disagreeing with the statement. This is also different from the evaluation for Learning Load (other), where respondents were less extreme in their answers.

Overall, the evaluation of the second prototype via the SUS questionnaire got similar results as for the first prototype, with the lowest scores going to Learning Load (other) and Familiarity. It is unclear however why Learning Load (self) gets a more positive evaluation for the second prototype. A possible explanation might be that the changed user interface made respondents believe they would learn it faster. There is however no indication that the ease of use improved dramatically, looking at the evaluations of the other statements. Another, more radical explanation might be that the primarily young demographic in the survey sample are more confident towards their own learning capabilities, especially concerning smartphone applications, than older respondents.

In total, the average SUS score of the second prototype is 80,1 out of 100, which is slightly higher than the one of the first prototype (78,1) and still significantly higher than the average SUS score of 68. Bangor, Kortum, & Miller (2009) researched how SUS scores would compare with acceptability ranges, school grading scales and adjective ratings. A score of 80,1 would be very acceptable, between a C and B score, and closer to 'excellent' than 'good' when people would describe the system. This is very positive, although there is still room for improvement.

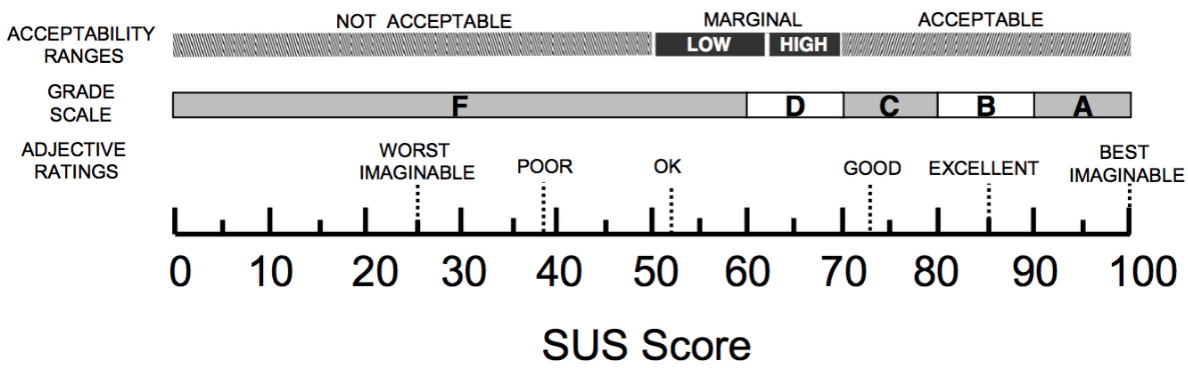


Figure 53. A comparison of the adjective ratings, acceptability scores, and school grading scales, in relation to the average SUS score (Bangor et. al., 2009)

Finally, respondents were asked to rate their general satisfaction with the application through adjusting a smiley face over five stages (Figure 54). Most of the respondents indicated that they were generally very satisfied (52%), while 43% indicated they were rather satisfied. Seven respondents remained neutral. This is again a very positive score, although it should certainly be taken into account that there is a risk for non-response bias (those who did not fill in the questionnaire), and that a large number of respondents were reached via Facebook, and could thus be naturally more positive towards the project because they are friends or acquaintances of the researcher.

Figure 54. Overall satisfaction with the second prototype

In the final section where respondents could enter any other remarks, suggestions or questions, 35 respondents gave feedback. The most recurring remark was the respondents' fears about the accuracy of real-time information (5 respondents). This will be further discussed in the practical implications of section 13. Two respondents suggested to include a ticket sale functionality in the application, one respondent said that notifications are very important for this application, and one other respondent asked how the battery life would fare. Another respondent suggested to include spoken instructions for visually-impaired people. Five respondents indicated that they would not need the application because they are satisfied with Google Maps or because they do not use public transport frequently. On the other hand, six respondents explicitly stated that they saw potential in the application. Other remarks comprised comments on the interface layout, questions about its functionalities, and congratulations.

The results of this survey will be taken into account for a final improvement of the second prototype, so that a well-evaluated application concept is delivered in this thesis.

12 Final improvements

Based on feedback from the survey, final improvements to the prototype are implemented, which complete the iterated development cycle that started with the literature review and the first paper-based concepts. Before getting started with designing these last improvements, professional feedback was pursued from two user interface designers (Gärtner, 2016; Morgan-Jones, 2016), one of which is active at a travel app startup company.

Both designers advised to implement a functionality that shows the intermediate stops when the user is in a public transport vehicle. This had always been the idea, but was not yet implemented. Another advice from both was to implement a visual notification that the user has to interact with before opening the travel advice screen, because it would be too intrusive for user experience to have it pop up without any warning. An extra suggestion made by one of them was to include exit navigation so that the user can end the assistance at any time. He also suggested to remove the small arrow below the vertical progress tracker that indicated that swiping left would open the overview screen, and to rely on the tooltip for novice users to learn how to open the screen. The tooltips should be made more visually distinct from the rest of the screen, so that there can be no confusion with other interface elements.

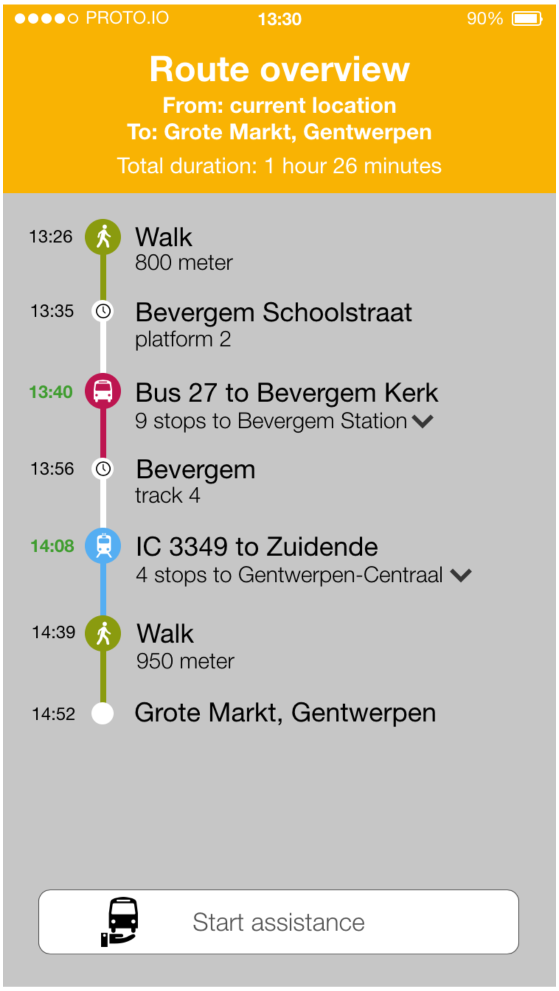


Figure 55. v3 Start screen

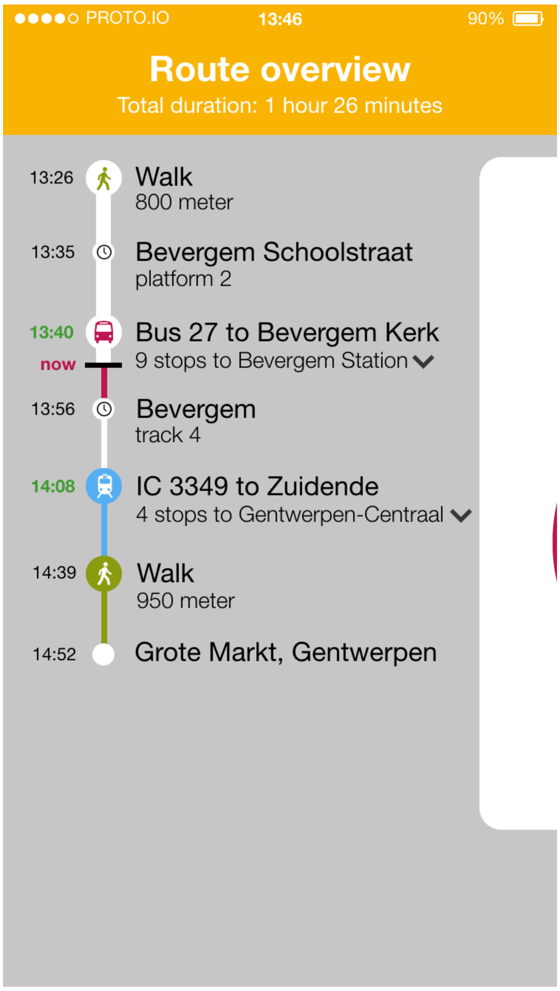


Figure 56. v3 Overview screen during bus ride

The biggest changes were made to the start and overview screens (Figure 55 and Figure 56), as these received the most comments from survey respondents. The orange background colour was changed to light grey which, together with black text, should provide better contrast. To create more clarity and structure in the route overview, all time indications were moved to the left of the vertical progress bar. These time indications are now colour-coded in green or orange to visualise whether vehicles are on time or delayed. Per request from several respondents, walking distance has been added in the same fashion as intermediate stop information for public transport. Arrows are added next to this line of text, which shows the list of intermediate stops when the user taps it. To provide greater consistency, platform information has been moved below the stop name, instead of next to it. Finally, in the in-assistance overview, the current position is better indicated with a horizontal time bar and the word 'now', like in the current step screens.

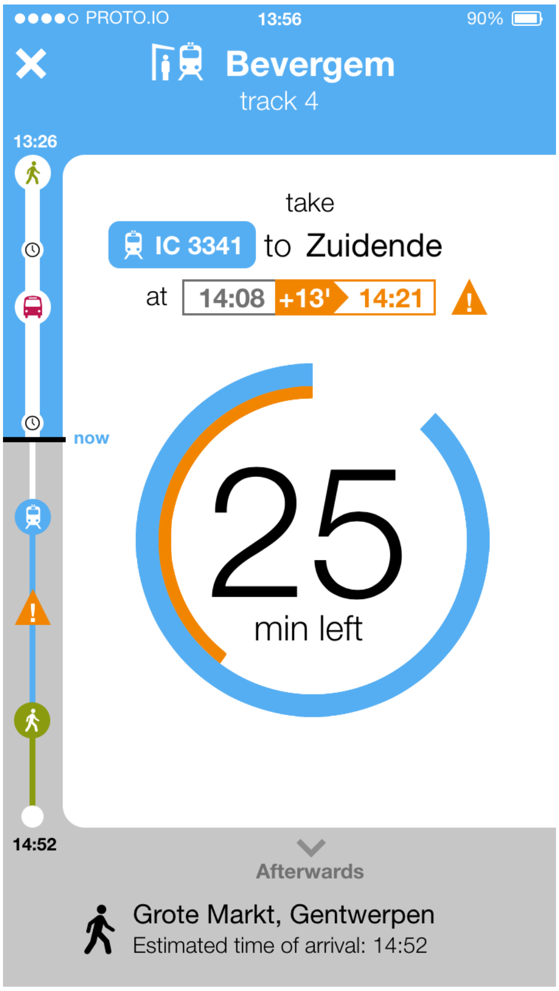


Figure 57. v3 Screen at train station (delayed)

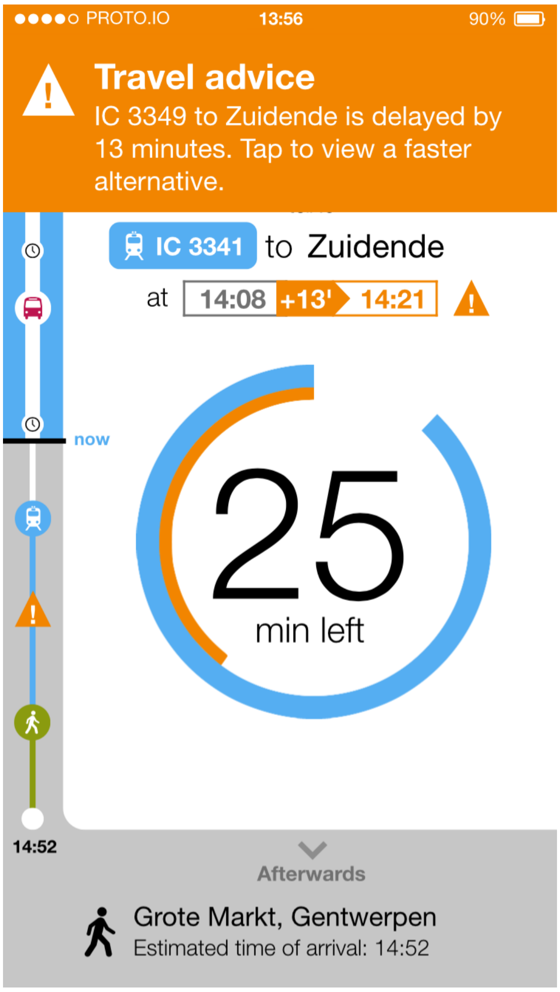


Figure 58. v3 Screen at train station with notification

Furthermore, the way that travel advice shows up has been altered. Instead of immediately showing the full screen with the vertical time bars, a smaller notification slides down from the top of the screen that tells the user that an alternative is available (Figure 58). The user can tap this notification or slide up to hide it. If the user wants to view the alternative anyway, he can still do so by tapping the warning triangle. In the progress tracker, the same triangle is shown to indicate that there is a notification for this part of the journey. Additionally, exit navigation is added in the form of an 'X'-symbol at the top left of the screen (Figure 57). The small arrow below the progress tracker was removed.

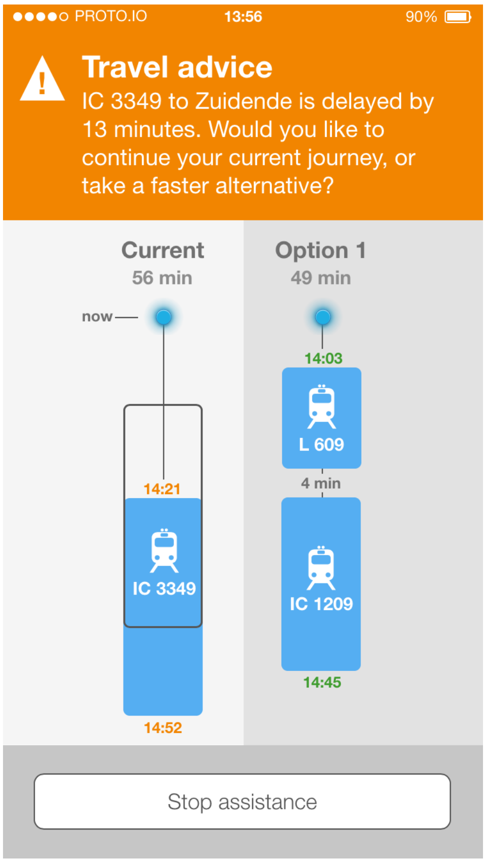


Figure 59. v3 Travel advice

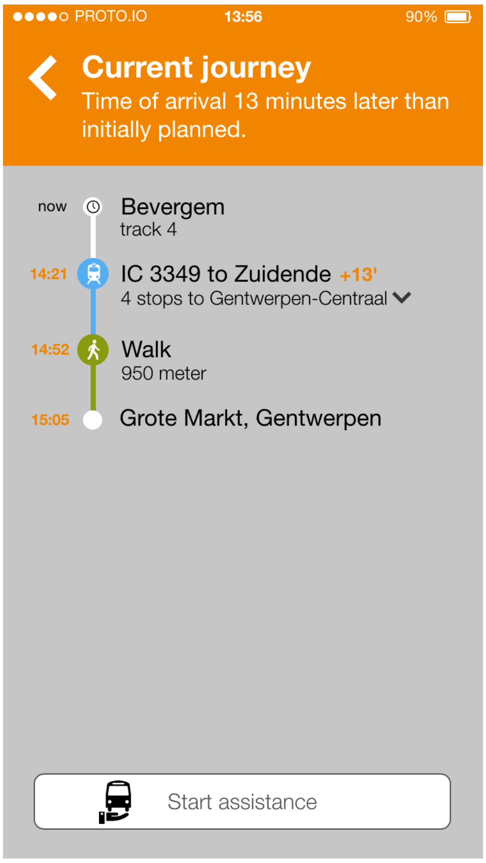


Figure 60. v3 Current journey option details

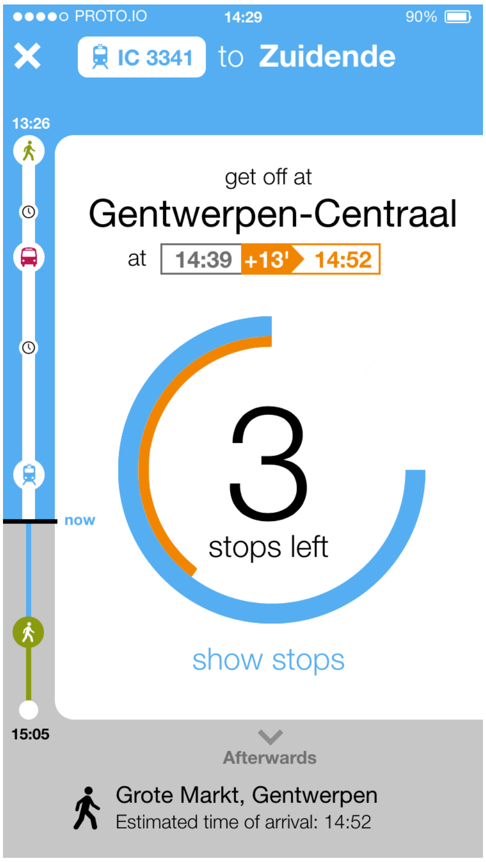


Figure 61. v3 Screen during train ride (Current)

Figure 62. v3 In-train stop details (Current)

In the travel advice screen, the introduction text was changed to end with a question that invites action (Figure 59). The journey details were changed to look similar to the start and overview screens in the rest of the application (Figure 60). The title bar colour for the travel advice screens now resembles the colour for delay indications.

Many respondents suggested to indicate the delay part of the remaining time in the circle counter. This has been implemented by adding an orange part inside it (Figure 61). The user also has the possibility to show the list of intermediate stops by tapping 'Show Stops'. The circle counter is then reshaped into a vertical progress tracker of the vehicle's trip, with the user's progress indicated in white (Figure 62). Both arrival and departure times are shown in this screen. This could be especially relevant especially for train trips, as well as the track numbers for the respective stations.

The rest of the final version's screens, which got limited or no alterations, can be viewed in the annexes. In the following section, the development of the application and its feedback results will be discussed, together with the limitations of the research, practical implications, and ideas for future development.

13 Discussion

In this section, the prototype development and its evaluation results are discussed and its limitations mentioned. Afterwards, practical implications and ideas for future research and development are envisioned.

Looking at the evolution of the concept, it becomes clear that it has undergone major transformations from the initial paper mock-ups to the final prototype. Thanks to the initial literature review and best-practices evaluation, together with the iterated design with the interviews, focus groups and survey for evaluation, a concept has been delivered that stands both on scientific and empirical foundations. Results from these evaluations have already been discussed in detail in the previous sections, but a general review will be made here.

Overall, test users were fairly satisfied with the application, with an SUS-score of 78,1 out of 100 for the first prototype and 80,1 for the second one. The items that were most negatively evaluated in the SUS questionnaires were familiarity and, to a lesser extent, learning load. This indicates that some users feel inexperienced and that they need to learn a lot before getting accustomed to the application. This could be partly due to the lack of context during testing. A possible solution to increase familiarity with the application would be to include a short 'getting started'-introduction to the application for novice users. Both this lack of context and possible additions to the application will be discussed further.

A stronger evolution can be seen in the general satisfaction with the prototype, where 2 out of 9 focus group participants indicated they were very satisfied (22%), but 77 out of 134 of the survey respondents indicated the same (57%). However, it is more difficult to draw conclusions out of this, as the number of focus group participants is far lower and the question was not asked in the same way in the survey. As the survey was completely anonymous, it was not possible to check the satisfaction evolution of focus group participants that filled in the survey. There are some other limitations to this that are discussed further.

Looking at the number of categories of concerns that were brought up during the evaluations, a decrease can be found insofar as the second prototype is concerned. From the individual interviews and focus groups, there were 18 categories of concern for which improvement actions were found. After the survey results and the professional designer feedback, 11 actions were taken for the final improvements, most of which were cosmetic improvements. It should however be taken into account that different evaluation types for both prototypes could have led to different numbers and types of remarks. This and other limitations will be discussed next.

13.1 Limitations

One of the major limitations of the prototype evaluation, which has also been mentioned by some of the focus group participants, is that the context that the application requires is absent. This is a major drawback for a context-aware travel application that will primarily be used while underway. The consequence is that test users had to imagine the environment in which they would use the information, and that they needed to be aware that there are different environments for different screens of the application. Furthermore, the context-dependent automatic switching between screens could not be tested, so users had to manually interact with the application to make progress, while this would normally not be necessary. This certainly had an impact on the way test users perceived and understood the prototype. Positively, this may imply that the application would be easier to understand and use in real life. However, it might be possible that real life usage brings new issues in understanding the relevant information, issues that have not been found in the test phase. For example, differences in the way information is shown in the environment and in the application, like different time indications and slightly varying destination names, could confuse users. It goes without saying that the application should be rigorously tested in a real environment before release.

For the evaluation of the first prototype, it should be taken into account that the individual interviews were held with family and friends, which might have led to more positive evaluations than from random test users. Another bias might have occurred in the focus groups, which were held with university employees of which three were from the faculty for which this thesis was written. University employees are generally more educated than the general population, which could have had an impact on the number and type of remarks. Nevertheless, this evaluation received a wide variation of critical remarks that could be used to improve the prototype, so these biases are not estimated to have a great impact on the overall process.

A number of limitations to the survey can be mentioned. To start with, there is a bias in the respondent demographics towards younger people, whom we expect to have more experience with mobile applications. A large share of these younger respondents were friends or acquaintances reached via Facebook, which could make them naturally more positive towards the application than respondents who were reached via the university e-mail or other channels. Besides this unconscious bias, further reasons could have led survey respondents to react positively to the prototype: first, surveys that are filled in by a convenience sample are susceptible to non-response error, which means that people who are more negative towards the application may decide not to fill in the survey or to exit before completion. Second, the survey was rather long and required focused attention from respondents to test the prototype and give remarks on the different screens. This could have led to fatigue and a less critical evaluation of the prototype than during the focus group sessions, when participants took a longer time to study the application in detail. 17% of respondents took less than five minutes to complete the survey, which could be problematic for a thorough and critical evaluation. All these limitations imply that the evaluation of the second prototype might give more positive results than what random users of the application would do. More in-depth evaluations of the prototype with other respondent samples could give a better insight into the satisfaction of users with the application.

13.2 Practical implications

Although this proof-of-concept can give a good idea of what a travel assistant could look like and how it could behave, there is still a lot of work required to create a proper working version of this application. The full development of a working application falls beyond the scope of this thesis, but a number of practical implications can already be addressed.

The most important implication for application developers is that there needs to be a very precise combination of the user's current location, activity, public transport schedules and real-time data in order to provide the user with the relevant information at the right moment. This requires specific algorithms that can correctly guess if the user is waiting at a stop, walking or aboard the correct vehicle. Similarly, the travel advice in case of disruptions requires continuous processes that check the user's current journey, compare it with other possible journeys and decide whether or not route alternatives should be shown. Other processes should monitor the user's walking speed and use it to predict travel times and whether the public transport vehicle can be caught. Algorithms should be designed that decide if and when to notify the user when it seems they might not reach the stop in time or when they deviate from the route. Additionally, material constraints like power consumption (battery usage) should be taken into account. Some of the necessary processes of the travel assistant could be active on the server side of the application instead of on the device itself, which could have a beneficial impact on power consumption and computation speeds, but this requires a constant data connection.

Scenarios should be designed that tell the application how to react in case (part of) the necessary information is not available. For example, when the device's GPS signal gets weak or lost, the application can only assume to a certain level where the user is. In that case, the vehicle's real-time info could function as a secondary support. However, when the mobile data connection gets weak or lost as well, a single reliance on schedule data might not be enough to provide all of the assistant's functionalities. The application should also indicate when a certain information source is missing, so that the user knows that the information might not be completely reliant.

This still assumes that real-time data is always correct. However, this is not the case all the time. Many test users indicated that they would not trust real-time information, because they know from experience that this information often lacks precision, to the extent that they cannot rely on it. It is difficult for the application itself to gauge the quality of the data it receives, but a good strategy would be to rely on the user's location instead whenever possible. For example, the GPS location can be used to calculate the number of remaining stops. If no real-time data is available, it could also be used to estimate the current vehicle's delay.

Furthermore, this concept is not a standalone app, but is meant to be integrated into a fully functioning travel app in which users can set their destination and time, and choose a route option to begin with. The travel advice functionality could be used for favourite routes set by the user, without him needing to start the travel assistance. In that way, it would also be an interesting functionality for regular public transportation users and commuters who could do without extensive assistance.

Finally, in this application, the user should have the ability to choose for which alerts they want to be notified and how these notifications should happen. For example, a user might want notifications in case the current journey cannot be performed anymore, but might not want to pay attention to faster travel alternatives in case of delays. Another user might want to be notified to exit at the right stop, but not when the vehicle they are waiting for is about to arrive at the stop. Additionally, users might want only specific alternative suggestions. For example, a user who is travelling by bus might not want to see train alternatives if it means buying an extra ticket. Another user might not want any alternatives in which they need to transfer. To give the user enough power over the travel assistance, these are things that should be customized in the settings.

13.3 Future research and development

In order to improve the prototype further, a number of ideas for future research and development are discussed here.

From the test user evaluations, it became clear that people paid significant attention to the walking instructions and gave a lot of feedback on how to improve those. The inclusion of a Street View functionality was received very positively. More research should go into how such Street View walking navigation would work and if this would help people to find their way in unfamiliar environments. More detailed walking instructions should be possible, especially in complex locations like train and metro stations. Showing the relevant station's signage towards the correct platform in the application could help travellers who have trouble navigating inside buildings. Public transport operators should also make efforts to better distinguish bus platforms with the same name. For example, in London, every bus stop shelter or pole has a letter indication, which can easily be used for navigation to the right platform. This could then be used in the application to better guide the user.

In this prototype, journeys on a regional scale were used to show the application's capabilities. This implied that frequencies for public transport lines were rather low, with one vehicle every hour or half hour. In urban areas however, the number of possible routes between two locations grows exponentially because of a higher network density and higher frequencies. This means that the application would be able to give much more travel alternatives, and that even the slightest disruption could lead to the application providing faster travel alternatives. More research should go into such network effects and the algorithms that are used to decide if and which travel alternatives are shown. It is possible that different parameters should be used for different types of network.

Furthermore, various types of public transport might require different information needs. It was already mentioned that for a frequent metro service travellers are less interested in scheduled times and delays. The travel assistant might differentiate its time and delay information depending on the scale and frequency of the lines. More research is needed to decide which types of services have which information needs. Additionally, research should go into when the application should show if a vehicle is on time or not. Currently, a vehicle is delayed if it is at least one minute late, but this could be the standard rather than the exception for a lot of public transport networks. In such case, it might be interesting to show small delays in a different way than large delays. Moreover, no case has been presented in which a vehicle was early. How should this information be shown, and what kind of notification does such a situation warrant? This could also depend on the service type: usually, train services do not depart before their scheduled time even if they arrive too early. For buses however, early-running is a more serious problem. Similarly, no case has been presented in which the user was so early that he could take a train or bus earlier than planned. These are all things to take into account in further development of the travel assistance tool.

Considering the application interface, the current prototype is somewhat static: different screens follow each other but they are still separate from each other. This is partly due to the prototyping tool that was used, which is primarily based on a screen-per-screen principle. It would be interesting however to create a more dynamic application in which a simple step-by-step list for the route gets automatically expanded with relevant information for each step. The user could then choose how much extra information they want to see for that step by interacting with specific parts of the screen. In that way, the distinction between overview and step-by-step assistance is blurred, so that users do not need to look for information in different screens. Such an application would however require a lot more energy to prototype and develop. Furthermore, a more dynamic approach to the travel advice would make it easier to understand and use. The vertical time bars should also be made more visually similar to the other time bars in the application, to increase consistency and clarity.

During the development of the application, extensive evaluations should happen through additional focus groups and other types of feedback. For example, when the application is mature enough to be used ‘in the field’, observational studies could be used to check how test participants use the application and behave during their journey. Afterwards, interviews can be held to gauge participants’ satisfaction with the application.

In the future, more functionalities could be added to the application. For example, a version can be developed that would function on wearable devices like the Apple Watch. Developing applications for a device with such a small screen intended for brief interactions requires a completely new approach, leaving in only the most relevant information at any time while trying to keep it clear and informative. Another suggestion is to include more travel modes into the application, so that it becomes an intermodal travel assistant. Some test users already indicated that they would like integrated navigation for cycling. Another possibility is the inclusion of car-sharing services.

Extra functionalities could also be added for disabled people. For example, audio instructions could give vision-impaired and blind people indications throughout their journey. The application could also take into account wheelchair restrictions and only display routes that are wheelchair-accessible. It could then factor in the extra time needed for entering and exiting vehicles, transferring in stations and getting to and from the station.

Finally, a ‘getting started’ screen could be shown to new users of the application, introducing them to the assistant’s functionalities and explaining how to use it. This would be helpful for people that feel unfamiliar with the application, as was already discussed earlier.

Conclusions

The goal of this thesis was to create a prototype of a mobile public transport travel assistant, and to improve it with the means of evaluations by test users in an iterated development cycle. The initial concept was based on scientific research around the information needs of travellers, context-awareness and early versions of such applications, as well as best-practice comparisons. It was then further improved, based on feedback from individual interviews and focus groups, and later from an online survey and professional feedback. The final product is a proof-of-concept travel assistant that does not only guide the traveller during each step of the journey, but also gives route alternatives in case of delays or other disruptions. Such an assistant would be the logical next step for mobile app development, using the latest findings in activity recognition, context-awareness and artificial intelligence, and would not only help travellers that are unfamiliar with taking public transport, but also assist regular commuters that want to get to their destination without putting too much energy into figuring out what to do in case of disruptions.

Overall, test users were more than satisfied with the application. The second prototype got a System Usability Scale evaluation of 80,1 out of 100, which lies between 'good' and 'excellent'. 94,7% of survey respondents indicated to be somewhat or very satisfied with the general prototype. Their comments were used to improve the application even further, so it may be that general satisfaction would be even higher than for the second prototype. However, it should be noted that there are some limitations to the interview, focus group and survey evaluations, which might lead to more positive evaluations than from a random sample of users.

Developing a user interface is an inherently subjective process based on a system of values, ideas, styles and norms that are different from person to person and may evolve over time. This became clear during the evaluations with test users, when respondents did not always agree with each other, and sometimes changed their minds during the evaluation process. Nevertheless, it does not mean that all decisions taken throughout the development are purely subjective: in fact, with the analysis of remarks and trade-offs between the pros and cons of any modification, the improvement of the prototype was always intended to satisfy most users. As people differ in their preferences, there can never be 'one size fits all', but the cycles of development and feedback proved to be very beneficial for the general satisfaction with the application.

Travel information is essential to get from A to B, especially in organised systems like public transportation. Whereas that information in the past was primarily diffused by the public transport organisations themselves, the digitalisation and 'appification' of information has led to a shift in information provision from those organisations towards dedicated services like Google Maps and Citymapper. Mobile travel information is here to stay, and it is an integral part of the travel experience. This is why travel information should also be designed from a transportation background, not only from a technical and user experience perspective. Together, these different perspectives can synergise the way that travel information is created and used.

References

Baldauf, M., Dustdar, S., & Rosenberg, F. (2007). A survey on context-aware systems. *International Journal of Ad Hoc and Ubiquitous Computing*, *2*(4), 263–277.

Bangor, A., Kortum, P., & Miller, J. (2009). Determining what individual SUS scores mean: Adding an adjective rating scale. *Journal of Usability Studies*, *4*(3), 114–123.

Baus, J., Kray, C., Krüger, A., & Wahlster, W. (2001). A Resource-Adaptive Mobile Navigation System, 5–9.

Beul-Leusmann, S., Jakobs, E.-M., & Ziefle, M. (2013). User-centered design of passenger information systems. In *Professional Communication Conference (IPCC), 2013 IEEE International* (pp. 1–8). IEEE. Retrieved from http://ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber=6623931

Beul-Leusmann, S., Samsel, C., Wiederhold, M., Krempels, K.-H., Jakobs, E.-M., & Ziefle, M. (2014). Usability evaluation of mobile passenger information systems. In *Design, User Experience, and Usability. Theories, Methods, and Tools for Designing the User Experience* (pp. 217–228). Springer. Retrieved from http://link.springer.com/chapter/10.1007/978-3-319-07668-3_22

Biagioni, J., Agresta, A., Gerlich, T., & Eriksson, J. (2009). Transitgenie: a context-aware, real-time transit navigator. In *Proceedings of the 7th ACM Conference on Embedded Networked Sensor Systems* (pp. 329–330). ACM. Retrieved from http://dl.acm.org/citation.cfm?id=1644085

Brakewood, C., Barbeau, S., & Watkins, K. (2014). An experiment evaluating the impacts of real-time transit information on bus riders in Tampa, Florida. *Transportation Research Part A: Policy and Practice*, *69*, 409–422. http://doi.org/10.1016/j.tra.2014.09.003

Brakewood, C., Macfarlane, G. S., & Watkins, K. (2015). The impact of real-time information on bus ridership in New York City. *Transportation Research Part C: Emerging Technologies*, *53*, 59–75. http://doi.org/10.1016/j.trc.2015.01.021

Brooke, J. (1996). SUS-A quick and dirty usability scale. *Usability Evaluation in Industry*, *189*(194), 4–7.

Caulfield, B., & O'Mahony, M. (2007). An Examination of the Public Transport Information Requirements of Users. *IEEE Transactions on Intelligent Transportation Systems*, *8*(1), 21–30. http://doi.org/10.1109/TITS.2006.888620

Chorus, C. G., Arentze, T. A., & Timmermans, H. J. P. (2007). Information impact on quality of multimodal travel choices: conceptualizations and empirical analyses. *Transportation*, *34*(6), 625–645. http://doi.org/10.1007/s11116-007-9120-1

Dal Fiore, F., Mokhtarian, P. L., Salomon, I., & Singer, M. E. (2014). "Nomads at last"? A set of perspectives on how mobile technology may affect travel. *Journal of Transport Geography*, *41*, 97–106. http://doi.org/10.1016/j.jtrangeo.2014.08.014

Davis, F. D. (1989). Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology. *MIS Quarterly*, *13*(3), 319. http://doi.org/10.2307/249008

De Pessemier, T., Dooms, S., & Martens, L. (2014). Context-aware recommendations through context and activity recognition in a mobile environment. *Multimedia Tools and Applications*, *72*(3), 2925–2948.

Dey, A. K., Abowd, G. D., & Salber, D. (2001). A conceptual framework and a toolkit for supporting the rapid prototyping of context-aware applications. *Human-Computer Interaction*, *16*(2), 97–166.

Does Adding One More Question Impact Survey Completion Rate? | SurveyMonkey Blog. (2010, December 8). Retrieved May 15, 2016, from https://www.surveymonkey.com/blog/2010/12/08/survey_questions_and_completion_rates/

Dziekan, K., & Kottenhoff, K. (2007). Dynamic at-stop real-time information displays for public transport: effects on customers. *Transportation Research Part A: Policy and Practice*, *41*(6), 489–501. http://doi.org/10.1016/j.tra.2006.11.006

European Commission. (2014). MG-2.2-2014 - Smart Rail Services. Retrieved December 12, 2015, from http://cordis.europa.eu/programme/rcn/664893_en.html

Feng, T., & Timmermans, H. J. P. (2013). Transportation mode recognition using GPS and accelerometer data. *Transportation Research Part C: Emerging Technologies*, *37*, 118–130. http://doi.org/10.1016/j.trc.2013.09.014

Garcia, C. R., Candela, S., Ginory, J., Quesada-Arencibia, A., & Alayon, F. (2012). On Route Travel Assistant for Public Transport Based on Android Technology. In *Innovative Mobile and Internet Services in Ubiquitous Computing (IMIS), 2012 Sixth International Conference on* (pp. 840–845). http://doi.org/10.1109/IMIS.2012.103

Gärtner, P. (2016, May 18). Prototype Feedback (E-mail).

Goto, K., & Kambayashi, Y. (2002). A new passenger support system for public transport using mobile database access. In *Proceedings of the 28th international conference on Very Large Data Bases* (pp. 908–919). VLDB Endowment. Retrieved from http://dl.acm.org/citation.cfm?id=1287449

Grotenhuis, J.-W., Wiegmans, B. W., & Rietveld, P. (2007). The desired quality of integrated multimodal travel information in public transport: Customer needs for time and effort savings. *Transport Policy*, *14*(1), 27–38. http://doi.org/10.1016/j.tranpol.2006.07.001

Hannikainen, M., Laitinen, A., Hamalainen, T., Kaisto, I., & Leskinen, K. (2001). Architecture of a passenger information system for public transport services. In *Vehicular Technology Conference, 2001. VTC 2001 Fall. IEEE VTS 54th* (Vol. 2, pp. 698–702 vol.2). http://doi.org/10.1109/VTC.2001.956860

Hemminki, S., Nurmi, P., & Tarkoma, S. (2013). Accelerometer-based transportation mode detection on smartphones (pp. 1–14). ACM Press. http://doi.org/10.1145/2517351.2517367

Hickman, & Wilson. (1995). Passenger travel time and Path choice implications of real-time passenger information. *Transportation Research Part C: Emerging Technologies*, *3*(4), 211.

Hoerger, M. (2010). Participant dropout as a function of survey length in Internet-mediated university studies: Implications for study design and voluntary participation in psychological research. *Cyberpsychology, Behavior, and Social Networking*, *13*(6), 697–700.

ISO 9241-11:1998 - Ergonomic requirements for office work with visual display terminals (VDTs) - Part 11: Guidance on usability. (1998, March 19). International Organization for Standardization, Geneva, Switzerland. Retrieved from http://www.iso.org/iso/catalogue_detail.htm?csnumber=16883

Keller, C., Korzetz, M., Kühn, R., & Schlegel, T. (2011). Nutzerorientierte Visualisierung von Fahrplaninformationen auf mobilen Geräten im öffentlichen Verkehr. In *Mensch & Computer* (pp. 59–68). Retrieved from http://books.google.com/books?hl=en&lr=&id=6U0qIA_Vlb0C&oi=fnd&pg=PA59&dq=%22k%C3%B6nnen+so+Auskunft+%C3%BCber+Versp%C3%A4tungen+im+Zugverkehr+oder+%C3%BCber+Staus+auf+den%22+%22oft+erschwert.+Zwei+Screenshots+solcher+Anwendungen+sind%22+%22wurden+dann+verschiedene+Visualisierungen+erstellt.+In%22+&ots=ls1SHdFKHB&sig=Nn24eWAU9daOzqUsJ7e8Cc7OoKo

Kramers, A. (2014). Designing next generation multimodal traveler information systems to support sustainability-oriented decisions. *Environmental Modelling & Software*, *56*, 83–93. http://doi.org/10.1016/j.envsoft.2014.01.017

LaRose, R., & Tsai, H. S. (2014). Completion rates and non-response error in online surveys: Comparing sweepstakes and pre-paid cash incentives in studies of online behavior. *Computers in Human Behavior*, *34*, 110–119. http://doi.org/10.1016/j.chb.2014.01.017

Lyons, G. (2006). The role of information in decision-making with regard to travel. *IEE Proceedings - Intelligent Transport Systems*, *153*(3), 199. http://doi.org/10.1049/ip-its:20060001

Lyons, G. D. (2001). Towards integrated traveller information. *Transport Reviews*, *21*(2), 217–235. http://doi.org/10.1080/01441640118614

Morgan-Jones, N. (2016, April 25). Thesis Prototype (E-mail).

Nham, B., Siangliulue, K., & Yeung, S. (2008). Predicting mode of transport from iphone accelerometer data. *Standford University Class Project*. Retrieved from http://cs229.stanford.edu/proj2008/NhamSiangliulueYeung-PredictingModeOfTransportFromIphoneAccelerometerData.pdf

Nielsen, J. (1997). The use and misuse of focus groups. *Software, IEEE*, *14*(1), 94–95.

Nielsen, J., & Landauer, T. K. (1993). A mathematical model of the finding of usability problems. In *Proceedings of the INTERACT'93 and CHI'93 conference on Human factors in computing systems* (pp. 206–213). ACM. Retrieved from http://dl.acm.org/citation.cfm?id=169166

Nyblom, Å. (2014). Making plans or "just thinking about the trip"? Understanding people's travel planning in practice. *Journal of Transport Geography*, *35*, 30–39. http://doi.org/10.1016/j.jtrangeo.2014.01.003

Politis, I., Papaioannou, P., Basbas, S., & Dimitriadis, N. (2010). Evaluation of a bus passenger information system from the users' point of view in the city of Thessaloniki, Greece. *Research in Transportation Economics*, *29*(1), 249–255. http://doi.org/10.1016/j.retrec.2010.07.031

Reddy, S., Mun, M., Burke, J., Estrin, D., Hansen, M., & Srivastava, M. (2010). Using mobile phones to determine transportation modes. *ACM Transactions on Sensor Networks*, *6*(2), 1–27. http://doi.org/10.1145/1689239.1689243

Samsel, C., Beul-Leusmann, S., Wiederhold, M., Krempels, K.-H., Ziefle, M., & Jakobs, E.-M. (2014). Cascading Information for Public Transport Assistance: (pp. 411–422). SCITEPRESS - Science and and Technology Publications. http://doi.org/10.5220/0004793304110422

Sauro, J. (2011). *A Practical Guide to the System Usability Scale: Background, Benchmarks & Best Practices*. CreateSpace Independent Publishing Platform. Retrieved from https://books.google.co.uk/books?id=BL0kKQEACAAJ

Stenneth, L., Wolfson, O., Yu, P. S., & Xu, B. (2011). Transportation Mode Detection using Mobile Phones and GIS Information. Retrieved from http://dl.acm.org/citation.cfm?id=2093973

System Usability Scale - Dutch. (2012). MeasuringU. Retrieved from http://www.measuringu.com/System%20Usability%20Scale%20-%20Dutch.pdf

Tang, L., & Thakuriah, P. (Vonu). (2012). Ridership effects of real-time bus information system: A case study in the City of Chicago. *Transportation Research Part C: Emerging Technologies*, *22*, 146–161. http://doi.org/10.1016/j.trc.2012.01.001

Vanhaelewyn, B., Pauwels, G., De Wolf, P., Accou, T., & De Marez, L. (2015). *iMinds Digimeter 2015*. iMinds.

Vieira, V., Salgado, A. C., Tedesco, P., Times, V., Ferraz, C., Huzita, E., … Steinmacher, I. (2012). The UbiBus Project: Using Context and Ubiquitous Computing to build Advanced Public Transportation Systems to Support Bus Passengers.

Walsh, A. (2012). Mobile information literacy: a preliminary outline of information behaviour in a mobile environment. *Journal of Information Literacy*, *6*(2), 56–69.

Watkins, K. E., Ferris, B., Borning, A., Rutherford, G. S., & Layton, D. (2011). Where Is My Bus? Impact of mobile real-time information on the perceived and actual wait time of transit riders. *Transportation Research Part A: Policy and Practice*, *45*(8), 839–848. http://doi.org/10.1016/j.tra.2011.06.010

Wirtz, S., Jakobs, E.-M., & Beul, S. (2010). Passenger information systems in media networks: Patterns, preferences, prototypes (pp. 131–137). IEEE. http://doi.org/10.1109/IPCC.2010.5529825

Xia, H., Qiao, Y., Jian, J., & Chang, Y. (2014). Using Smart Phone Sensors to Detect Transportation Modes. *Sensors*, *14*(11), 20843–20865. http://doi.org/10.3390/s141120843

Zhang, Z., & Poslad, S. (2013). A New Post Correction Algorithm (PoCoA) for Improved Transportation Mode Recognition. In *Systems, Man, and Cybernetics (SMC), 2013 IEEE International Conference on* (pp. 1512–1518). IEEE. Retrieved from http://ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber=6722014

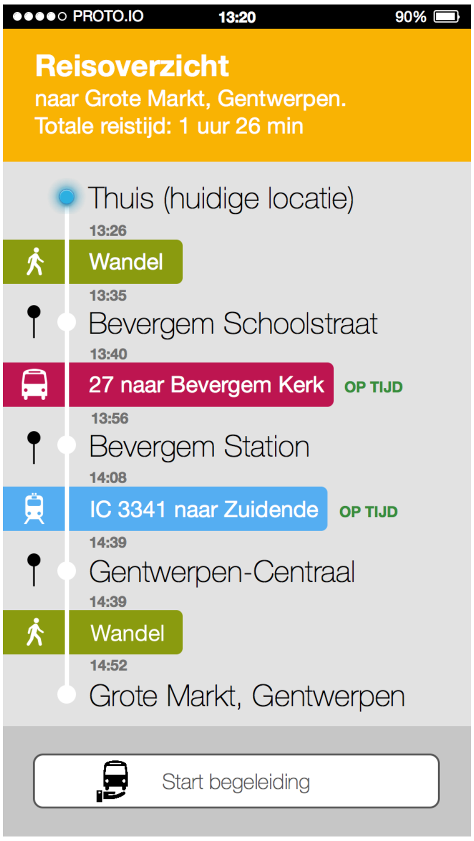
Zheng, Y., Chen, Y., Li, Q., Xie, X., & Ma, W.-Y. (2010). Understanding transportation modes based on GPS data for web applications. *ACM Transactions on the Web*, *4*(1), 1–36. http://doi.org/10.1145/1658373.1658374

Annexes

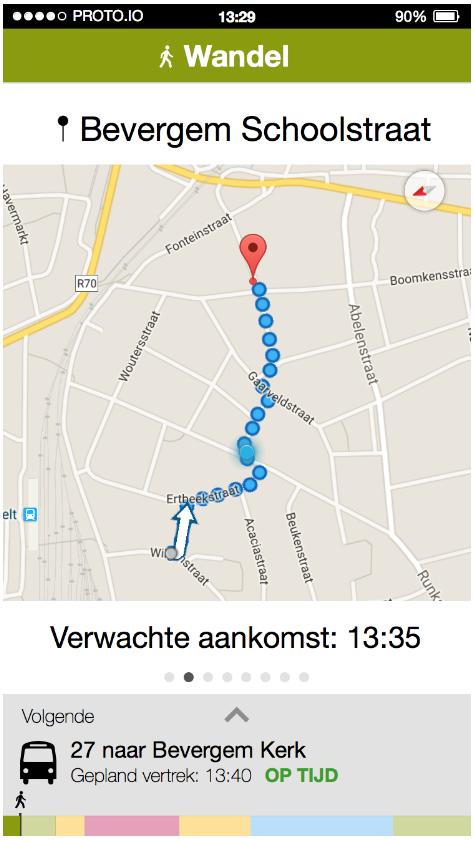
Focusgroep:
een mobiele reisassistent

Naam: ___________________________

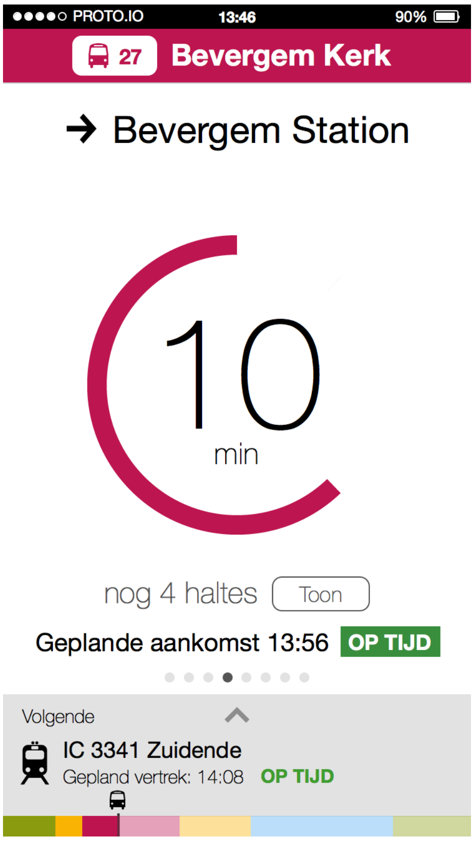
Bestudeer rustig de applicatie. Beeld je in dat je met een app voor openbaar vervoer werkt (bijvoorbeeld die van De Lijn of NMBS). Je hebt reeds je bestemming ingegeven, en daarna een route gekozen om op je bestemming te geraken. Je kan met de app werken door op bepaalde plaatsen te drukken of te vegen. Indien je vragen of opmerkingen hebt kan je die bij de respectievelijke schermen op de volgende pagina's schrijven. Je kan alles wat in je opkomt opschrijven (bijvoorbeeld: 'Dit vind ik goed', 'Dit deel vind ik onduidelijk', 'Ik zou dit liever zo zien', …). Als je geen opmerkingen hebt bij een bepaald scherm hoef je niets in te vullen. Daarna bespreken we de app in groep.


●●●●○ PROTO.IO
13:20
90%
Reisoverzicht
naar Grote Markt, Gentwerpen.
Totale reistijd: 1 uur 26 min
Thuis (huidige locatie)
13:26
Wandel
13:35
Bevergem Schoolstraat
13:40
27 naar Bevergem Kerk
OP TIJD
13:56
Bevergem Station
14:08
IC 3341 naar Zuidende
OP TIJD
14:39
Gentwerpen-Centraal
14:39
Wandel
14:52
Grote Markt, Gentwerpen
Start begeleiding

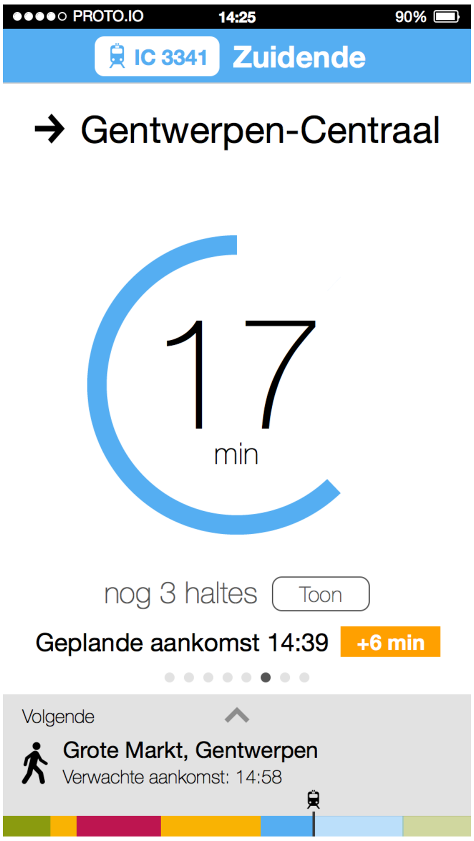

●●●●○ PROTO.IO
13:22
90%
Wandel
Bevergem Schoolstraat
Vertrek over
4
min
Toon route
Verwachte aankomst: 13:35
Volgende
27 naar Bevergem Kerk
Gepland vertrek: 13:40
OP TIJD


●●●●○ PROTO.IO
13:29
90%
Wandel
Bevergem Schoolstraat
Fonteinstraat
Boomkensstraat
Woutersstraat
Abelenstraat
Gaarveldstraat
Ertbeekstraat
Acaciastraat
Beukenstraat
R70
Verwachte aankomst: 13:35
Volgende
27 naar Bevergem Kerk
Gepland vertrek: 13:40 OP TIJD

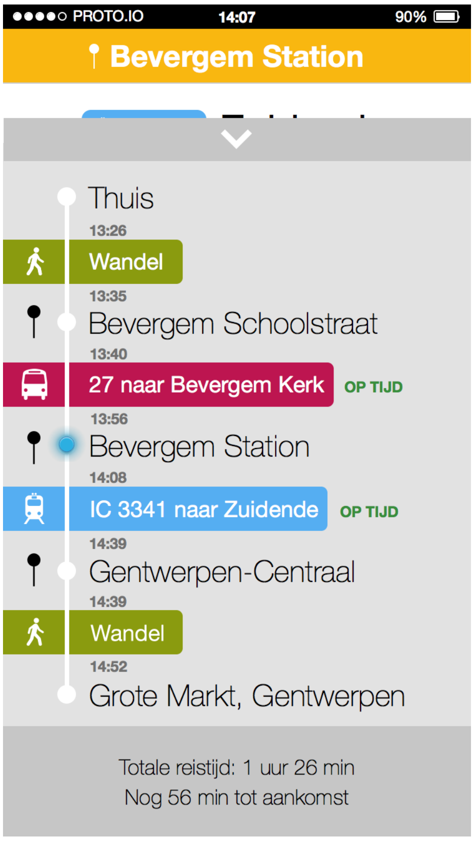

●●●●○ PROTO.IO
13:36
90%
Bevergem Schoolstraat
27 Bevergem Kerk
4
min
Gepland vertrek 13:40 OP TIJD
Volgende
IC 3341 naar Zuidende
Gepland vertrek: 14:08 OP TIJD


PROTO.IO
13:46
90%
27
Bevergem Kerk
Bevergem Station
10
min
nog 4 haltes
Toon
Geplande aankomst 13:56
OP TIJD
Volgende
IC 3341 Zuidende
Gepland vertrek: 14:08
OP TIJD


PROTO.IO
14:04
90%
Bevergem Station
IC 3341
Zuidende
Spoor 4
11
min
Gepland vertrek 14:08
+7 min
Volgende
Grote Markt, Gentwerpen
Verwachte aankomst: 14:59

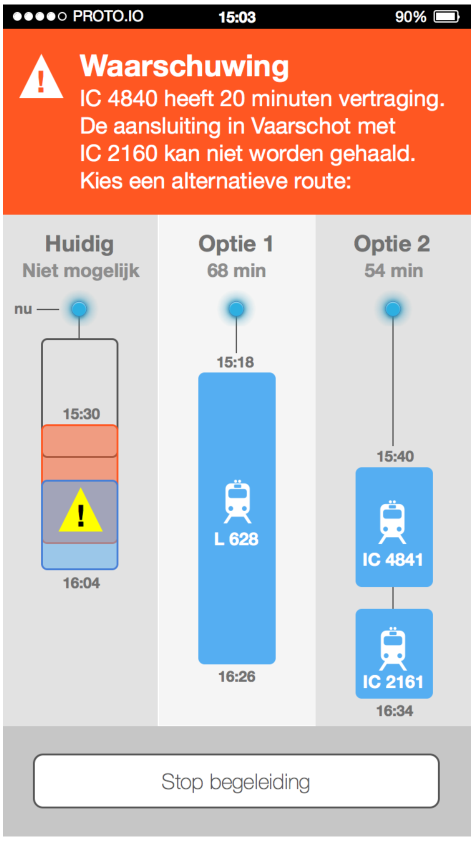

●●●●○ PROTO.IO
14:25
90%
IC 3341
Zuidende
→ Gentwerpen-Centraal
17
min
nog 3 haltes
Toon
Geplande aankomst 14:39
+6 min
Volgende
Grote Markt, Gentwerpen
Verwachte aankomst: 14:58

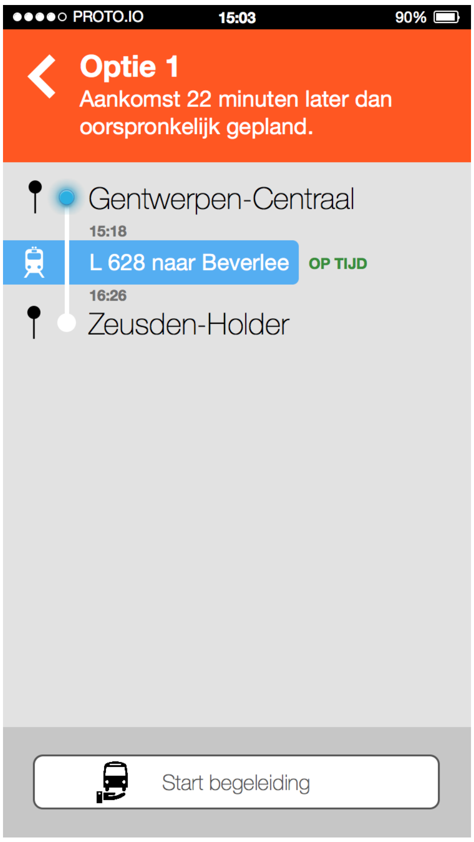

●●●●○ PROTO.IO
14:50
90%
Wandel
Grote Markt, Gentwerpen
Citadel
Warandepark
HOF
EZELDIJK
Vallaan
Boudewijnvest
Turnhoutsebaan
Fort Leopol
Geschatte aankomst 14:55
Bestemming
Grote Markt, Gentwerpen
Totale reistijd: 1 uur 29 minuten

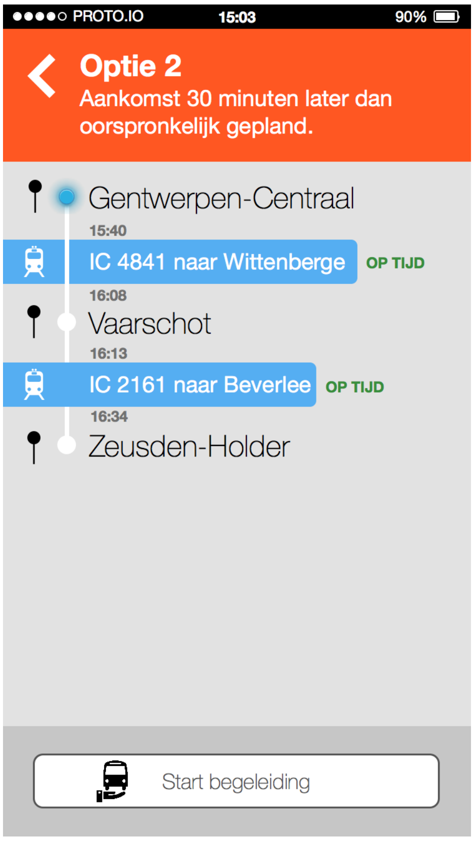
<table>
<tr>
<td>


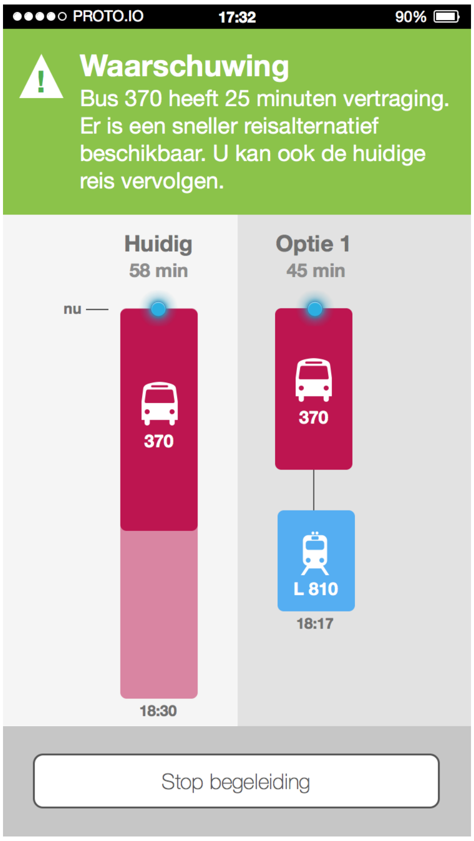
</td>
<td>(Dit scherm kan je bereiken vanuit alle andere schermen.)</td>
</tr>
<tr>
<td>

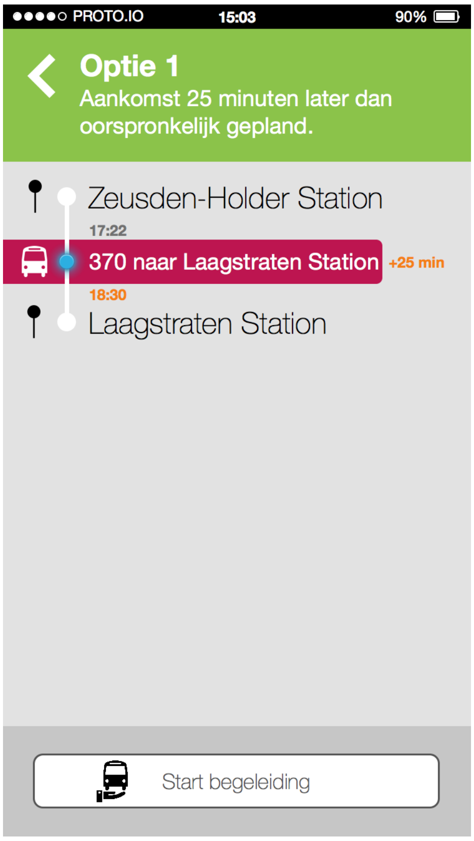

</td>
<td>(Dit is het laatste scherm. Druk nog niet op ‘Nieuwe reis vanaf hier’ of ‘Zoek terugreis’.)</td>
</tr>
</table>

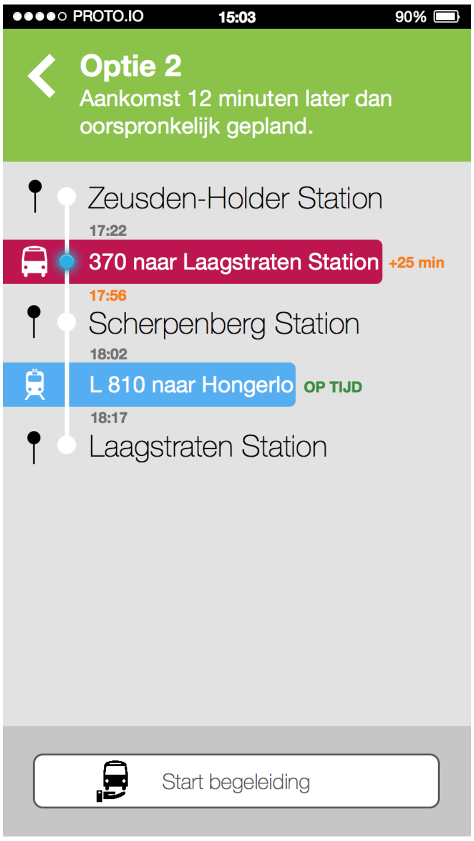

●●●●○ PROTO.IO
15:03
90%
Waarschuwing
IC 4840 heeft 20 minuten vertraging.
De aansluiting in Vaarschot met
IC 2160 kan niet worden gehaald.
Kies een alternatieve route:
Huidig
Niet mogelijk
Optie 1
68 min
Optie 2
54 min
nu
15:30
16:04
15:18
L 628
16:26
15:40
IC 4841
IC 2161
16:34
Stop begeleiding


●●●●○ PROTO.IO
15:03
90%
Optie 1
Aankomst 22 minuten later dan
oorspronkelijk gepland.
Gentwerpen-Centraal
15:18
L 628 naar Beverlee
OP TIJD
16:26
Zeusden-Holder
Start begeleiding

	
	(Dit is het laatste scherm – voor Optie 1 ziet het er iets anders uit. Je kan het scenario opnieuw doorlopen door naar rechts te vegen.)


●●●●○ PROTO.IO
17:32
90%
Waarschuwing
Bus 370 heeft 25 minuten vertraging. Er is een sneller reisalternatief beschikbaar. U kan ook de huidige reis vervolgen.
Huidig
58 min
nu
370
18:30
Optie 1
45 min
370
L 810
18:17
Stop begeleiding


●●●●○ PROTO.IO
15:03
90%
Optie 1
Aankomst 25 minuten later dan oorspronkelijk gepland.
Zeusden-Holder Station
17:22
370 naar Laagstraten Station
+25 min
18:30
Laagstraten Station
Start begeleiding



(Dit is het laatste scherm – voor Optie 1 ziet het er iets anders uit. Je kan het scenario opnieuw doorlopen door naar rechts te vegen.)

Vragenlijst

Beschouw de applicatie die we zojuist hebben besproken in haar geheel. Duid bij elke stelling op de numerieke schaal aan of je akkoord gaat of niet.

Stelling	Sterk mee oneens				Sterk mee eens
1. Ik denk dat ik de applicatie graag regelmatig wil gebruiken	1	2	3	4	5
2. Ik vond de applicatie onnodig complex	1	2	3	4	5
3. Ik vond de applicatie gemakkelijk te gebruiken	1	2	3	4	5
4. Ik denk dat ik hulp nodig heb van iemand anders om deze applicatie te kunnen gebruiken	1	2	3	4	5
5. Ik vond dat de verschillende functies in deze applicatie goed geïntegreerd zijn	1	2	3	4	5
6. Ik vind dat er teveel tegenstrijdigheden in deze applicatie zaten	1	2	3	4	5
7. Ik kan me voorstellen dat de meeste mensen zeer snel leren om deze applicatie te gebruiken	1	2	3	4	5
8. Ik vond de applicatie heel omslachtig in gebruik	1	2	3	4	5
9. Ik voelde me erg vertrouwd met de applicatie	1	2	3	4	5
10. Ik moest erg veel leren voor ik aan de gang kon met deze applicatie	1	2	3	4	5

Over het algemeen, hoe (on)tevreden ben je met deze applicatie?

Heel ontevreden	Eerder ontevreden	Noch tevreden, noch ontevreden	Eerder tevreden	Heel tevreden
☐	☐	☐	☐	☐

Heb je nog andere opmerkingen? Vul deze dan gerust in in onderstaand kader.

Hartelijk bedankt voor uw medewerking!

Q1.1 Welkom! Bedankt dat je deel wil nemen aan deze enquête. In het kader van mijn Masterthesis maak ik een prototype van een mobiele applicatie die je begeleidt tijdens het nemen van openbaar vervoer, en die je verder moet helpen in geval van vertraging of andere moeilijkheden. In deze enquête ga ik je een paar basisvragen stellen en je dan kennis laten maken met het prototype. In totaal duurt het ongeveer 15 minuten, maar ik beloof dat het niet saai wordt!

Arne Nys - Master in Transportation Sciences - Universiteit Hasselt

Q2.1 Ik ben een...

❍ man (1)
❍ vrouw (2)

Q2.2 Wat is uw leeftijd?

Q2.3 Hoe vaak gebruik je het openbaar vervoer?

❍ (bijna) elke dag (1)
❍ enkele keren per week (2)
❍ enkele keren per maand (3)
❍ minder dan enkele keren per maand (4)

Q2.4 Heb je een smartphone?

❍ Ja (1)
❍ Nee (2)

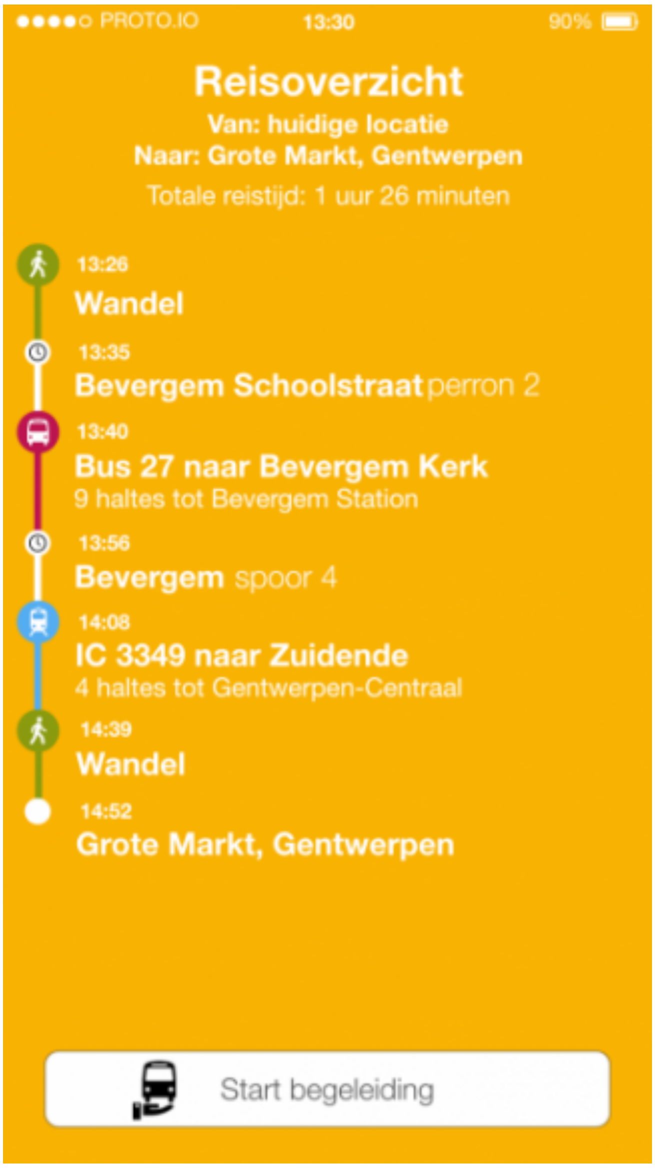
Q2.5 Gebruik je soms een reisapplicatie op je smartphone? Zo ja, welke?

❑ De Lijn (1)
❑ NMBS (2)
❑ Google Maps (3)
❑ Citymapper (4)
❑ Andere (5) ____________________
❑ Ik gebruik geen reisapplicaties op mijn smartphone (6)

Q2.6 Nu ik wat basisinformatie verzameld heb kunnen we overgaan naar het spannende gedeelte. Het prototype dat je nu kan bekijken start op het moment dat je (bijvoorbeeld in de NMBS-app) een bepaalde route hebt gekozen om op je bestemming te geraken. De applicatie zal je stap voor stap begeleiden tijdens je reis, en je iets laten weten als er vertragingen of andere problemen zijn. Je kan op verschillende plaatsen in de applicatie klikken om er mee te interageren. Probeer het eens uit, en kom daarna hier terug! Het prototype vind je hier: [link] Opgelet: Nog niet alle functionaliteiten in dit prototype werken! Het kan zijn dat sommige knoppen geen reactie geven. Het kan ook zijn dat het prototype er op verschillende beeldschermen iets anders uitziet. In de volgende vragen krijg je telkens een voorbeeld te zien van hoe het scherm er precies uit dient te zien. Je kan de applicatie ook openen op je smartphone, door de link op je telefoon te openen!

Q3.1 Nu je het prototype hebt kunnen bekijken, ga ik je per type scherm vragen wat je ervan denkt. Als je wil kan je ook nog extra opmerkingen erbij schrijven. Alle opmerkingen, suggesties en vragen zijn welkom! Je kan altijd terugkeren naar het prototype: [link]

Q3.2 In dit scherm zie je het overzicht van je reis voor je aan de begeleiding begint.



Q3.3 Hoe tevreden ben je met dit scherm? (overweeg leesbaarheid, duidelijkheid, overzichtelijkheid, relevantie van de informatie op het juiste moment, etc...)

- ❍ Heel ontevreden (1)
- ❍ Eerder ontevreden (2)
- ❍ Tevreden noch ontevreden (3)
- ❍ Eerder tevreden (4)
- ❍ Heel tevreden (5)

Answer If Tevreden noch ontevreden/Eerder tevreden/Heel tevreden Is Selected

Q3.4 Heb je vragen, opmerkingen of suggesties voor dit scherm? Laat ze dan hier achter:

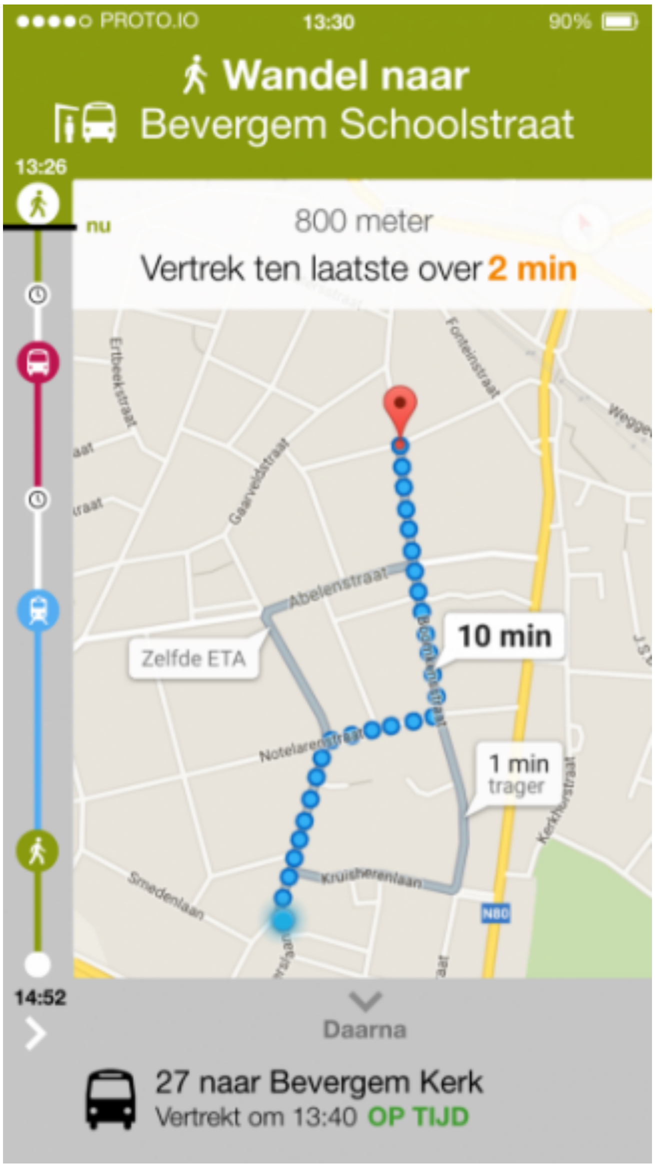
Answer If Eerder ontevreden/Heel ontevreden Is Selected

Q3.5 Als je ontevreden bent over dit scherm, waaraan ligt dit dan?

- ❑ Leesbaarheid van de tekst (1)
- ❑ Duidelijkheid van de informatie (2)
- ❑ Overzichtelijkheid van het scherm (3)
- ❑ Relevantie van de informatie (4)
- ❑ Anders: (5) ____________________

Q4.1 Je kan altijd terugkeren naar het prototype: [link]

Q4.2 In dit scherm zie je de wandelroute voor je begint, en het aantal resterende minuten voordat je zeker moet vertrekken. De applicatie updatet de juiste informatie in real-time aan de hand van jouw locatie en activiteit: je zal dus, in tegenstelling tot het huidige prototype, niet zelf moeten tikken om naar de volgende stap te gaan.



Q4.3 Hoe tevreden ben je met dit scherm? (overweeg leesbaarheid, duidelijkheid, overzichtelijkheid, relevantie van de informatie op het juiste moment, etc...)

- ❍ Heel ontevreden (1)
- ❍ Eerder ontevreden (2)
- ❍ Tevreden noch ontevreden (3)
- ❍ Eerder tevreden (4)
- ❍ Heel tevreden (5)

Answer If Tevreden noch ontevreden/Eerder tevreden/Heel tevreden Is Selected

Q4.4 Heb je vragen, opmerkingen of suggesties voor dit scherm? Laat ze dan hier achter:

Answer If Eerder ontevreden/Heel ontevreden Is Selected

Q4.5 Als je ontevreden bent over dit scherm, waaraan ligt dit dan?

- ❑ Leesbaarheid van de tekst (1)
- ❑ Duidelijkheid van de informatie (2)

- ❑ Overzichtelijkheid van het scherm (3)
- ❑ Relevantie van de informatie (4)
- ❑ Anders: (5) ____________________

Q5.1 Je kan altijd terugkeren naar het prototype: [link]

Q5.2 Dit is een voorbeeld van een scherm waarin je ergens naartoe wandelt. Je kan kiezen tussen begeleiding met Street View of een gewone kaart. Aan de hand van je wandelsnelheid wordt dan berekend hoeveel wachttijd je nog over hebt aan de halte.

Q5.3 Hoe tevreden ben je met dit scherm? (overweeg leesbaarheid, duidelijkheid, overzichtelijkheid, relevantie van de informatie op het juiste moment, etc...)

- ❍ Heel ontevreden (1)
- ❍ Eerder ontevreden (2)
- ❍ Tevreden noch ontevreden (3)
- ❍ Eerder tevreden (4)

❍ Heel tevreden (5)

Answer If Tevreden noch ontevreden/Eerder tevreden/Heel tevreden Is Selected
Q5.4 Heb je vragen, opmerkingen of suggesties voor dit scherm? Laat ze dan hier achter:

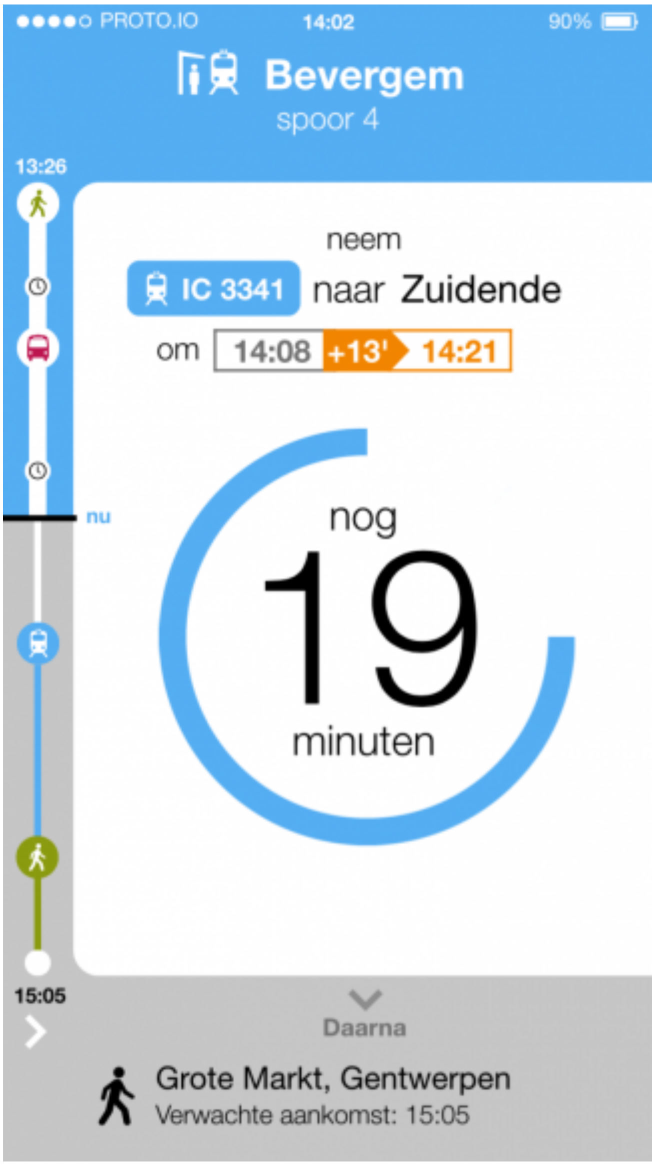
Answer If Eerder ontevreden/Heel ontevreden Is Selected
Q5.5 Als je ontevreden bent over dit scherm, waaraan ligt dit dan?

- ❑ Leesbaarheid van de tekst (1)
- ❑ Duidelijkheid van de informatie (2)
- ❑ Overzichtelijkheid van het scherm (3)
- ❑ Relevantie van de informatie (4)
- ❑ Anders: (5) ____________________

Q6.1 Je kan altijd terugkeren naar het prototype: [link]

Q6.2 Dit is een voorbeeld van een scherm waarin je op je bus wacht. Het aantal resterende minuten tot de bus aankomt wordt weergegeven en telt automatisch af.

Q6.3 Zo ziet het eruit als je trein vertraging heeft:



Q6.4 Hoe tevreden ben je met dit scherm? (overweeg leesbaarheid, duidelijkheid, overzichtelijkheid, relevantie van de informatie op het juiste moment, etc...)

- ❍ Heel ontevreden (1)
- ❍ Eerder ontevreden (2)
- ❍ Tevreden noch ontevreden (3)
- ❍ Eerder tevreden (4)
- ❍ Heel tevreden (5)

Answer If Tevreden noch ontevreden/Eerder tevreden/Heel tevreden Is Selected

Q6.5 Heb je vragen, opmerkingen of suggesties voor dit scherm? Laat ze dan hier achter:

Answer If Eerder ontevreden/Heel ontevreden Is Selected

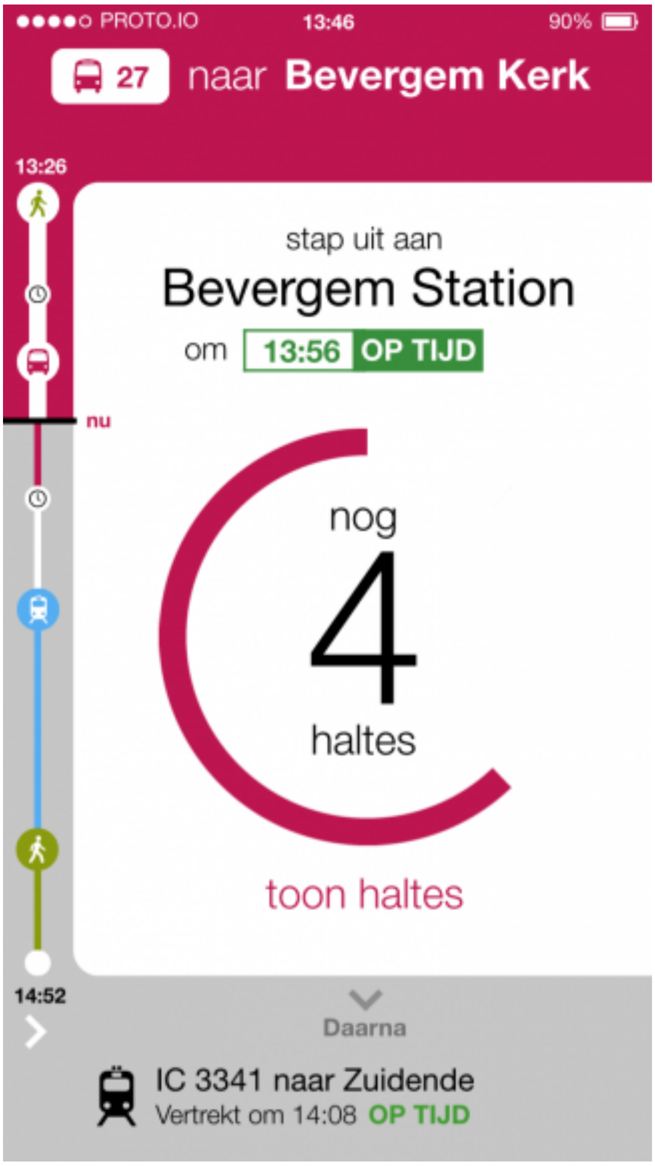
Q6.6 Als je ontevreden bent over dit scherm, waaraan ligt dit dan?

- ❑ Leesbaarheid van de tekst (1)
- ❑ Duidelijkheid van de informatie (2)

- ❑ Overzichtelijkheid van het scherm (3)
- ❑ Relevantie van de informatie (4)
- ❑ Anders: (5) ____________________

Q7.1 Je kan altijd terugkeren naar het prototype: [link]

Q7.2 Dit is een voorbeeld van een scherm waarin je in een voertuig zit. Het aantal resterende haltes tot wanneer je moet uitstappen wordt weergegeven en telt automatisch af. Je kan kiezen om de lijst met volgende haltes weer te geven, maar dit is in de huidige versie nog niet geïmplementeerd.



Q7.3 Zo ziet het eruit als je trein vertraging heeft:

Q7.4 Hoe tevreden ben je met dit scherm? (overweeg leesbaarheid, duidelijkheid, overzichtelijkheid, relevantie van de informatie op het juiste moment, etc...)

- ❍ Heel ontevreden (1)
- ❍ Eerder ontevreden (2)
- ❍ Tevreden noch ontevreden (3)
- ❍ Eerder tevreden (4)
- ❍ Heel tevreden (5)

Answer If Tevreden noch ontevreden/Eerder tevreden/Heel tevreden Is Selected

Q7.5 Heb je vragen, opmerkingen of suggesties voor dit scherm? Laat ze dan hier achter:

Answer If Eerder ontevreden/Heel ontevreden Is Selected

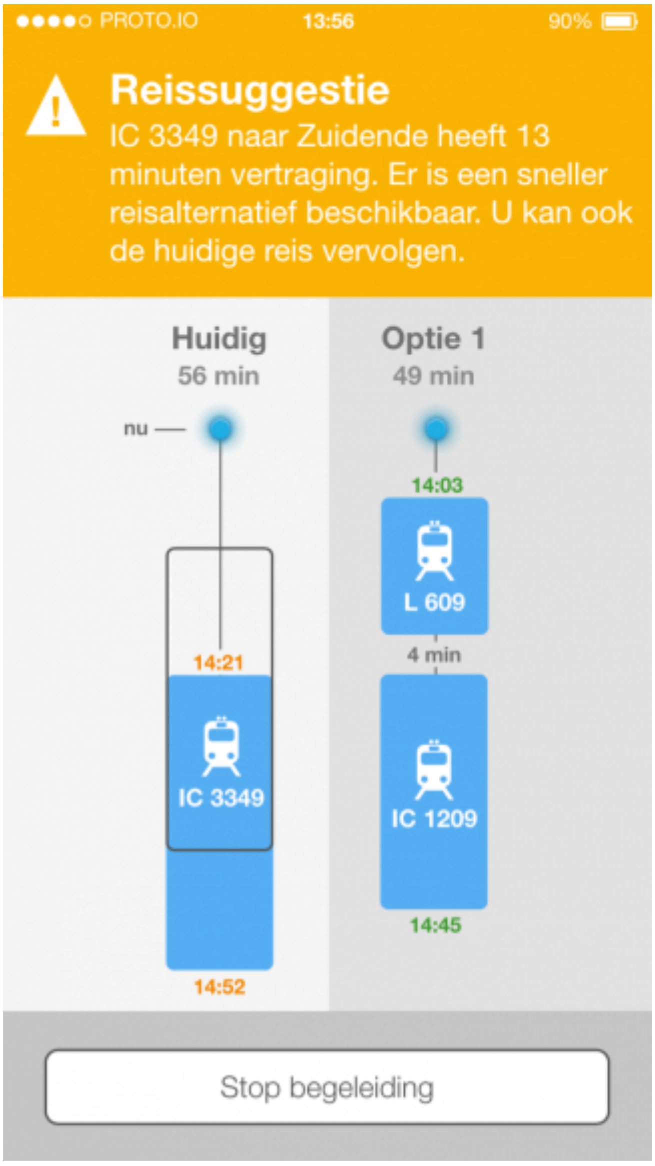
Q7.6 Als je ontevreden bent over dit scherm, waaraan ligt dit dan?

- ❑ Leesbaarheid van de tekst (1)
- ❑ Duidelijkheid van de informatie (2)

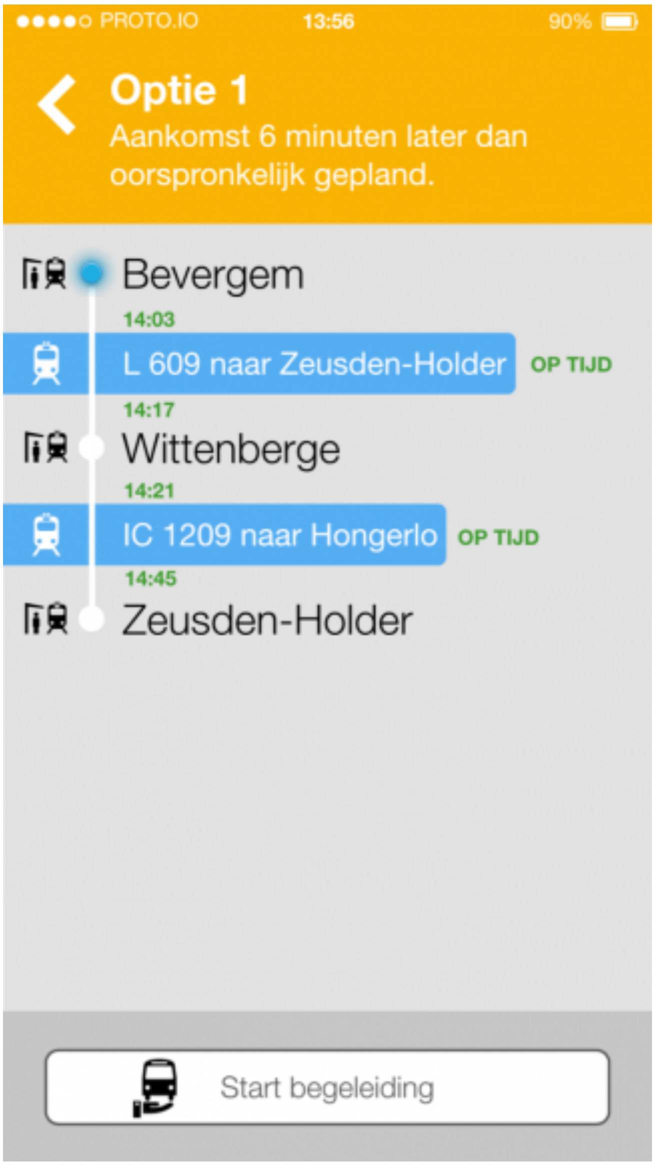
❑ Overzichtelijkheid van het scherm (3)
❑ Relevantie van de informatie (4)
❑ Anders: (5) ____________________

Q8.1 Je kan altijd terugkeren naar het prototype: [link]

Q8.2 Wanneer er iets mis gaat geeft de applicatie je automatisch suggesties over wat je kan doen. In dit geval heeft je trein zoveel vertraging dat er een sneller alternatief beschikbaar is. Wanneer je bus of trein zoveel vertraging heeft dat je je aansluiting niet meer kan halen, word je verplicht een andere optie te kiezen. In dit geval kon je ook nog verder met de huidige reis.



Q8.3 Zo ziet het eruit als je een optie kiest:



Q8.4 Hoe tevreden ben je met dit scherm? (overweeg leesbaarheid, duidelijkheid, overzichtelijkheid, relevantie van de informatie op het juiste moment, etc...)

- ❍ Heel ontevreden (1)
- ❍ Eerder ontevreden (2)
- ❍ Tevreden noch ontevreden (3)
- ❍ Eerder tevreden (4)
- ❍ Heel tevreden (5)

Answer If Tevreden noch ontevreden/Eerder tevreden/Heel tevreden Is Selected

Q8.5 Heb je vragen, opmerkingen of suggesties voor dit scherm? Laat ze dan hier achter:

Answer If Eerder ontevreden/Heel ontevreden Is Selected

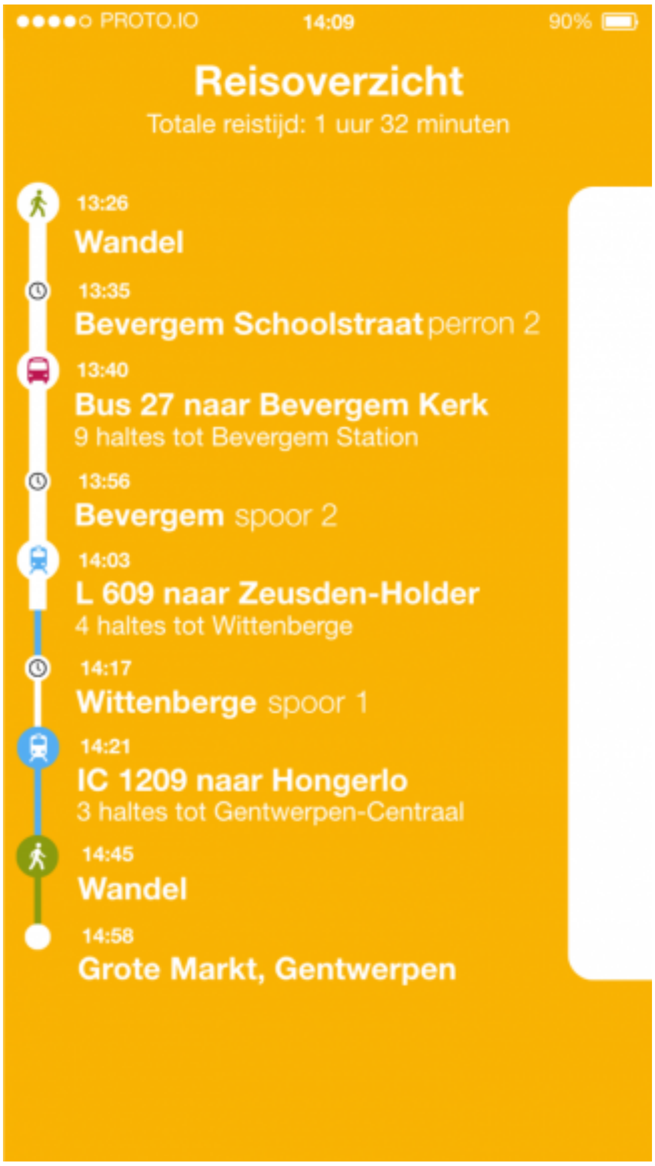
Q8.6 Als je ontevreden bent over dit scherm, waaraan ligt dit dan?

- ❑ Leesbaarheid van de tekst (1)
- ❑ Duidelijkheid van de informatie (2)

❑ Overzichtelijkheid van het scherm (3)
❑ Relevantie van de informatie (4)
❑ Anders: (5) ____________________

Q9.1 Je kan altijd terugkeren naar het prototype: [link]

Q9.2 Bijna klaar! Vanuit elk begeleidingsscherm kan je ook teruggaan naar een overzicht van je reis door op de verticale tijdslijn links te tikken of het witte gedeelte in de applicatie naar rechts te vegen. Hier zie je alle stappen die je moet uitvoeren om op je bestemming te geraken, en hoe ver je al bent geraakt.



Q9.3 Hoe tevreden ben je met dit scherm? (overweeg leesbaarheid, duidelijkheid, overzichtelijkheid, relevantie van de informatie op het juiste moment, etc...)

❍ Heel ontevreden (1)
❍ Eerder ontevreden (2)
❍ Tevreden noch ontevreden (3)
❍ Eerder tevreden (4)

- Heel tevreden (5)

Answer If Tevreden noch ontevreden/Eerder tevreden/Heel tevreden Is Selected

Q9.4 Heb je vragen, opmerkingen of suggesties voor dit scherm? Laat ze dan hier achter:

Answer If Eerder ontevreden/Heel ontevreden Is Selected

Q9.5 Als je ontevreden bent over dit scherm, waaraan ligt dit dan?

- [ ] Leesbaarheid van de tekst (1)
- [ ] Duidelijkheid van de informatie (2)
- [ ] Overzichtelijkheid van het scherm (3)
- [ ] Relevantie van de informatie (4)
- [ ] Anders: (5) ____________________

Q10.1 Je bent bijna klaar! Ik zou enkel nog je mening willen weten over de applicatie in haar geheel. Duid aan hoe sterk je het eens of oneens bent met de volgende stellingen:

	1 (Sterk oneens)	2	3	4	5 (Sterk eens)
Ik denk dat ik de applicatie graag regelmatig wil gebruiken (1)	❍	❍	❍	❍	❍
Ik vond de applicatie onnodig complex (2)	❍	❍	❍	❍	❍
Ik vond de applicatie gemakkelijk te gebruiken (3)	❍	❍	❍	❍	❍
Ik denk dat ik hulp nodig heb van iemand anders om deze applicatie te kunnen gebruiken (4)	❍	❍	❍	❍	❍
Ik vond dat de verschillende functies in deze applicatie goed geïntegreerd zijn (5)	❍	❍	❍	❍	❍
Ik vind dat er teveel tegenstrijdigheden in deze applicatie zaten (6)	❍	❍	❍	❍	❍
Ik kan me voorstellen dat de meeste mensen zeer snel leren om deze applicatie te gebruiken (7)	❍	❍	❍	❍	❍

Ik vond de applicatie heel omslachtig in gebruik (8)	❍	❍	❍	❍	❍
Ik voelde me erg vertrouwd met de applicatie (9)	❍	❍	❍	❍	❍
Ik moest erg veel leren voor ik aan de gang kon met deze applicatie (10)	❍	❍	❍	❍	❍

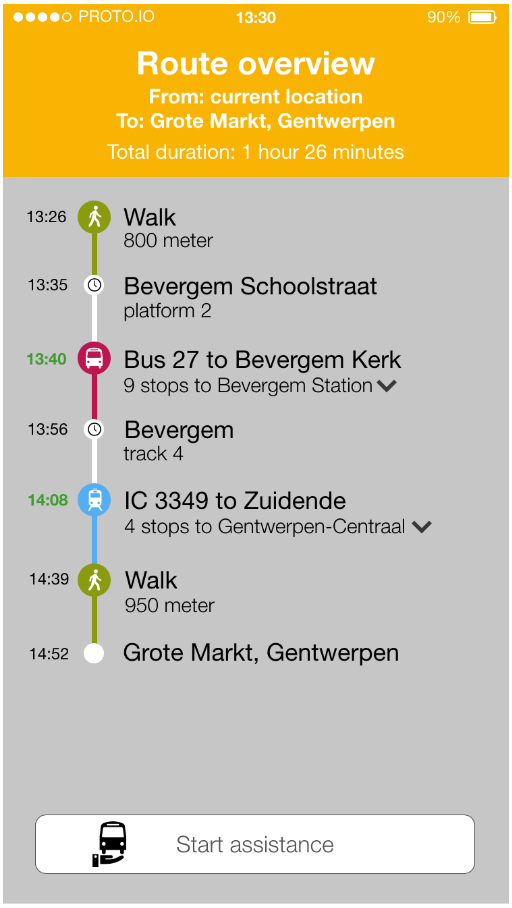
Q10.2 Ten slotte, hoe tevreden ben je in het algemeen met deze applicatie? (Smiley)

- ❍ 1 (Very unsatisfied)
- ❍ 2 (Rather unsatisfied)
- ❍ 3 (Neither satisfied nor unsatisfied)
- ❍ 4 (Rather satisfied)
- ❍ 5 (Very satisfied)

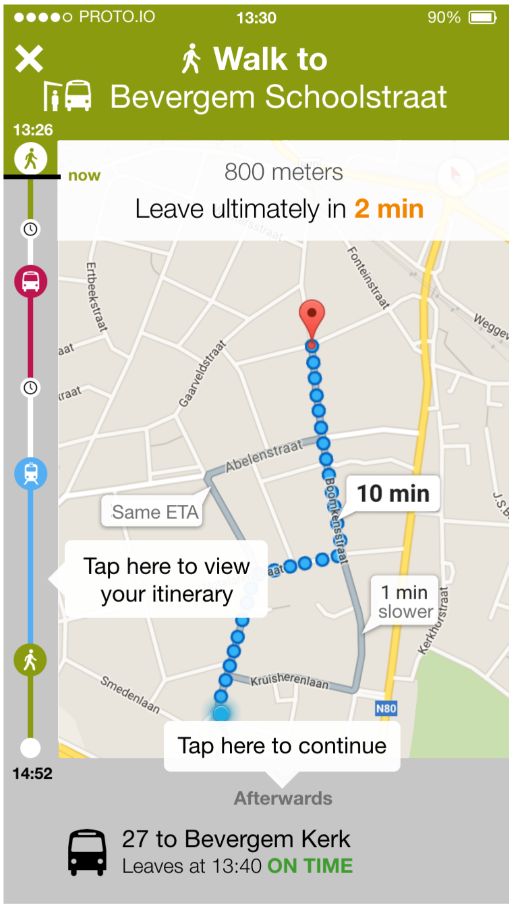
Q11.1 Klaar! Bedankt om deel te nemen aan dit onderzoek. Jouw (anonieme) feedback zal worden gebruikt om het prototype nog verder te verbeteren. Indien je nog andere vragen, opmerkingen of suggesties hebt, kan je ze invullen in onderstaand tekstvak:

Q65 Indien je op de hoogte wil gehouden worden van het verdere verloop van mijn onderzoek, kan je je email-adres hier invullen. Ik stuur je dan een samenvatting van mijn thesis wanneer deze klaar is!

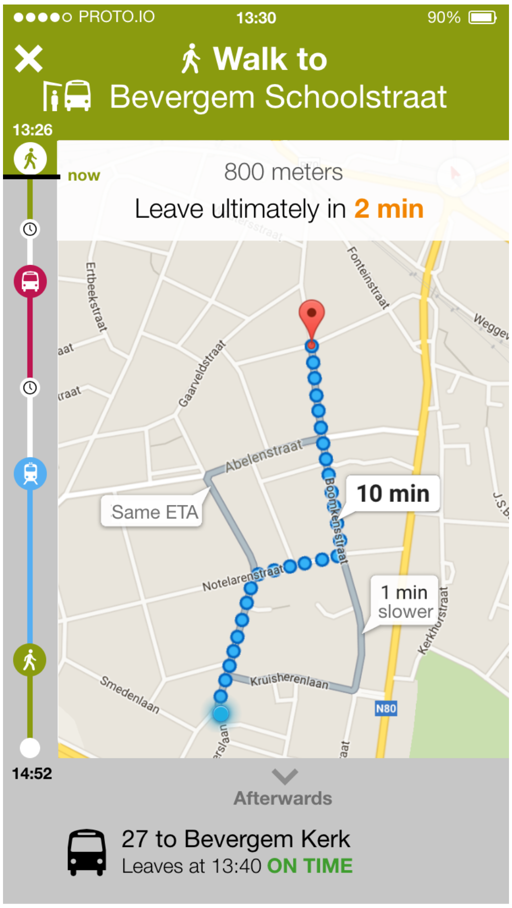
Q11.2 Vergeet niet om nog op Volgende (>>) te klikken om je resultaten te verzenden!



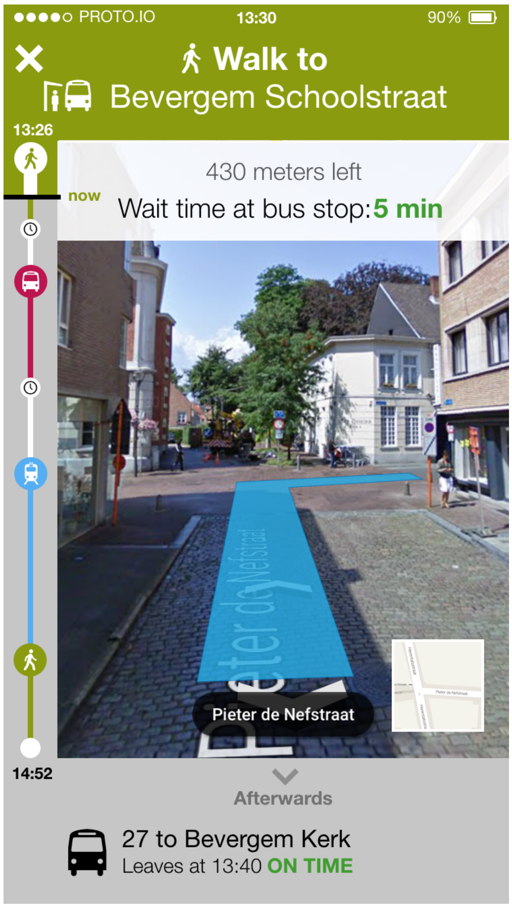
●●●●○ PROTO.IO 13:30 90%
Route overview
From: current location
To: Grote Markt, Gentwerpen
Total duration: 1 hour 26 minutes
13:26 Walk
800 meter
13:35 Bevergem Schoolstraat
platform 2
13:40 Bus 27 to Bevergem Kerk
9 stops to Bevergem Station
13:56 Bevergem
track 4
14:08 IC 3349 to Zuidende
4 stops to Gentwerpen-Centraal
14:39 Walk
950 meter
14:52 Grote Markt, Gentwerpen
Start assistance



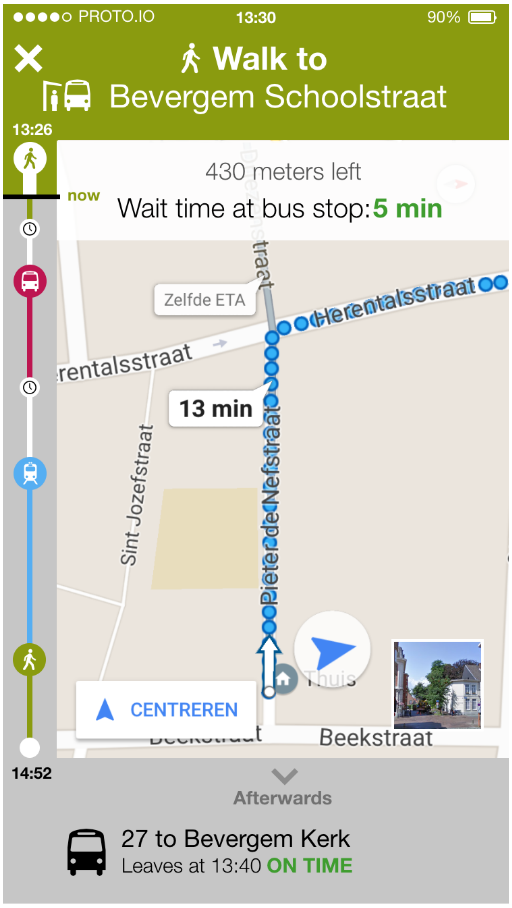
●●●●○ PROTO.IO 13:30 90%
Walk to
Bevergem Schoolstraat
13:26
now
800 meters
Leave ultimately in 2 min
10 min
Same ETA
Tap here to view your itinerary
1 min slower
Tap here to continue
14:52
Afterwards
27 to Bevergem Kerk
Leaves at 13:40 ON TIME

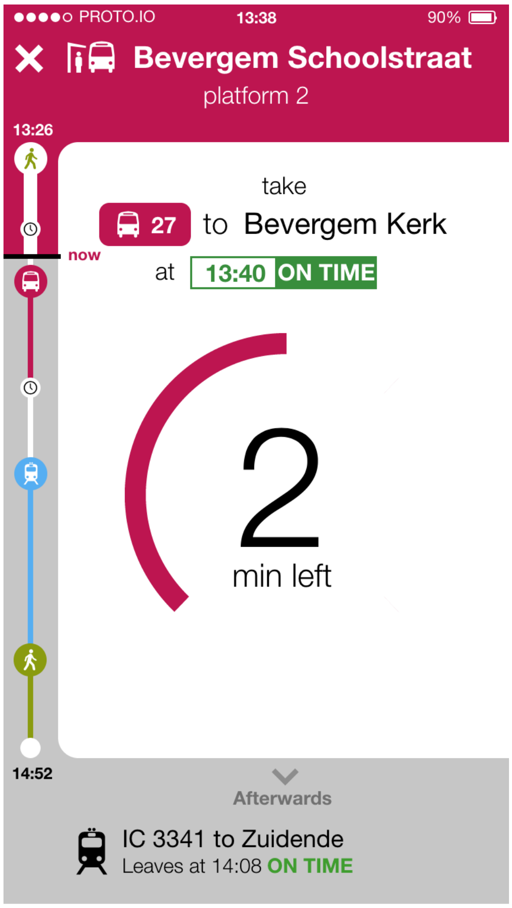


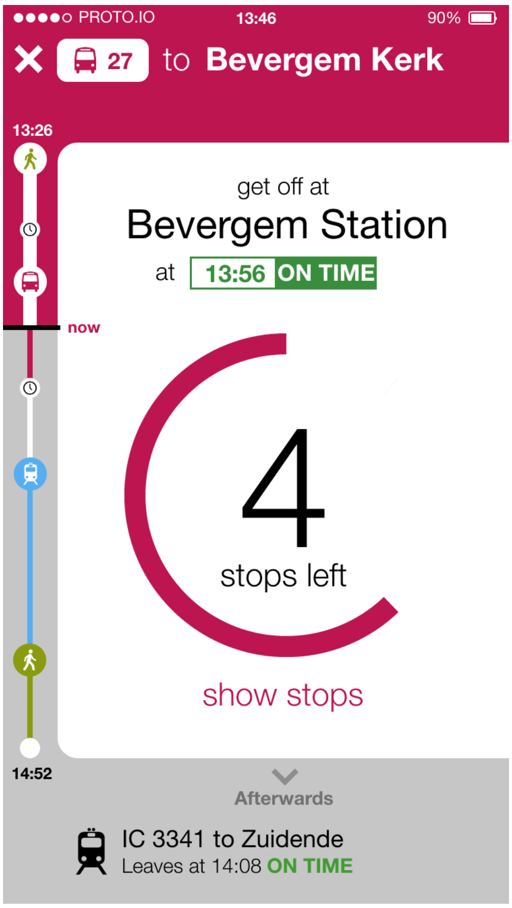
●●●●○ PROTO.IO 13:30 90%
Walk to
Bevergem Schoolstraat
13:26
now
800 meters
Leave ultimately in 2 min
10 min
Same ETA
1 min slower
14:52
Afterwards
27 to Bevergem Kerk
Leaves at 13:40 ON TIME

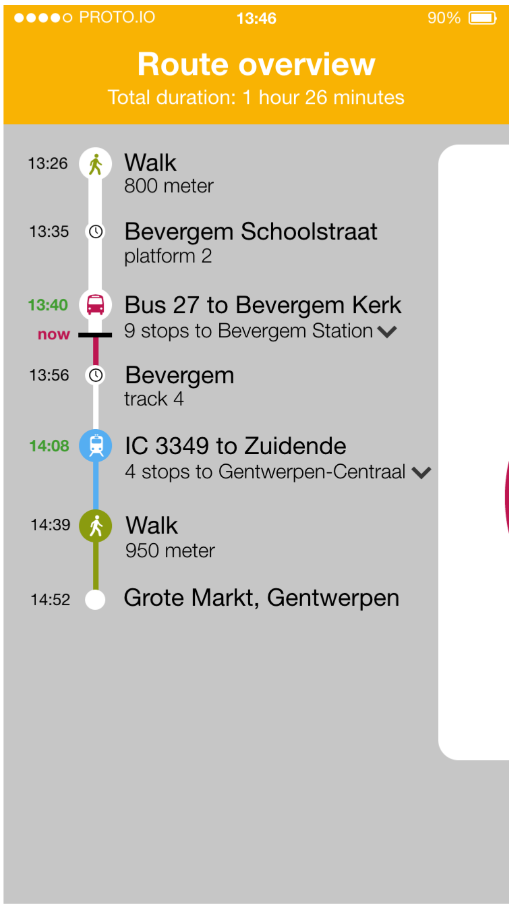


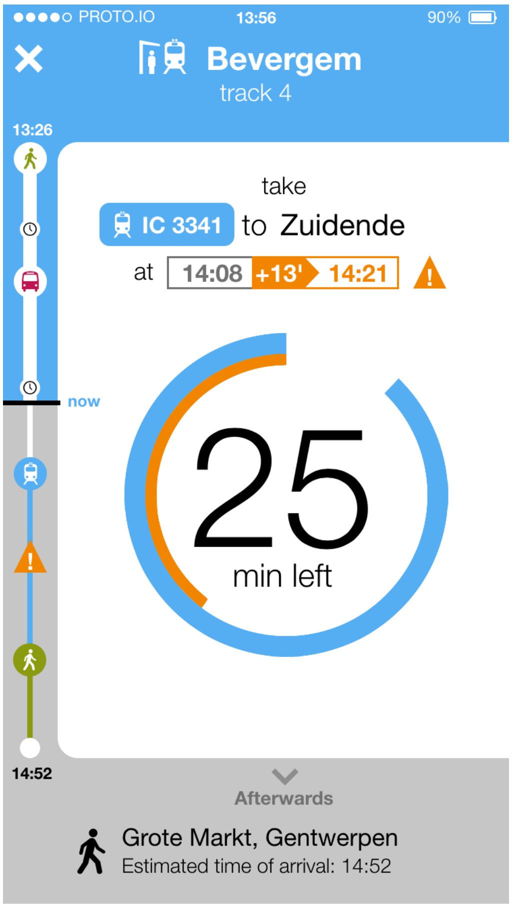
●●●●○ PROTO.IO 13:30 90%
Walk to
Bevergem Schoolstraat
13:26
now
430 meters left
Wait time at bus stop:5 min
Pieter de Nefstraat
14:52
Afterwards
27 to Bevergem Kerk
Leaves at 13:40 ON TIME


●●●●○ PROTO.IO
13:30
90%
Walk to
Bevergem Schoolstraat
13:26
430 meters left
now
Wait time at bus stop: 5 min
Zelfde ETA
Herentalsstraat
rentalsstraat
13 min
Sint Jozefstraat
Pieter de Nefstraat
CENTREREN
Beekstraat
14:52
Afterwards
27 to Bevergem Kerk
Leaves at 13:40 ON TIME

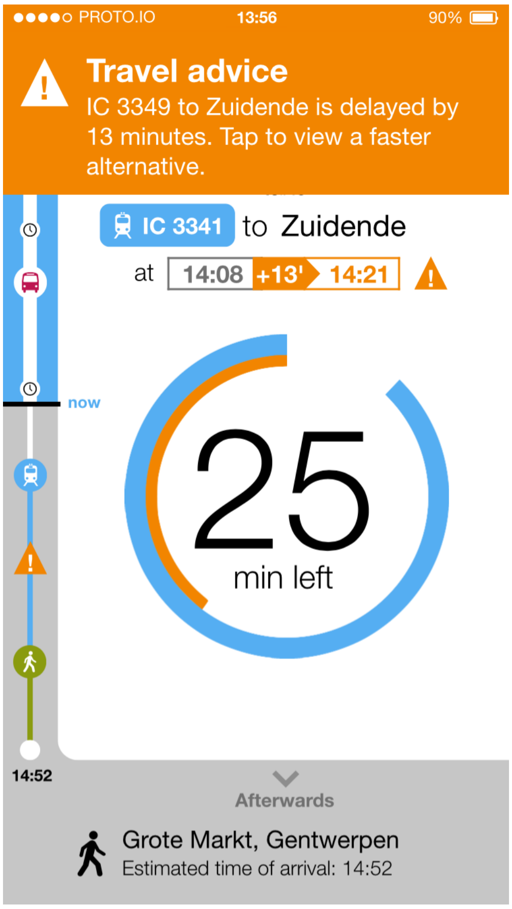

●●●●○ PROTO.IO
13:38
90%
Bevergem Schoolstraat
platform 2
13:26
take
27 to Bevergem Kerk
now
at 13:40 ON TIME
2
min left
14:52
Afterwards
IC 3341 to Zuidende
Leaves at 14:08 ON TIME


●●●●○ PROTO.IO
13:46
90%
27 to Bevergem Kerk
13:26
get off at
Bevergem Station
at 13:56 ON TIME
now
4
stops left
show stops
14:52
Afterwards
IC 3341 to Zuidende
Leaves at 14:08 ON TIME

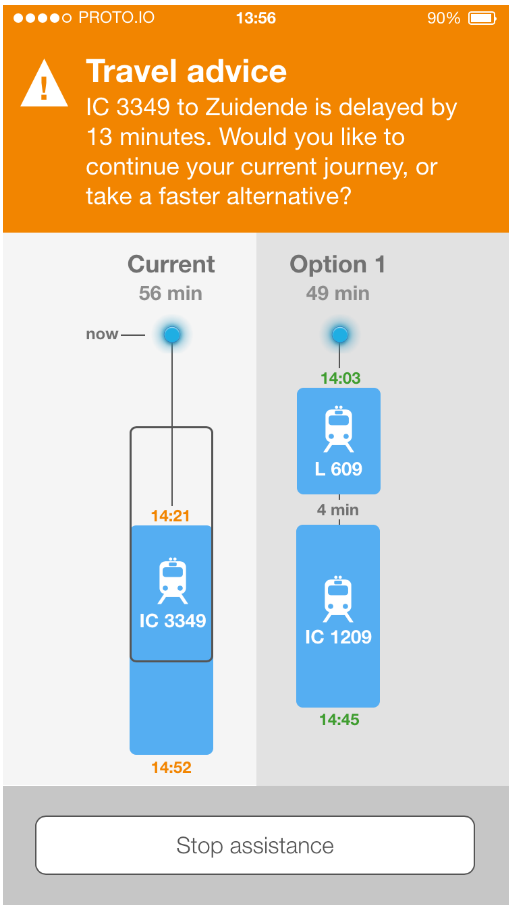

●●●●○ PROTO.IO
13:46
90%
Route overview
Total duration: 1 hour 26 minutes
13:26 Walk
800 meter
13:35 Bevergem Schoolstraat
platform 2
13:40 Bus 27 to Bevergem Kerk
now 9 stops to Bevergem Station
13:56 Bevergem
track 4
14:08 IC 3349 to Zuidende
4 stops to Gentwerpen-Centraal
14:39 Walk
950 meter
14:52 Grote Markt, Gentwerpen



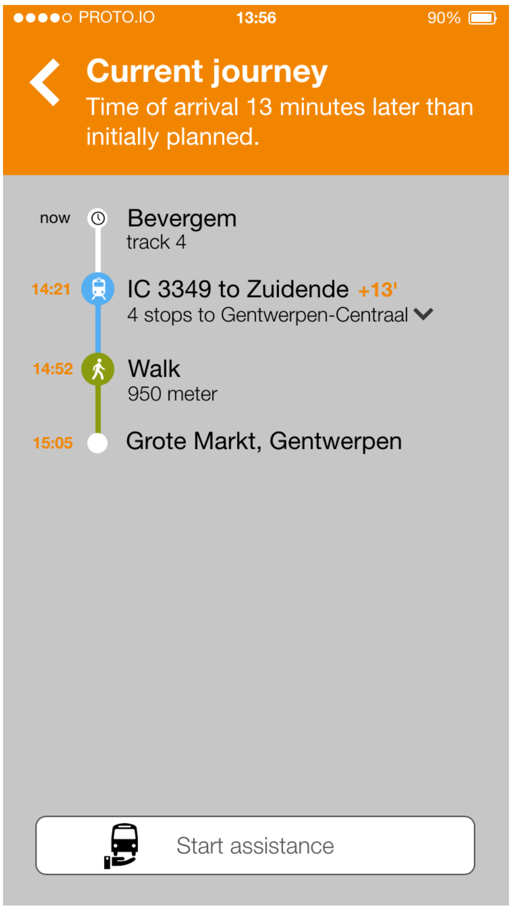
PROTO.IO
13:56
90%
Bevergem
track 4
13:26
now
take
IC 3341 to Zuidende
at 14:08 +13' 14:21
25
min left
14:52
Afterwards
Grote Markt, Gentwerpen
Estimated time of arrival: 14:52



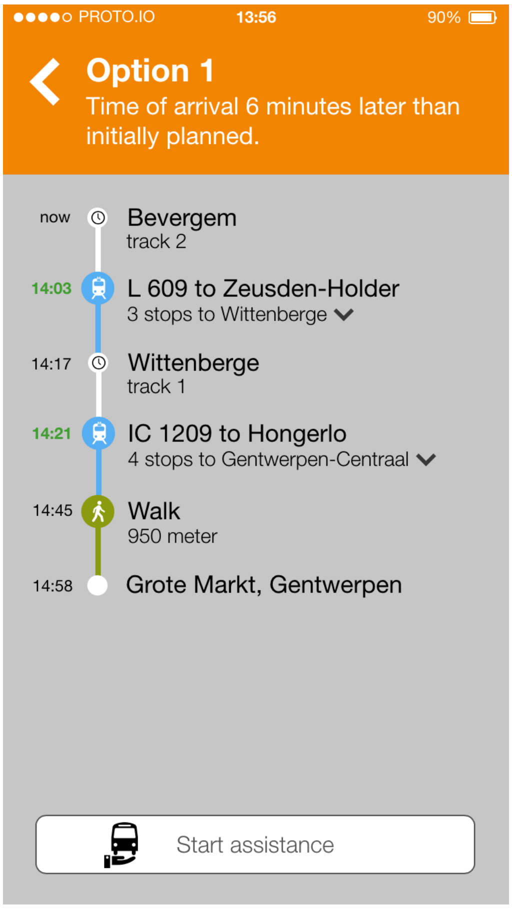
PROTO.IO
13:56
90%
Travel advice
IC 3349 to Zuidende is delayed by 13 minutes. Tap to view a faster alternative.
IC 3341 to Zuidende
at 14:08 +13' 14:21
now
25
min left
14:52
Afterwards
Grote Markt, Gentwerpen
Estimated time of arrival: 14:52

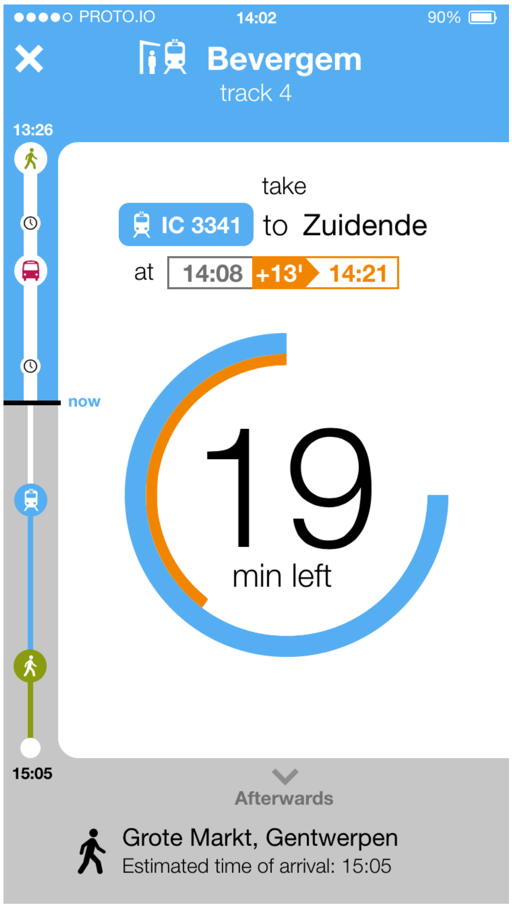


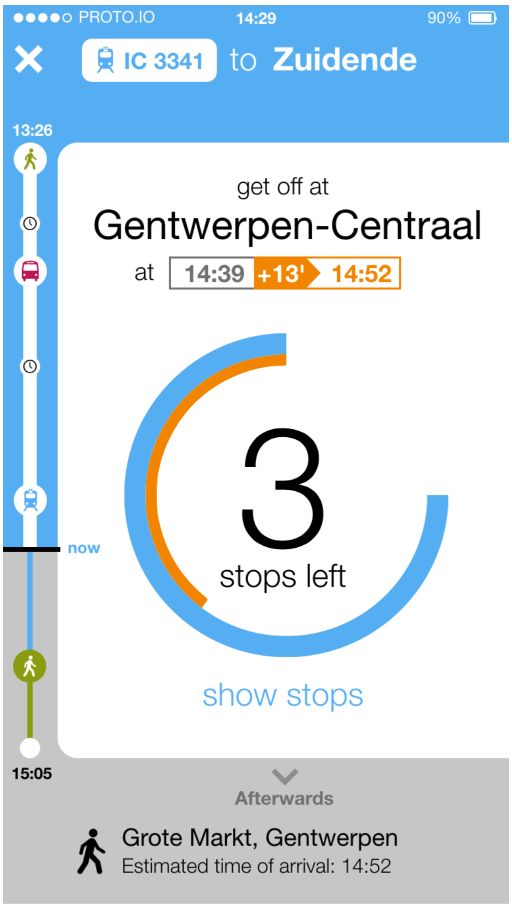
PROTO.IO
13:56
90%
Travel advice
IC 3349 to Zuidende is delayed by 13 minutes. Would you like to continue your current journey, or take a faster alternative?
Current
56 min
Option 1
49 min
now
14:03
L 609
4 min
14:21
IC 3349
IC 1209
14:45
14:52
Stop assistance



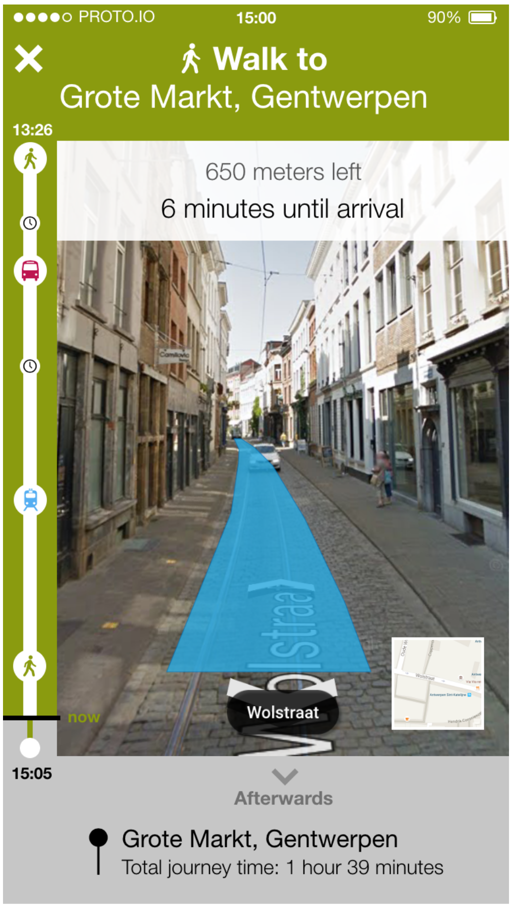
PROTO.IO
13:56
90%
Current journey
Time of arrival 13 minutes later than initially planned.
now
Bevergem
track 4
14:21
IC 3349 to Zuidende +13'
4 stops to Gentwerpen-Centraal
14:52
Walk
950 meter
15:05
Grote Markt, Gentwerpen
Start assistance

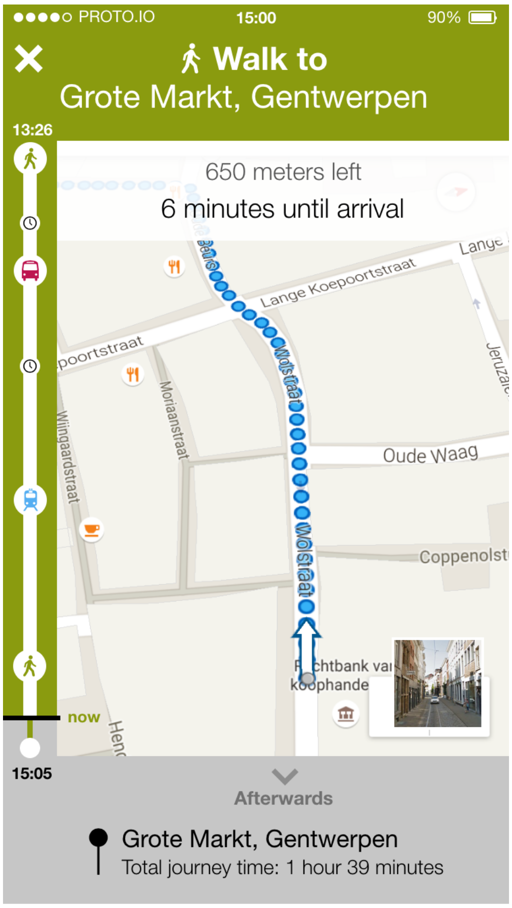

●●●●○ PROTO.IO
13:56
90%
Option 1
Time of arrival 6 minutes later than initially planned.
now
Bevergem
track 2
14:03
L 609 to Zeusden-Holder
3 stops to Wittenberge
14:17
Wittenberge
track 1
14:21
IC 1209 to Hongerlo
4 stops to Gentwerpen-Centraal
14:45
Walk
950 meter
14:58
Grote Markt, Gentwerpen
Start assistance

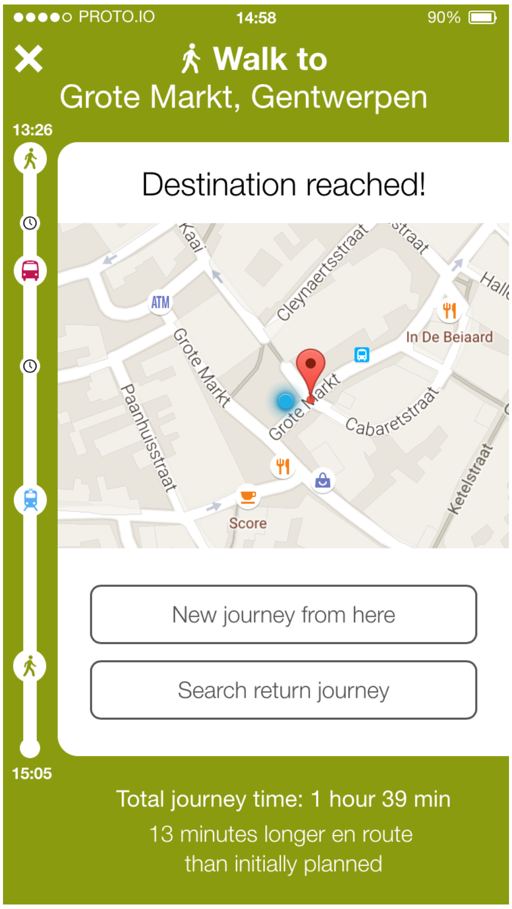

●●●●○ PROTO.IO
14:02
90%
Bevergem
track 4
13:26
take
IC 3341
to Zuidende
at
14:08
+13'
14:21
now
19
min left
15:05
Afterwards
Grote Markt, Gentwerpen
Estimated time of arrival: 15:05

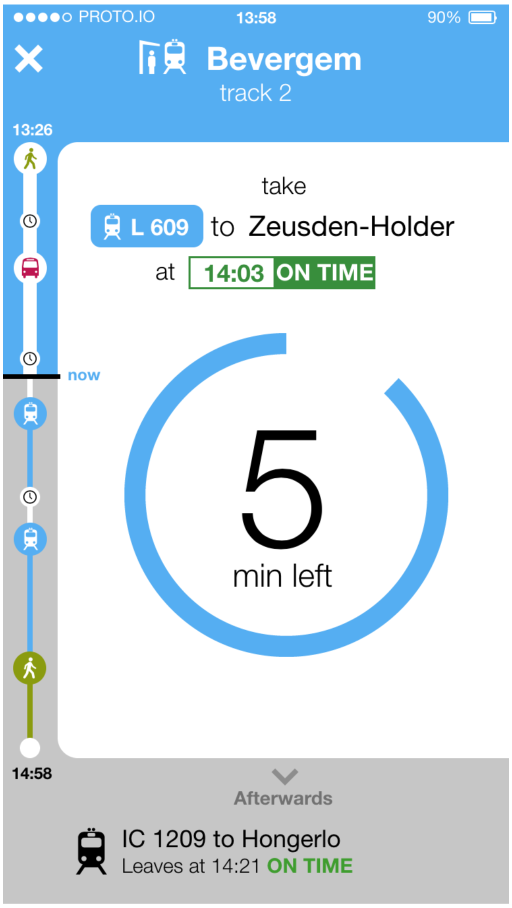

●●●●○ PROTO.IO
14:29
90%
IC 3341
to Zuidende
13:26
get off at
Gentwerpen-Centraal
at
14:39
+13'
14:52
now
3
stops left
show stops
15:05
Afterwards
Grote Markt, Gentwerpen
Estimated time of arrival: 14:52

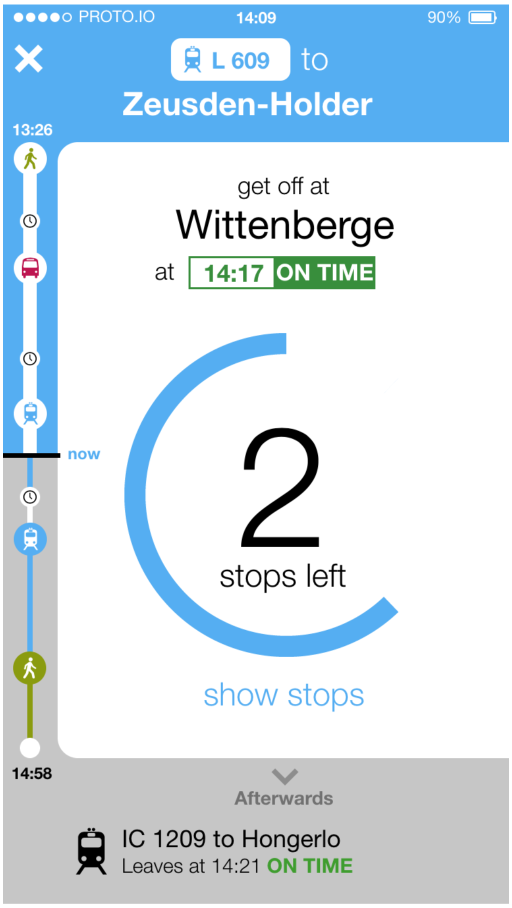

●●●●○ PROTO.IO
14:29
90%
IC 3341
to Zuidende
13:26
get off at
Gentwerpen-Centraal
at
14:39
+13'
14:52
14:21
Bevergem track 4
14:26
14:27
Laagstraten track 1
14:38
14:38
Veerhout track 1
now
14:45
14:46
Gentwerpen-Noord track 3
14:52
Gentwerpen-C'aal track 8
hide stops
15:05
Afterwards
Grote Markt, Gentwerpen
Estimated time of arrival: 14:52

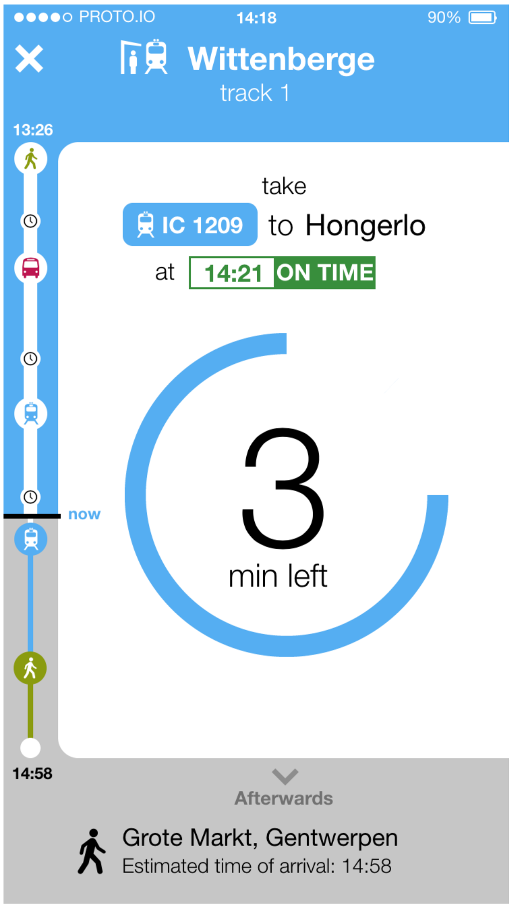

PROTO.IO
15:00
90%
Walk to
Grote Markt, Gentwerpen
13:26
650 meters left
6 minutes until arrival
Wolstraat
now
15:05
Afterwards
Grote Markt, Gentwerpen
Total journey time: 1 hour 39 minutes

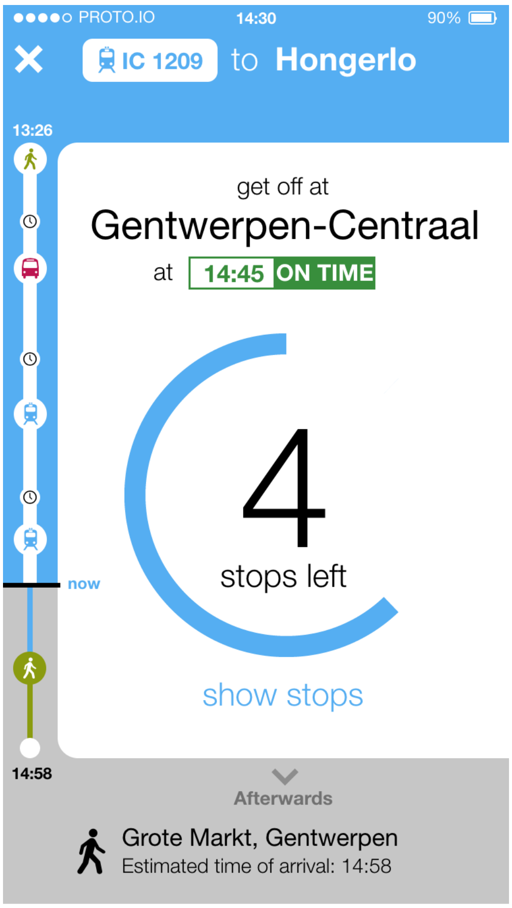

PROTO.IO
15:00
90%
Walk to
Grote Markt, Gentwerpen
13:26
650 meters left
6 minutes until arrival
Lange Koepoortstraat
Wolstraat
Oude Waag
Coppenolst
now
15:05
Afterwards
Grote Markt, Gentwerpen
Total journey time: 1 hour 39 minutes

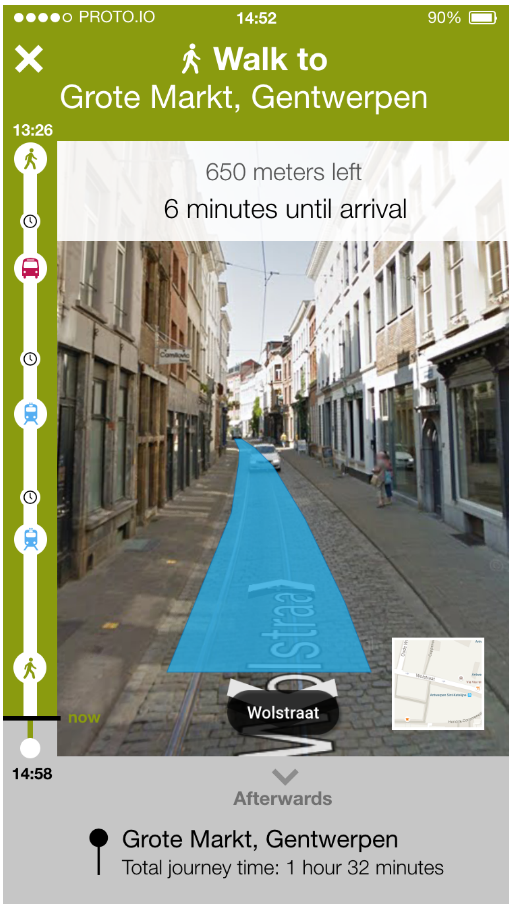

PROTO.IO
14:58
90%
Walk to
Grote Markt, Gentwerpen
13:26
Destination reached!
Cleynaertsstraat
Grote Markt
Paanhuisstraat
In De Beiaard
Cabaretstraat
Score
New journey from here
Search return journey
15:05
Total journey time: 1 hour 39 min
13 minutes longer en route
than initially planned

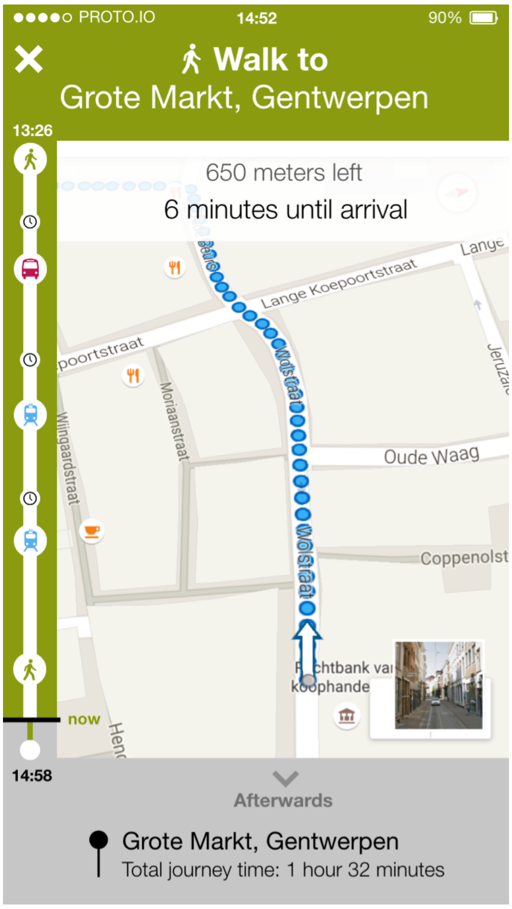

PROTO.IO
13:58
90%
Bevergem
track 2
13:26
take
L 609 to Zeusden-Holder
at 14:03 ON TIME
now
5
min left
14:58
Afterwards
IC 1209 to Hongerlo
Leaves at 14:21 ON TIME

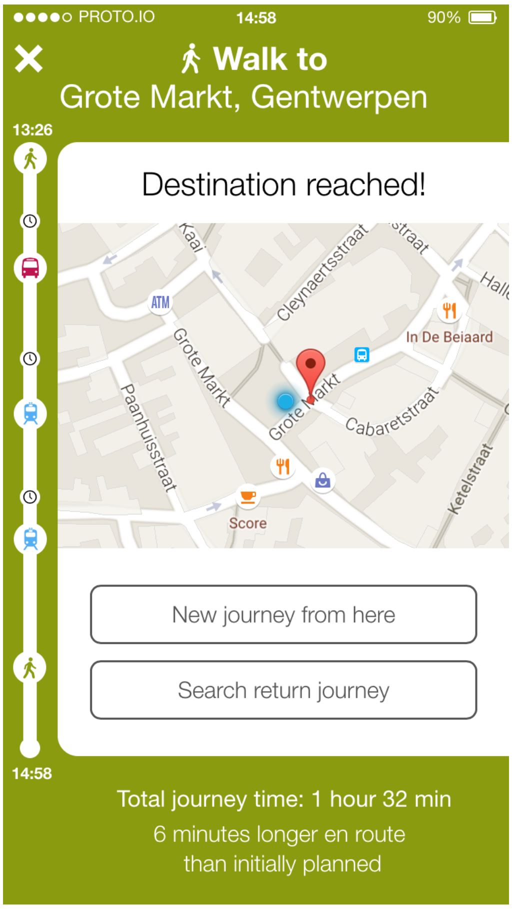

●●●●○ PROTO.IO 14:09 90%
L 609 to
Zeusden-Holder
13:26
get off at
Wittenberge
at 14:17 ON TIME
2
stops left
now
show stops
14:58
Afterwards
IC 1209 to Hongerlo
Leaves at 14:21 ON TIME


●●●●○ PROTO.IO 14:18 90%
Wittenberge
track 1
13:26
take
IC 1209 to Hongerlo
at 14:21 ON TIME
3
min left
now
14:58
Afterwards
Grote Markt, Gentwerpen
Estimated time of arrival: 14:58


●●●●○ PROTO.IO 14:30 90%
IC 1209 to Hongerlo
13:26
get off at
Gentwerpen-Centraal
at 14:45 ON TIME
4
stops left
now
show stops
14:58
Afterwards
Grote Markt, Gentwerpen
Estimated time of arrival: 14:58


●●●●○ PROTO.IO 14:52 90%
Walk to
Grote Markt, Gentwerpen
13:26
650 meters left
6 minutes until arrival
Wolstraat
now
14:58
Afterwards
Grote Markt, Gentwerpen
Total journey time: 1 hour 32 minutes


●●●●○ PROTO.IO
14:52
90%
Walk to
Grote Markt, Gentwerpen
13:26
650 meters left
6 minutes until arrival
Lange Koepoortstraat
Oude Waag
Coppenolst
Moriaanstraat
Wijngaardstraat
now
14:58
Afterwards
Grote Markt, Gentwerpen
Total journey time: 1 hour 32 minutes


●●●●○ PROTO.IO
14:58
90%
Walk to
Grote Markt, Gentwerpen
13:26
Destination reached!
Cleynaertsstraat
Grote Markt
Paardhuisstraat
Cabaretstraat
In De Beiaard
Score
Ketelstraat
ATM
New journey from here
Search return journey
14:58
Total journey time: 1 hour 32 min
6 minutes longer en route
than initially planned