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Investigation of Västtrafik's real-time system

Implementation of a new iPhone application for public transport travellers in Göteborg

Master of Science Thesis in Interaction Design

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Göteborg, Sweden, June 2010

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Abstract

Most of today's public transportation companies make use of real-time information system. This master thesis is about the evaluation of the current real-time information that is distributed by Västtrafik AB to their customers. Based on the result of the evaluation an iPhone application was developed. The development of the application is the biggest part of the project. The application is a tool for people who are travelling with Västtrafik and introduces some new and innovative features including; filtered disturbance information, and showing a vehicle's position on map. This report describes the evaluation of Västtrafik's real-time system, the development of the application, and the results. During the development of the application a questionnaire, an expert evaluation, and a user study were carried out. Those studies are also included in the report.

Sammandrag

De flesta av dagens kollektivtrafikföretag använder sig av realtidssystem och realtidsinformation. Den här rapporten handlar om en utvärdering av realtidsinformation som Västtrafik AB distribuerar till sina kunder. Resultatet av utvärderingen låg till grund för en iPhone applikation som utvecklats under större delen av projektet. Applikationen är ett hjälpmedel för Västtrafiks resenärer och innehåller nya och innovativa funktioner, bland annat; filtrerad störningsinformation och möjligheten att se ett fordons position på en karta. Rapporten beskriver utvärderingen av Västtrafiks realtidssystem, samt utvecklingen av applikationen och resultatet. Under utvecklingen av applikationen genomfördes: en enkätundersökning, en expertutvärdering och ett användartest. De undersökningarna beskrivs också i rapporten.

We would like to thank some people that have helped us during this project; Maria Gustafsson our contact at Västtrafik, Olof Torgersson our tutor at Chalmers, and Pontus Engelbrektsson at Chalmers. We also want to thank all the people that participated in the different studies that we conducted during the project.

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1. Introduction

In today's modern public transportation it is very common to make use of real-time information systems. Companies invest a considerable amount of money in this kind of equipment and applications [1]. This report describes a master thesis done in cooperation with such a company; Västtrafik AB, which are responsible for the public transportation in the region Västra Götaland. The focus of the thesis was Västtrafik's real-time system, and more precisely the information provided by the real-time system to the end users. The initial plan was to evaluate the system and then come up with ways to improve the system for one or more of the issues that had appeared during the evaluation. After the evaluation the decision was made to develop a new iPhone application. This paper will describe why we choose to make an iPhone application, and the design process to make it as well as the results.

1.1. Background

In 2009 Västtrafik introduced a new payment system; the new system received massive criticism [2]. The system was confusing and users didn't understand how it was working, as this report is written a lot of people are still confused about the system. We took contact with Västtrafik to see if they wanted any help with the payment system, and if it was possible to form a master thesis around this problem. We thought that, as interaction designers, we could evaluate the design and together with the users redesign the system to make people understand how it should be used. But they had already made the required reinforcements to fix it and it wasn't possible to include us in the process. We had a meeting with Västtrafik anyway, to discuss a few other possible master theses. After some discussions with Västtrafik and with our examiner a project was formed. The focus of the project was to evaluate Västtrafik’s real-time system, and based on the evaluation come up with solutions that could improve parts of the system where the users aren't totally satisfied.

Throughout the project regular meetings with Västtrafik were held and they gave input on the project and helped us navigate in the right direction. During the meetings we also gave feedback on the different systems that belongs to Västtrafik that we used, the homepage, the iPhone application and most important the API. Hopefully the work that we have done will influence the systems that will be developed in the future by Västtrafik.

1.1.1. Real-time systems

Real-time systems in the context of this thesis concerns the different systems that provides users with information that can aid them in their travels. The displays at the bus and tram stops might be the first thing that comes in mind when talking about real-time information in public transportation. But real-time information can also be presented through other channels. Cell phones can present real-time information for the user before, during, and after a journey. The information that is presented today is usually only useful before the journey, to check when a bus or a tram will depart, or to search for a journey. The same information can be presented on the internet, that might be a more common place to search for journeys and check for departures than using the cell phone. Displays on the vehicle you are travelling with are also presenting real-time information. They usually give you information about upcoming stops and important information.

Information regarding disturbances is another form of real-time information. It might be crucial that this information reaches the users as soon as possible. There are different ways of presenting the information. The most common ways are to make use of displays and speakers at the stops; however it is not so common to make good use of digital media.

1.2. Objectives

The two main objectives of this thesis is to investigate what problems users have with the real-time information distributed by Västtrafik today, and then try to come up with ideas that solves some of those problems and realize one or more of those.

With users in this report we refer to people in the Göteborg region that currently travel with public transportation. It is not our goal to develop systems that will attract more people to travel with public transportation, but rather to enhance the experience for people that already do. The reason that we have decided to not try to attract more users by improving the real-time system is because we believe that it is not changes in the real-time systems that will make people take the bus rather than take their car. We believe that other changes have to be made to reach those users.

1.3. Dictionary

API: Or application programming interface is a set of rules describing how the communication between two applications should look like.

Journey: A journey is when you travel from a stop to another, a journey can involve transfers.

Trip: A trip is a part of a journey. A journey with one transfer consists of two trips, one trip to the place of the transfer, and one trip to the destination.

Route: Is the way of a journey or a trip marked on a map.

Line number: The number of a specific vehicle.

Stop: The places where a vehicle stops. Each stop has at least two traffic islands. The traffic islands are different places at a stop where vehicles depart from.

Trip planner: Is a tool for searching for journeys.

Region: In the data from Västtrafik Västra Götaland is divided into four regions.

County: Each region is divided into counties.

2. Methods

This section will describe the various methods that have been used during the realization process. Focus groups were used in the pre-study to evaluate the Västtrafik's current real-time system. As soon as it was decided that an iPhone application would be made we started working with paper prototypes. A questionnaire was made in digital format to gather data about what functionality that was most wanted in the application. When we started to code the application we were influenced by extreme programming (XP), for example we were programming in pair. Expert evaluations where used during the project to test our application and to get some feedback on the usability and the design of the application. Towards the end of the project a user study was held to evaluate the final prototype and gather any last design issues.

2.1. Focus groups

Focus groups [3] is a qualitative research method where a group of people are interviewed at the same time. What makes it different from most group interviews is that it generates data based on the communication between the participants. Which means that instead of asking questions and let the participants answer one at a time, people are encouraged to discuss their experiences and thoughts with each other. Focus groups are especially useful to explore users' experiences and knowledge. It can also be used to examine not only what the people think, but also why they think that way.

In a focus group session you start a discussion with the help of open ended questions for the participants to discus. The people will communicate with each other around the topic while the organizers takes notes and keeps the discussion going. When the group dynamic is working well the organizers and the participants are working together and are exploring new ways of looking at the topic. It is more likely that some unexpected discussions will appear and it is a good way of gathering data.

Because the interview is held with a group of people, it enables the organizers to use a more varied type of communication types to get a better group dynamic. For example it is easier to make jokes, tell anecdotes, arguing, and teasing when working with a group rather than with individuals. Having this large set of communication techniques to choose from makes it easier to get information from persons that might feel uncomfortable in a normal interview and might not open up.

A downside with doing group interviews is that the individual thoughts that stick out might have a hard time reaching through the big noise from the group. However it is up to the organizers to make sure they collect correct data from each of the participants and not draw conclusions too fast. It is important that the preparations are good for the interviews to be successful. The organizers should have a red line to follow, even though the questions should be open-ended to encourage discussion.

2.2. Paper prototyping

Nowadays development processes tend to get shorter and shorter and to find quick solutions for tasks that usually take a lot of time is good. Instead of using HTML or any other digital prototype that might be very time consuming it can be a good idea to make paper prototypes [4]. Paper prototypes are simple prototypes that don't require anything else that pens, scissors, and papers. It also invites people that don't have any technical background into the design process. They will probably understand a paper prototype better than a digital one.

The paper prototyping technique enables you to experiment a lot with very short iterations. The paper pieces are easy to move around in your design while a digital prototype might take more time to change. If something has to be changed or removed in a paper prototype it is easily thrown away and you can move on. It can be used within the development team to quickly try out a few design ideas for themselves. It is a quick and cheap way to try out the design and the flow in the product.

Figure 1: Example of a paper prototype

2.3. Questionnaire

A questionnaire [5] consists of a set of questions with a few different options as answer. Questionnaires can be distributed in many ways; the most common way is in paper format. However since most people have a computer these days, a good way of distributing a questionnaire is through the internet. Digital questionnaire can be made in any number of copies and can be sent to a large number of people.

The main advantages of using a questionnaire are:

- Usually a very low-cost data collection method.
- The results are easy to process. If it was a digital questionnaire the processing will be even easier. Sometimes the processing is done automatically by the service you are using.
- The range of people you can come in contact with increases a lot. Those people might not be able to attend interviews but you can easily reach them with a questionnaire.

The main disadvantages of using questionnaire are:

- Generally low response rates.
- Some people are unable to complete a questionnaire for different reasons. It could be old or handicapped people or young children.
- The organizers are unable to support the participant during the questionnaire. If any misunderstandings will occur explanations can't be presented which might end up with unreliable results.
- No control of how the questionnaires are answered. The questions could be answered in the wrong order and by someone else than the intended person.
- Unable to collect ratings or assessments based on observations.

The layout of the questionnaire could affect the response rate. If you start the questionnaire with some big open ended questions the respondents might feel that too much work and time has to be invested in answering the questionnaire. A better way is to start with some short awareness questions to get some information about the respondents. Towards the end more advanced questions could be added, since now the respondents are almost done and feel that they can spend a little more time.

The questions in a questionnaire can be either open or closed. In general a questionnaire has mostly open questions or mostly closed questions. An open question is a question where there are no answers to choose from and the respondents has to come up with an answer that he or she thinks is correct. Closed questions come with a set of answers to choose from.

Questionnaires are mostly used as a quantitative data collection method but it can be used as a qualitative data collection method as well. If used correctly the questionnaire can be a powerful tool in a design process. It doesn't cost much to invest in a questionnaire and the result is easily processed and very useful.

2.4. Extreme Programming

The development process used during this project was influenced by extreme programming [6]. The most fundamental aspect of extreme programming used in this project is pair programming, which means that you're programming in pairs. The reason for this is that both know how all the code works and both can improve the code anywhere they want. This makes it a very rapid development technique. The result is also more stable since two people have had an eye open for solutions that aren't foolproof. Another benefit of working in pairs is the knowledge exchange that constantly is going on.

Other techniques from XP that were also borrowed into this project were; the system was fully integrated at all times, several builds were made every day, and the design evolved during the whole project. Supporters of XP believe that the end result will be better if you let the design evolve during the development instead of doing one big design in the beginning. The benefit of keeping the system integrated throughout the project is that you are sure that it will work in the end. You don't have to spend time on integrating different parts and you will avoid any integration errors.

2.5. Expert evaluation

To avoid any errors to be found later in the design process it is crucial to perform evaluations throughout the project. But performing user tests too frequently is very time consuming and expensive. The normal user might also have difficulties to explain the experience of interaction while using a prototype. An expert though, could give feedback on the interaction and come up with possible solutions. On top of that it is quick and cheap to perform expert analysis. The basic idea about expert evaluations is to see if there are any areas that are likely to cause problem for the end users. The expert checks if the design violates any known cognitive principles or ignore accepted empirical results. The expert evaluation [7] might sound very powerful, and it is, however it doesn't give any feedback on the actual use of the system. It only gives results on the design and if the system upholds accepted usability principles.

2.6. Colour-coded sections

Colour-coded sections [8] is a technique used when dividing information of an application or site into sections. It is done by colouring the surrounding in different colours depending on what section you are looking at. Using colour-coded sections is good as it makes it easier to identify what section of an application or site a page belongs to. It might also be easier to remember where to find a specific page if you can remember them by colour. Colour-coding sections are especially good to use when the different sections have a unique purpose or audience. It has been used and is still used on web pages to make the navigation easier.

3. Pre-study

In this section we will present the work done during the pre-study. It starts with a description of Västtrafik's current real-time system, and of their API. The section continues with a description of the focus groups. Based on the outcome of the focus groups we narrowed down the scope of the project, this is reported in section 3.4: Delimitations. After the delimitations were done, a questionnaire was sent out to gather additional input; this is described in section 3.5. In the last part of the section the specifications for the remainder of the project are stated.

3.1. Västtrafik's current real-time system

In order for us to evaluate and make suggestions for changes on Västtrafik's real-time system we had to make an investigation of the current system. In this section we will present the information provided to the customers by Västtrafik today.

Perhaps the most common place where users get their travel information is through the web, and the most prominent feature on Västtrafik's homepage is the trip planner. This allows the users to specify: a starting point, an end point, and a time. The trip planner then gives the traveller a suggested trip, with departure time, arrival time, and transfers. The trip planner also has an extended search feature, which gives the travellers more functionality. For example the user can specify where he or she wants to travel by selecting stops from a map. The trip planner is also available as a widget or gadget to Windows Vista/7 or Mac OS X. The trip planner gets its information from the time table, not from the real-time information. It is possible for the travellers to get information about departures in real-time by navigating to the next departure section. Here the user can specify a stop and get information about the departures from that stop.

Figure 2: A screenshot from Västtrafik's homepage (www.vasttrafik.se) showing next trip in the middle and the trip planner to the right

If the user goes through a rather extensive registration process, he or she can make the homepage more personalized and select information about favourite stops and journeys that is shown immediately when they visit the homepage in the future. There is also disturbance information available on the homepage; this information can also be accessed through RSS or Twitter. If the user is logged in it is possible to filter the disturbance information a bit. But the smallest amount of information that you can receive if you're interested about Göteborg is the whole region. This includes more information than you would possibly want, no matter how much you are travelling.

Västtrafik has released an application for iPhone that allows the users to access the trip planner and the next departure feature through their iPhones. The trip planner is similar to the one you find on Västtrafik's homepage but it lacks the advanced settings which the trip planner on the homepage has. The iPhone application comes with some new functionality that the homepage doesn't have. It is possible to send SMS tickets, the application helps you with: what ticket you should have and how to send it. You can see journeys on a map; it might be worth pointing out that the map view is static and won't change during the journey. The iPhone has a GPS in it which is used in the application to find stops that are located nearby.

Figure 3: A screenshot from Västtrafik's iPhone application

There are also two third party applications available on iPhone, "Res i väst" and "Lokaltrafik", these applications don't introduce any new functionality besides a slightly different new interface and unfiltered disturbance information.

There is also information available during the journey. On some of the stops, very common at central stops, there is a real-time information display available that shows the next departures from that stop. At bigger stops that are composed by many traffic islands, like Brunnsparken, there is sometimes a display that shows the departures from all the different locations. The traveller can also get information about upcoming stops on some of the vehicles.

3.2. Västtrafik's API

Västtrafik has an open API that allows third party developers to develop applications that uses their traffic information. The API is divided into three parts: disturbance information, departures in real-time, and trip planning. Trip planning is the heart of the API; the most important methods are to translate a name into a stop id, and to search a journey. The trip planning part only uses time-table information; the response from the trip planning method won't change according to the current traffic information. To get real-time information you have to use departures in real-time, which take a stop id as input and return all departures from that stop. The final part; disturbance information, takes no input and returns all valid disturbances in the entire Västra Götaland.

3.3. Focus groups

To investigate the current real-time system focus groups was arranged, the use of focus groups is described in section 2.1. We decided to only include people who already travel with public transport since our aim is not to make people travel more with public transport but rather to improve the experience for the current users. To make the analysis process easier we recorded the interviews using a microphone and a computer.

3.3.1. Participants

To gather participants to the focus groups we tried a few different methods. We put up posters all over the city of Göteborg, on the universities, on the streets, on the libraries and on billboard spots around the city. The poster contained information about the focus groups and three different time slots that participants could attend to, one spot at 10 am, one at 2 pm, and one at 5 pm. The poster can be found in Appendix D. Västtrafik has a database with people who have registered that they are interested in participating in marketing researches. We tried to get an extract from this database but unfortunately we weren't allowed to because of restrictions in Västtrafik's privacy policy.

Since we didn't get access to the database we were left with the participants that we could get in touch with on our own. To help us get participants Chalmers sponsored us with some cinema tickets that were used as a bait to get participants and that was also stated on the posters. Unfortunately we were only able to get in touch with students, since they were the only ones who showed any interest in participating in our interviews. We took the decision that conducting the interviews and gathering information from a limited group of our entire user group was better than to postpone the interviews and put the entire project on a hold.

Twelve people all around 24 years old participated in the focus groups. As mentioned earlier they were all students but from different educations ranging from technological educations to nursing school. They all travelled by public transport at least a few times a week. Out of the twelve participants there were four females and eight males, they were divided into two groups with six participants each. Also important is that they lived in different areas of Gothenburg, so we got input from those who lived very central but also from those who lived a bit outside the centre of town.

3.3.2. Questions

Since we were interested in the users' entire experience of the real-time system we tried to develop topics of discussion that covered all aspects of the system that the users encountered. Västtrafik was also interested in investigating how you should inform users about disturbances so we also included a topic about that. The topics were:

1. Information available on the internet
2. Information available on the stops
3. Disturbance information
4. Information available on the vehicles
5. Information available in mobile devices

To stimulate the discussion we used images representing the current real-time information and presented those to the participants during the interviews, examples of the images can be seen in Figure 4. The questions that we asked on the topics above were mostly open ended questions to encourage discussion. A few short and closed questions were used as warm up and cool off questions.

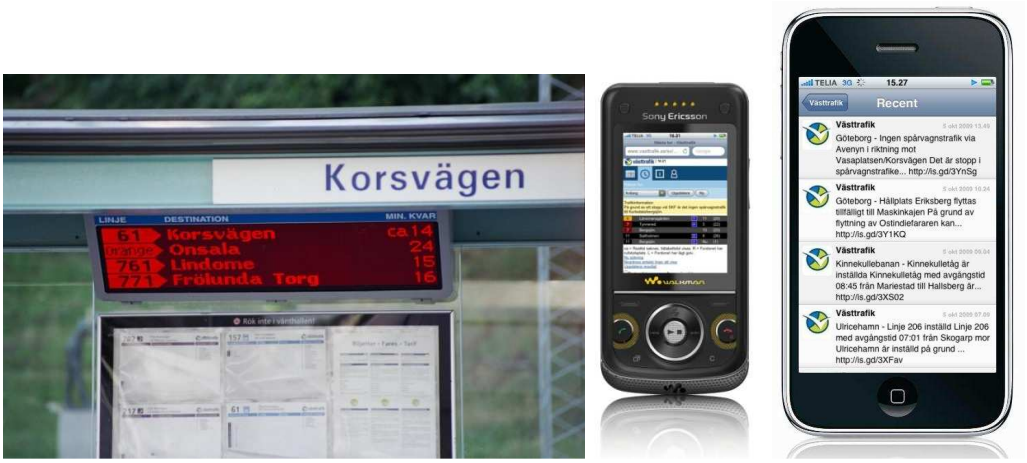

Figure 4: Examples of pictures used during the focus groups

3.3.3. Results

In this section a summary of the results from the two focus groups is presented. The results are divided into the different topics presented in the previous section.

Topic 1: Information available on the Internet

Very few of the participants knew that the next departure feature, which was presented on one of the pictures, exists. Some of them asked where they could find the function and one of them even stated that he had actively been looking for it without finding it. On this topic there was also discussion regarding the short comings of the trip planner, some of the participants thought that the trip planner in some situations gave strange answers. The strange answers can come when there are two stops close to each other with no trams or busses connecting them. Some of the participants also thought that the trip planner gave strange suggestions when there were transfers involved. There was also discussion regarding making the homepage more personal so that you would have your favourite trips and departures from your favourite stops more easily accessible.

Topic 2: Information available on the stops

People were overall satisfied with the information available on the stops, if real-time information displays are available on the stop. One thing that most people didn't understand was what the "ca", before the departure time, was standing for. There were also some discussion regarding the possibilities to include information about departures from stops nearby, the outcome of this discussion was however that the participants thought that it would probably be too complicated. The

participants also discussed the possibility to give information about how many available seats there are on a vehicle, but they didn't see the value of such a function.

Topic 3: Disturbance information

Regarding the disturbance information there was much discussion regarding the appearance of the messages on the displays, and the participants thought that it could be presented in a more understandable way. There were suggestions that you could work more with colour coded line numbers in the messages to make it more obvious which lines that are affected. There were also opinions about the formulation of the disturbance messages, and the participants thought that it would be possible to make it more clear, what it was that had happened and when the departure would be. None of the participants checked the disturbance information available through Västtrafik's website or on twitter, and they all agreed that you should be able to filter the information for it to be useful. They were also positive to have disturbance information in their mobile phones, if the information is filtered enough to be relevant. They also discussed the possibility to connect a service like this to a more personal website, mentioned in the first topic.

Topic 4: Information available on the vehicles

A few of the participants told us that they used to look out the window at the real-time displays on the stops to get information about departures from the current stop. This discussion resulted in the idea to put a display, similar to the one at the stops, inside the vehicles. This display would show the departures from the next stop, and would probably aid people when they make transfers. The participants had some suggestion regarding the information available today; the display telling the next two upcoming stops. They wanted to be able to, not only, get the next two stops but also the arrival time. There were some suggestions that you should also include arrival time to major stops on the way, since that it's likely that people will make transfers there.

Topic 5: Information available in mobile devices

About a third of the participants had iPhones and used Västtrafik's application. They were fairly satisfied with the application but thought that it could be improved. Some wanted to be able to make it more personal similar to the demands on the first topic, others wanted to more utilize the fact that you carry your iPhone with you while you make your trip. There were also some ideas to make a new application that allowed you to track a vehicles location on a map in real-time.

3.4. Delimitations

Based on the results from the previous section we prepared five ideas that we could focus on for the remainder of the project. These suggestions were discussed with our tutor and with Västtrafik and in the end the list was narrowed down to just one idea. The five ideas are presented here; the last idea was the selected.

Idea 1: Redesigning the website

Many of the features that the participants wanted from a website are already present. Very few of the participants knew that they could watch departures in real-time on the website. The participants also wanted to be able to personalize the website, this is possible today, but people don't know that it exists. Users who want to personalize the website are forced to go through a very extensive registration process.

Another problem with the website is that most people that visits Västtrafik's website go there to get travel information. That is not the most prominent parts, the trip planner is on the right hand side, and the departures in real-time is in the navigation list to the left. The middle of the website is filled with news from Västtrafik that most people don't have any interest in.

The idea was to make a redesign of the website and make it more accessible, and more easily personalized. This was an interesting idea but it was discarded because that we felt that it would be very hard to convince Västtrafik to change their website according to our suggestions. Even if our suggestions were good and got accepted, changing a whole website for such big company isn't done over night and the idea was therefore discarded.

Idea 2: Design and functionality of a future trip planner

The trip planner that exists today takes its information from the timetables. It doesn't react to any real-time information and it's not unrealistic that they will purchase a new trip planner in the future. It would be interesting to investigate how a new trip planner that reacts to real-time information could look like. Examples of this could be how disturbance information should be presented if the journey doesn't go according to the time-table. Some other ideas about how a new trip planner could work turned up during the pre-study, for example: that it should be smarter and give better suggestions when there are two stops close to each other.

Idea 3: Look, layout, and distribution of disturbance messages

The participants had many opinions about the disturbance messages that were displayed during the pre-study. It was opinions about the content of the message as well as the visual layout of them. The participants also had ideas on how the messages should be distributed. One idea that the participants were really excited about was to be able to get personal disturbance information in their cell phones. This could be really useful if a person travel the same route every day.

Idea 4: The information on the vehicle

On the vehicles today the only information that is given to the customers is the upcoming stops. One thought was to complement this with the time to the next stops. Other suggestions were to show the time to big junctions, where many people change vehicles. A few of the participants also said that they usually glared outside the window to look at the real-time displays on the stops; this information could be displayed inside the vehicles as well. This idea would however be hard to realize since it involves both displays and making changes in Västtrafik’s vehicles.

Idea 5: Making a new iPhone application

The last idea, the one that we selected, was to make a new iPhone application. We realized that we could include most of the ideas from the other suggestions into this one. One problem that we wanted to address was that the current application doesn’t utilize the fact that you carry the iPhone with you during the travel. The information in the iPhone is basically the same as on the website. One other feature that people wanted was to be able to see the vehicles position in real-time. We also came up with other features of our own.

We choose to develop for iPhone rather than to develop for another platform such as Android because we have previous experience from iPhone development. Besides from the functionality already available in Västtrafik's current iPhone application ours could include:

- Get relevant disturbance information
- Having the ability to make the application more personal
- Track the position of a vehicle
- Getting help at transfers by getting real-time information from upcoming stops
- Getting help at transfers by getting a map over the transfer stop
- Getting help during journey by getting information regarding when the destination is approaching

3.5. Questionnaire

After the decision was made to develop an iPhone application we prepared a questionnaire that was distributed over the internet to a set of people to answer. The motivation to do a questionnaire was to get some input on what features that users liked the most, and what we should focus on. The questions in the questionnaire were mostly about grading the functions, stated in the previous section, from 1-6 to give us a hint of what the end users think about the functions. The questionnaire and a summary of the result can be found in Appendix A. There were only 17 persons who answered the questionnaire, a bit too little to draw any real conclusions, the result however was only used as a guidance.

The feature that the people, who answered the questionnaires, liked the most was to be able to get relevant disturbance information in their phone. They were also very positive at; getting help at transfers by getting real-time information from upcoming stops, to be able to see a vehicles position, and to get help when their destination is approaching. The two features that the participants liked the least were to get help during transfers by seeing a map over the stop and to be able to make the application more personal.

3.6. Specifications

Based upon the results from the pre-study and the questionnaire a list of features was compiled. The features were arranged in three groups. In the first group we placed the basic features that are available in Västtrafik's iPhone application. The second contains features that should be implemented, and the third and final group contains features that could be implemented if there's enough time.

1. Basic features:
    - Trip planner
    - Departures in real-time
    - Favourites
2. Features that should be implemented:
    - Personal disturbance information
    - Be able to see a vehicle's position
    - Get real-time information during a travel
    - More map features than the current iPhone application
3. Features that could be implemented:
    - Be able to set an alarm that notifies you when your destination approaches
    - That the application automatically detects which vehicle you're on
    - Update the answers from the trip planner with real-time information

4. Development

Here we will describe the development of the application specified in the previous section. We started to do paper prototypes, and then we moved on to implement the application. During the implementation two studies were conducted: one expert evaluation half way through, and one user study in the end. Ten weeks were spent on the development, the plan as it looked when the development started can be seen in the Gantt chart in Appendix B.

4.1. IPhone development

IPhone is a smart phone developed by Apple. It has many features such as, touch screen, GPS, and an accelerometer. In many ways an iPhone works as a computer, it has an operative system and the user can run different applications on it. As of this writing users can only run one application at a time, multitasking is one of the features planned for the next version of iPhone's operating system [9]. Third party developers can develop applications that are distributed to the users by Apple. The applications are written in a development environment called Xcode using a language called Objective-C [10].

The different pages in an iPhone application are called views. As soon as a page disappears and a new page opens it is a new view which has been loaded. Throughout the rest of this report the term view will be used to describe a single page in the application.

One advantage with the development environment is that the developer gets access to built-in features that can be used in the applications. One of those features that is used in this project is tables which are used both to display data and for navigation. Tables are divided into different sections, and every section is built up by rows. In Figure 5 the view consists of one table divided into three sections, with three rows in the first two sections and one row in the last section.

Another built-in feature that was used in this project is the tab bar. The tab bar is a navigational menu that is good to use when the application is divided into different sections, it consists of set of icons and text labels. The developer can choose to display a number or a text on each icon; this number or text is called a badge value. The tab bar can be seen in the bottom of Figure 5 and there's a badge value on the icon to the right.

A drawback with using the built-in features in the development environment is that the developer sometimes loses control over the appearance of the application. For example it's only allowed to use gray scale icons in the tab bar; this had some implications on this project and will be further explained in section 4.3.1.

Figure 5: Example of the appearance of an iPhone application

4.2. Paper prototyping

When the specifications were stated we had to decide on the structure of the application, this included both the navigation and the design of the user interface. A good way for trying a lot of ideas in a short period of time is to use paper prototypes (see 2.2 Paper prototyping). The paper prototypes were used to get a feel about the application we were about to create, and to know where to start, one week were spent on doing the prototypes. More information about how the paper prototypes were realized in the application can be found in section 4.3 developing the application. In the remainder of the section we will first present our initial thoughts on the general navigation, and then we will describe the design of three parts of the application in more depth.

4.2.1. Navigation

In our initial design, the application had four sections. One section for the trip planner, another section to track vehicles on a map, a third section to read disturbance information, and the fourth section which would be used to manage the user's favourite journeys and stops. Below is a sketch over how the different views are connected in the initial design. In this sketch there's a lot of interaction between the different sections.

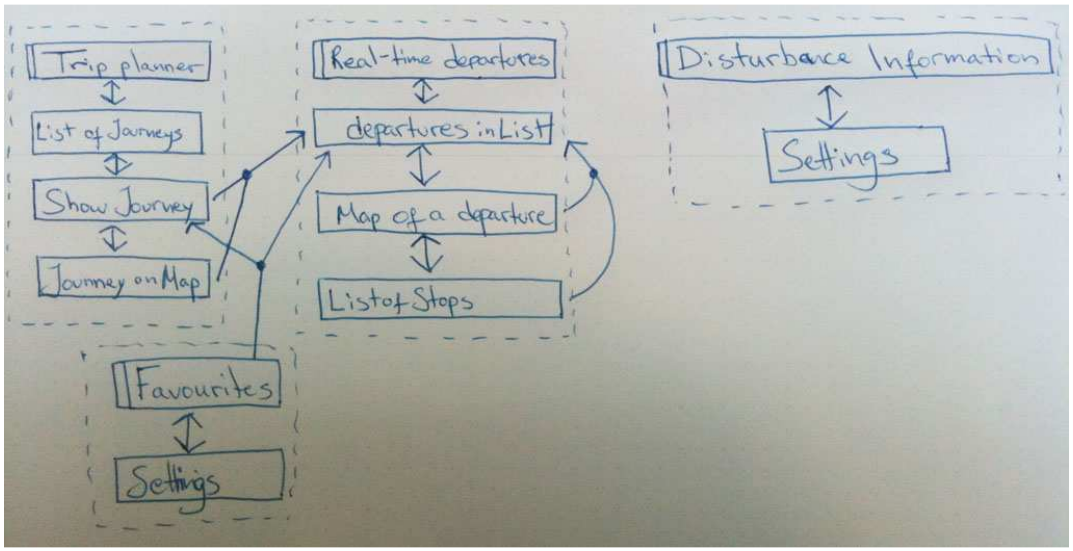

Figure 6: Sketch over the navigation in the application

4.2.2. Trip planner

The trip planner, shown in Figure 7, was something inevitable and had to be included in the application. But we wanted to make it special and more useful than the current ones on the market. The first view is basically the same as most other trip planners. Then you get the results of your search in the second view, here you select the journey most suitable for you. When a journey is selected a third view appears with detailed information about the journey. We had ideas to include even more functionality in this view. From the questionnaire we knew that the users were interested of help during changes and we also had the idea to show the journey on a map, similar to the real-time tracking of vehicles. As can be seen in the sketch over the navigation in the previous section, the user could from this view get to departures in real-time for a stop on the route by clicking on it.

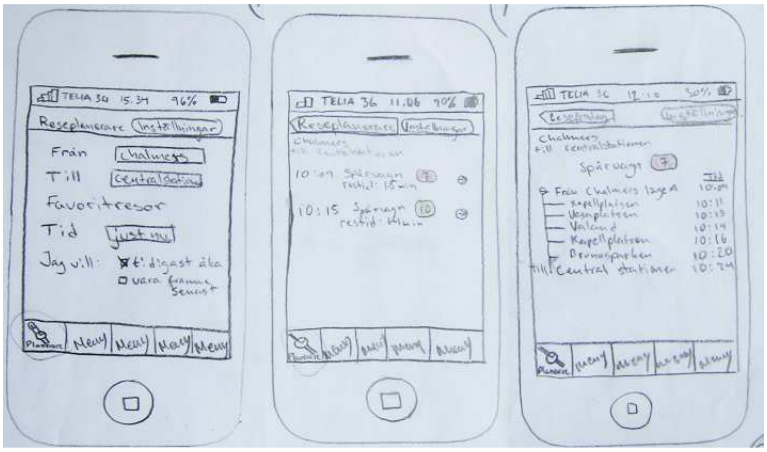

Figure 7: Paper prototype of the trip planner

4.2.3. Real-time departures

Another feature that the participants in the questionnaire liked was to be able to on a map see the position of a vehicle. To choose a vehicle you first have to pick a stop from where the vehicle will departure, that's done in the first view in Figure 8. Then a new view appears with departures from the selected stop. When the user clicks on one of those departures a map view will appear. On the map view the vehicle is shown at its current position so the user knows where it is. Each stop that the vehicle will visit is on the map and they are clickable. When they are clicked the user is shown the name and when the vehicle will arrive at the stop.

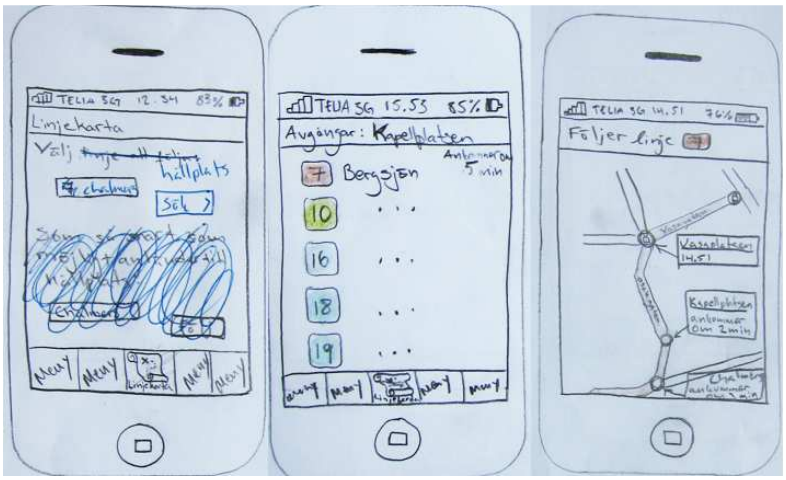

Figure 8: Paper prototype of real-time departures

At this stage we had the idea that when you click on a stop name in the map the departures from that stop should be shown, the same view that is in the middle above but with new content. The map view will show the progression of the vehicle, which means that when the vehicle moves to new stops the map view will show its current location. There was also a plan that the information that's available in the map should also be available in a table format, similar to the table in the trip planner section.

4.2.4. Disturbance information

We wanted to present the disturbance information in a better way than it is done today. We came up with two ways of filtering the information; by county and by line number. If you are travelling with a few specific line numbers you don't want disturbance information about the rest of the region. Or if you are mostly travelling within a certain county or several counties you only want disturbance information within those counties. To achieve this it was necessary to have a settings view where the user can set the lines and counties he or she wants to follow for disturbance information, see Figure 9. The disturbance messages that are connected to the lines and counties specified in the settings view will be presented in a table. To read about a disturbance you just click on it and then a new view will appear with the full message.

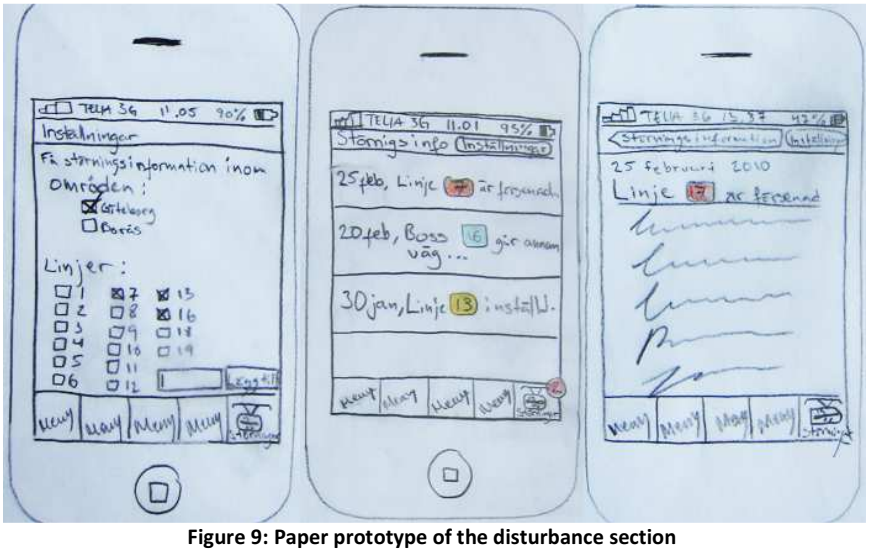

Figure 9: Paper prototype of the disturbance section

4.3. Development of the application

When we started out the development of the iPhone application we didn't know what in the specifications that was possible to accomplish or how to accomplish them. That's why we had to start out small and try different features without really knowing what the end result might look like. An example of such a feature that we didn't know whether we would be able to implement or not was to calculate the position of a vehicle, the development of that algorithm is described in section 4.3.3.

During the development we borrowed some concepts from extreme programming, especially pair programming. In the beginning of the development we worked on the same computer. Later on we worked on two computers, but were still sitting together. A typical morning started with a discussion about what we wanted to accomplish during the day, we also had a rule that the programme should be runnable during the end of each day before we went home.

4.3.1. Graphical design

We early did some general design decisions; to use Västtrafik's colour scheme, and to use colour-coded line numbers. The image below (Figure 10) shows the different colours used on Västtrafik's homepage. The idea to use colour-coded lines came from the focus groups in the pre-study; it allows the users to recognize a line faster.

Figure 10: Västtrafik's colour scheme

The colour scheme that Västtrafik is using was selected because of two reasons, mainly because that users are familiar with it, and also because we find it aesthetically appealing. Early all sections used the same colour coding, blue background and a lime green colour as a secondary colour, to indicate selections in tables and buttons etc. After the expert evaluation we decided to use different colours for each section, the use of colour coded sections is described in section 2.6.

The first section kept its blue background colour. In the second section we experimented with the lime green colour as background, but we decided to tone it down a bit to a darker green. The last section; disturbances, got a red colour. At this time in the project there were also a section called favourites who was given a yellow background. A yellow star icon was used in the button that added favourites. We wanted to use the colours of each section in the tab bar that users use to navigate in the application. Unfortunately this is prohibited, as is mentioned in section 4.1; developers are only allowed to use gray scale icons in the tab bar.

4.3.2. Navigation

In the beginning the application was divided into four different sections: a trip planner, real-time departures, disturbance information, and favourites. After the final user study the favourite section was removed, because it didn't add anything to the application it just made it confusing. In the previous designs the users could only remove already added favourite journeys and stops from this section. After this redesign favourite stops was removed from the application. The latest searches are saved in the application and the participants in the user study felt that they could use this feature instead of favourite stops. In most cases when you are searching for a stop you have already searched for it before and then it is easy to find.

Another difference with this navigation design compared to the one in section 4.2.1 is that we removed all navigation between the different sections; this was because that all the jumping between different sections in the previous sketch could be really confusing to the users. The change was done due to feedback that we received in the expert evaluation. A new sketch over the navigation is shown in Figure 11. There's also one more difference compared to the previous sketch, and that is that the user can view a map over a stop from show journey. The development of the three sections will be further explained in section 4.3.4 through 4.3.7.

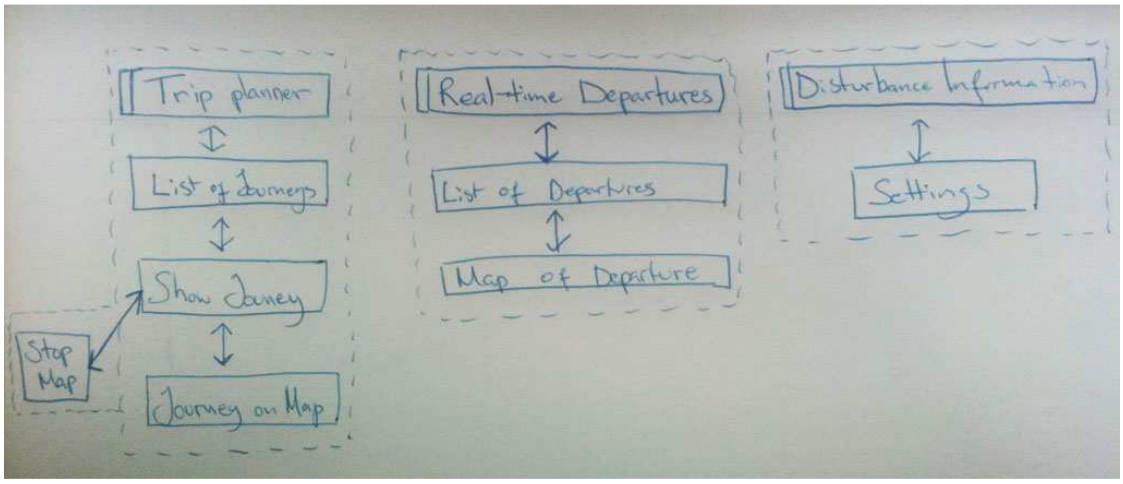

Figure 11: Sketch over the navigation in the application

4.3.3. Calculate a vehicle's position

There isn't any functionality in Västtrafik's API to get the position of a vehicle. Instead we had to develop a method to estimate the position. The method was one of the first things that we started to develop and the development continued throughout the project. The method is used both in the trip planner and in the departures in real-time, with small variations. This section will describe how the algorithm works, without going into too much detail. We will only describe how to estimate the vehicle's position before it reaches the starting stop of a journey; this stop would correspond to the selected stop if the algorithm is used in the real-time departures section. Estimating the vehicle's position during a journey works in a similar way.

To calculate the vehicle's position, a list of stops that the vehicle visits before it arrives at the given stop is needed. There isn't any function in Västtrafik's API to get the required list of stops; in order to get the list, two solutions were tried. In the first solution we did a search, saying that we wanted to travel from the given stop to the vehicle's end stop. Since the vehicle's destination and its ending stop aren't equal we were forced to build a table that translated a vehicle's destination to the id of the end stop. This solution had really only one advantage and it was that when it was working it was flexible and immune to future changes in a vehicle's route. This technique had however several disadvantages. Even if it worked for some lines and some stops, there were many combinations of stops and vehicles were the suggested trip didn't include the list of stops that was required. It also had the drawback that the search could take rather long time.

Because of the drawbacks already mentioned we decided to go with another solution. The solution was to code the routes of the vehicles into the programme. This has two major advantages: it's fast and in the normal case it gives a correct route. However it isn't perfect, during the night some of the vehicles changes their routes, this method can't handle that. Since the routes are coded into the programme it won't work if Västtrafik changes the route of a line. Perhaps the biggest drawback is the amount of work required to add a line to the programme. Because of the work this feature only works for lines 1 to 19.

Once that the list of stops is acquired we estimate the position by searching backwards in the list. Starting with the given stop and then continuing with the one before that. On each stop we make a request to the API to get the departures from that stop. Then we look at the departure for the given

vehicle and if the vehicle is at the current stop we've found the position. If the time is after the previous one that we've searched we know that the vehicle is between the two stops. Once that the vehicle is found the algorithm waits in 30 seconds before it makes a new search. It is worth mentioning that the algorithm doesn't use the iPhone's GPS when calculating the position. Although it would perhaps have been useful we didn't have time to include it in the calculations.

4.3.4. Trip planner

The first view when searching for a journey has looked about the same during the entire development process. It's fairly similar to the paper prototype described in section 4.2.2, and no bigger problems have been revealed during the testing. The biggest change during the development was that we changed the background of the search button to green to make it stand out more from the rest and encourage interaction. In the next view, the view that displays different search results our aim was to fit in as much information as possible without making it confusing and hard to understand. This view has received much appreciation from the participants in the user tests.

The next view, the detailed journey view, was the hardest view to design in the entire project. The problem was that there's much information about the journey to display. Since we managed to calculate a vehicle's position we decided to update the information from the trip planner with real-time information. Because of this, it got even more complicated. One feature that didn't receive good feedback in the questionnaire was to get a map over the stop that showed the locations of the traffic islands. This function was implemented anyway since it was fairly easy to do.

At first the information in the detailed journey view comes from the time-table but once that the application gets real-time information from the vehicle the times will update accordingly. One problem with this is that the times are only updated for the current trip, the trips that follow the current one wont update. If there's a delay on the current trip, this can lead to that the arrival time of the transfer is after the departure time. This will correct itself once that the delayed trip is finished. The motivation behind only getting information from one vehicle at a time was to keep the algorithm as simple as possible and to limit the number of calls to the API.

The detailed journey view received the worst criticism of all the views during the user tests, those issues have been corrected. The first design of the view can be viewed in section 4.5 and the final result is presented in section 5.1. The information in the table can also be viewed on a map; the design of the map is explained in section 4.3.6.

4.3.5. Real-time departures

In this section the users can view all departures from a specific stop. We tried to mimic the appearance of the real-time displays that are placed on the stops; an example of that appearance can be seen in Figure 12. The reason for this was that this is an appearance that people are used to. This view received good response in the user study in section 4.5, so there was never any reason to change it. If the users selects a departure he or she can get information about the vehicle's current position on a map, this is further explained in the next section. As is mentioned in the paper prototypes we had plans that the information on the map should be available in a table as well. This wasn't implemented since we felt that it didn't really add anything and none of the participants in the user study felt the need for it either.

Figure 12: The information displays available at stops

4.3.6. The map

The map appears both in the trip planner and in the real-time departures, with small variations in the two versions. The difference is that in departures in real-time the end stop will always be the destination of the vehicle, and there will never be any transfers, the two different versions can be seen in Figure 13. On the map a bus or tram line icon will move on a route, with dots indicating the different stops. We experimented with using an image of a tram instead of a line icon. We discarded the image of a tram since we early stated that we should use the vehicle icons as much as possible and it was easier to understand for the users.

To indicate on the map which different vehicles the user should take between stops, the routes are coloured with the background colours from the vehicle icons. The route that the vehicle travels before it reaches the starting stop is gray to indicate that it's not a part of the journey. We wanted to make the various types of nodes more distinguished, that's why the start node is green, the end node is red, and the transfer nodes are bigger than the intermediate stops.

Figure 13: Two versions of the map view, the one from the trip planner to the left

4.3.7. Disturbance Information

Disturbance information is something that has been in mind during the whole project. Today's disturbance information from Västtrafik is not very user friendly in the sense that it is hard to find information that is relevant for you. What we want to do is to pick out just the information that the user is interested in. The idea received positive feedback during the pre-study, described in section 3.

The initial thought that is described in section 4.2.4 was to filter the information on counties and on line numbers. To get disturbance information for only one or a few specific line numbers could be useful for those who only travel a certain route every day to work. In the data from the API there are three parameters on which we could filter the information received; region, county, and line number. Unfortunately county was the only parameter that was possible to use.

Region is the parameter on which Västtrafik filter their information on their website. The problem with this parameter is that it's too big, every region is composed by several counties and most persons rarely travel outside of their county. If the information is only filtered based on this parameter users get much information that doesn't concern them.

Unfortunately it wasn't possible to filter the information based on the lines either, the information wasn't structured enough. When the disturbance information messages are created there are no specific rules on how they should specify what line numbers that are affected by the disturbance. The tag where the line numbers are filled could look very different from message to message. Preferably the information would look something like: "1, 2, 3", if it did parsing it would be possible and the users would be able to filter information based on specific line numbers. Most of the time it isn't and it can look like: "841 and others" or some variation of "all lines".

The tag where the counties are filled in was better organized. The counties were in most cases correct and separated by commas. But even here there were a few messages that didn't follow any standards. An improvement in the way the disturbance information messages are created would enable both us and Västtrafik to make more use of the information and make it more attractive to the end users.

The appearance of this view is similar to the paper prototypes in section 4.2.4 with the exception that the users can't filter the information based on lines. We wanted to give the users notifications whenever new disturbances are received so they don't have to check the disturbance tab for new disturbances all the time. One way to do it and the one that we choose was to use the badge value of the tab bar icon. The badge value is small red circle that can be filled with any number or text. As soon as there are any unread disturbances relevant for the user, upon start of the application, the badge value will appear and make the user aware of new disturbance information messages. When the user has read all messages the badge value will decrease for each message and then disappear when it reaches 0. The final appearance of this section will be presented in section 5.3.

4.4. Expert evaluation

As is stated in 2.5 Expert Evaluation, it gets more and more expensive to discover design flaws the longer the project has gone. So to find out if there was anything that had to be changed in the application an expert evaluation was held half way through the development process.

We had some questions arranged but the idea was to let the experts navigate in our application and come with concrete feedback on the functionality and the graphical interface. Four people were asked to participate, three were interaction designers and one was a 2D-designer from HDK (School of Design and Crafts) in Göteborg. Some had previous iPhone experience and could give feedback on the standardization of the interface. One was quite new in town and didn't know much about the public transport system and had feedback to give that the others didn't have. Some of the participants were more focusing on the functionality and some on the user interface. The feedback from the expert evaluation is presented below.

The map view that was presented to the experts in this test didn't have the information field that in text states the vehicle's current position as can be seen in Figure 14. The idea to have such an information field came from this study, and it was later implemented.

Figure 14: The map view

The experts came with a lot of input regarding the appearance of the trip planner that helped to form the final look and feel. This was opinions regarding headers and what information that should be shown where. They also gave some input on which cells that should have an arrow on them, indicating that they are clickable. There was also other feedback given during the tests that was later implemented for example: we changed the colour of the search button. It was also during the expert evaluation that the later implemented idea to use colour-coded sections came up. We also added titles in the real-time departures table after the expert evaluation. It was also in this study that it was first hinted that we should remove the favourite section, this was confirmed in the next user study and finally the section was removed. The experts were positive towards the new functionality introduced in our application. Although they recognized that one of the biggest challenges for us was how we should make people aware that they can get help during the travel.

4.5. Evaluation

After the expert evaluation described in the previous section the application was changed according to the feedback that was given. Some additional functionality was added and a lot of time was spent on making the application more stable. There were some errors where the application crashed from

time to time that had to be dealt with. The user interface wasn't good enough and we had to make small changes.

When all this was fixed a user study had to be made to check the final prototype for any last changes. A poster was made and it was put up on various places to collect people for the user tests, the poster can be found in Appendix E. While waiting for people to contact us an interview guide was formed. In the study the users were given a few tasks that they should try to complete. And also some questions to get some additional information about the application, for example if there was any functionality that the users felt were missing. Six people participated in the user study and the interview guide can be found in Appendix C.

The testing sessions gave us some important feedback about the application. Especially one view had too much information presented and was confusing for the users; this was the third view in the trip planner, shown in the picture below (Figure 15). The users didn't understand what the “plus button” was for. The button is used to expand the list and show intermediate stops. As can be seen in the paper prototypes, in section 4.2.2, the plan all along was to use expandable lists. The solution presented here however was influenced by the way that expandable lists are implemented on computers, and that solution is perhaps not applicable on iPhones.

However when the users clicked the button they thought it was quite ok but they couldn't predict the outcome of the action. They told us that their first impression was that it should add something since this kind of button is usually used for that. To correct the problem we added one row to the table that was clickable with the text: “Show intermediate stops”, although it hasn't been tested it's reasonable to assume that this solution is more intuitive than the previous one.

Figure 15: The table that was presented to the users in the user study

Another thing that we discovered during the tests was that the button "Karta" (in the middle of the picture, not in the top right corner) had no feedback when touched. The button will load a map of the stop and then show it in a new view. But since the button had no feedback about the loading process the users did press it over and over again which caused the loading process to reset each

time they pressed. This was later fixed so that the new view appears directly after the button has been pressed.

We were unsure about the favourite tab and the usefulness of having favourite journeys and stops before the user tests. But it was left for the users to comment. There were not many users that understood how to add favourites and we had to tell them how to do it. They had to search for a journey or stop and then click on the star in the top right corner. Most users clicked on the favourite tab and tried to add favourites from here which is not possible, the favourite tab did only have functionality to remove current favourites. Because of this lack of functionality the favourite section was removed. There are still favourite journeys in the application, a few pointed out that they were using this on a regular basis so we kept it and moved the functionality to delete journeys from the favourite section to the favourite journeys view in the trip planner.

Favourite stops were removed from the application. The participants thought that the list of previous searches was enough and that favourite stops didn't really add anything. We also noticed that users were clicking on the star to add favourite multiple times. There was not enough feedback for them to understand that a favourite had been added. This was fixed after the user study, now a popup window appears when a journey has been added.

Figure 16: The favourite section that was later removed

The testing sessions that were held wasn't only useful to find errors in the design. It was also an opportunity to get some feedback on the application as whole. What did the user think about the new functionality that isn't in any other application today? Most users expressed specifically that they liked the view where they could see a vehicle's position on a map. The real-time information that is given feels more reliable if it is supported with a map view so you can actually see where the vehicle is. The help given on the map view for journeys was also appreciated, especially when you are travelling in areas you are not so familiar with. For the same reason they also liked the function to see intermediate stops in a list.

Disturbance information is something that not many were familiar with, not many people are reading the disturbance information that Västtrafik distributes today. The participants liked that they could filter the information so instead of having about 40 messages to read, where most messages are irrelevant, they only had about 1-5.

The overall design and interaction in the application received good feedback. The users found the application fast and smooth to interact with and that the graphical design was appealing. The users especially enjoyed the table that shows the result of the trip planner and the table that shows the departures in real-time, both is shown below, the users who had previous experience of Västtrafik's iPhone application thought that our views were better.

Figure 17: The two views that received the best feedback in the user study

5. Results

This section will describe the iPhone application that was made based on the pre-study, the later expert evaluation and the final user tests. The application is a tool used when travelling with Västtrafik. It will help you with finding a suitable journey and help you along the way, check out real-time departures from a specific stop, and show where the vehicle is on a map. It will also give you personalized disturbance information within the counties of your choice.

5.1. Trip planner

The first tab in the application which also is the main page that will be open upon start is the trip planner. The trip planner is a tool used when you know where you are travelling and when. First you will enter the stops in "From" and "To". This is done by selecting from a list of earlier stops or by searching for another one. You can also choose a journey from a list of favourite journeys. Then you select the time you want to leave or the time you want to arrive. Then you click search.

The next view is a list of suitable journeys. Each journey shows the vehicles that are used to reach the destination, for example in the first journey in the list you will start off by travelling by tram eight and then switch to tram eleven. The departure time, arrival time, total travel time, and number of changes are also written above the vehicles. In the top of the view there are buttons for going back to the main page, adding the journey as a favourite journey and to search for earlier or later journeys (ten minutes earlier or later). When you have found a suitable journey you click on it.

Then a third view appears with more detailed information about the journey, the first cell shows the basic information about departure, arrival time, travel time, and number of changes. The second cell shows the real-time information based position of the first vehicle in the journey. Then each trip in the journey has a section, starting off with the start stop, then a cell for showing the intermediate stops. The third cell is the end stop which also includes information about transfers if there are any. The transfer information tells the user to what traffic island he or she should go to and a button can be pressed to show a map of the stop with attached traffic island positions.

There is another feature in this view, the button in the top right corner will bring the user to a forth view where the journey is printed on a map. The lines are colour-coded based on the vehicle's colour. The green node is the start station and the red is the stop station. The big gray node indicates that it is a transfer here. Each node, including the vehicle, can be clicked for further information about the name of the stop and when the vehicle will arrive. At the bottom of the view there is a message that describes the location of the vehicle and also says when the vehicle will arrive to the start or the next transfer or end station.

Both views three and four are updated every 30th second. So the user can follow the journey in real-time. The vehicle will change position on the map based on the real-time information that is given from Västtrafik. The table will also change its appearance during the journey, once that a trip is finished, the trip's section in the table will disappear.

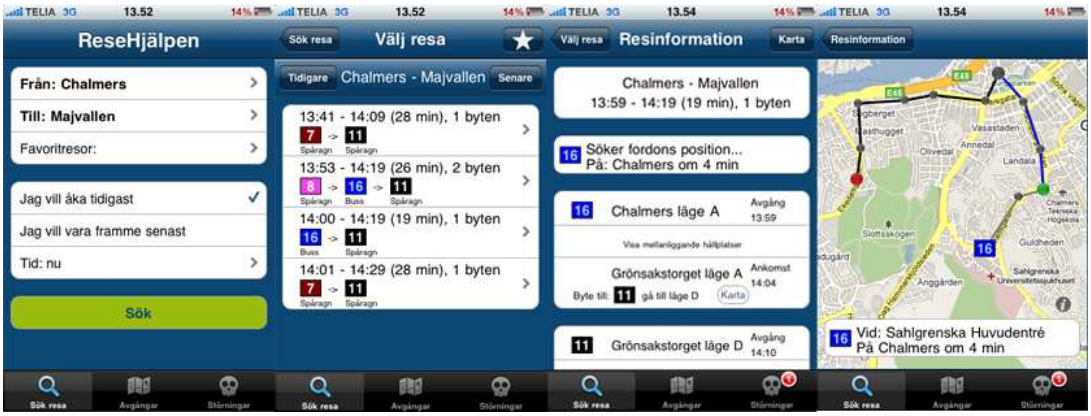

Figure 18: The different views in the trip planner section

5.2. Real-time departures

The second tab in the application is real-time departures. The first view that appears is the same kind of view as when you pick departure and arrival stops in the trip planner described in the previous section. You can either choose a stop from a list of earlier searches or by searching in the search bar for the stop you are looking for.

When a stop is chosen the next view appears with a table containing all departures from that stop, there's one departure for each row. Each departure consists of a line number, a destination, when it will arrive to the stop and when the next vehicle after that will arrive. Each departure might have an icon that indicates that the vehicle supports people with movement impairing effects. It's not possible to see all vehicles on a map; this is only possible for the trams and the bigger busses. The rest of the busses have gray background and no arrow indicator to indicate that they aren't clickable.

For the trams and the big busses the rows are clickable and when you click on a departure a third view appears. This view is very similar to the map view presented in the previous section, with the difference that this view doesn't have an end stop or any transfer stops. The map shows the current position of the vehicle that you are waiting for to arrive to your stop (the green dot). After the stop which you are waiting on, the route that the vehicle will take until its destination is shown. Each node can be clicked to show the arrival time and name of it.

This map view behaves in a similar way as the map view in the trip planner, the view is updated every 30th second and the vehicle will move along the route. The difference is that there will never be an end stop or any transfers. This means that the vehicle will continue on the route until its destination.

Figure 19: The views in the departures section

5.3. Disturbance information

When the disturbance information tab (Störningar) is clicked for the first time there are a lot of messages in a list. At the time those screen shots were taken it was 35 of them. The number 35 that is located in the tab icon indicates the number of unread disturbance information messages. To make the list of messages more personalized the user has to enter a view called settings (Inställningar).

The settings view controls the filter which is filtering the messages in the earlier view. To do this you have to choose what counties you are interested in. When you have selected a county you are automatically redirected to the first view and now only the messages connected to that county are presented. This procedure can be done multiple times to include messages from more counties at the same time. The number on the tab icon has changed from 35 to 5 when we chose to follow Göteborg. This is because now there are only five unread messages.

To read a message you just click on the message. Then you will be redirected to another view with more detailed information about the message. When you read an unread message the number on the tab icon will decrease by one until it is zero, when it will disappear. As soon as Västtrafik reports a new disturbance within one of the counties you are following the number will appear again to notify you about the disturbance.

Figure 20: The views in the disturbance section

6. Discussion

In this section we will give our final thoughts of the project. We will start of by commenting the known weaknesses of project, the section will proceed with an evaluation of the application against the specifications from section 3.6, and then we will give our thoughts on work that could be done in the future within this area. The section is finished with some reflections on our work.

6.1. Weaknesses

One problem that has already been mentioned in section 4.3.4 is that, on a journey only the times of the current trip are updated with real-time information. In some cases this can lead to that the arrival time at a transfer stop is after the departure time. This will correct itself once that the first vehicle reaches the transfer stop, but of course it's still not an optimal solution, and it's reasonable to assume that users can get confused by this. It's possible to correct this, although it isn't easy. If the arrival time is after the departure time, you could make a new trip search from the transfer stop to the destination. It wouldn't be easy to make changes in an already active journey, and since the results from the API don't use real-time information there's no guarantee that it will be correct.

Another weakness is that the routes of the different vehicles is built in to the programme, and those routes aren't static. Sometimes they change, especially during the night and our programme can't cope with that. As previously mentioned we've experimented with a solution that instead attempts to get the required list of stops by making a call to Västtrafik's API, but that solution is worse than the implemented one. The only solution that we can imagine to this problem is that Västtrafik's API is extended so that the position can be retained from there.

There are especially two functions that Västtrafik's application has that are missing in our application; to buy SMS-tickets in the iPhone, and to search the nearest stops using the iPhone's GPS. The main reason why these functions haven’t been implemented is because that they aren't needed to try out the new functionality that we've introduced. We felt that we should focus on implementing the new functionality first because that is the most interesting. If time would have allowed us to implement the SMS and GPS features we would have done it.

The new functionality that is introduced in the application, to show the position of the vehicle and to filter disturbance information, received positive feedback during the different user tests. However we've realized that to fully investigate people's opinions about these functions you probably need to perform an extended user study, a study where you let people use the application, in their real life, over a longer period of time. It would have been interesting to conduct a study like that, but because of time constraints is wasn't possible.

6.2. Evaluation against the goals of the application

In section 3.6 we listed and prioritized the features of the application. For simplicity the list is repeated here:

1. Basic features
    - Trip planner
    - Departures in real-time
    - Favourites

2. Features that should be implemented
    - Personal disturbance information
    - Be able to see a vehicle's position
    - Get real-time information during a travel
    - More map features than the current iPhone application
3. Features that could be implemented
    - Be able to set an alarm that notifies you when you destination approaches
    - That the application automatically detects which vehicle you're on
    - Update the answers from the trip planner with real-time information

All the basic features that exist in Västtrafik's current iPhone application are implemented in our application, with a small question mark on favourites. Favourites aren't implemented as was first planned during the early phases of the development, with a section of its own. Favourite stops were removed from the application entirely, since the participants felt that a long list with the latest searches was enough. Although the feature wasn't implemented as intended it doesn't mean that it's a failure, since the changes that were done received good feedback.

On the next level, features that should be implemented, we managed to, at some degree, finish all the features. It's possible to filter the disturbance to an extent that is possible with the current system; however it's not possible to filter it to the extent that we would have wanted. The first problem, as is already described in section 4.3.7, is that the information given about the affected lines is too unstructured. Even if it would have been possible to filter the disturbances based on the affected lines, we've come to realize during the project that you might want to go even further. The possibility to filter disturbances down to the individual stops has been discussed.

One feature that was implemented well, and received good feedback, was the ability to see the vehicle's position. One problem with this feature is that it might be hard to understand for the users that the position is quantified in the sense that it only shows if the vehicle is at a stop or between two. It would be good if you could be more exact with the position. The easiest solution for this would be if Västtrafik added a function in their API so that you would be able to get the vehicle's position from them.

However we've thought of a solution of how you could accomplish this without getting the position from Västtrafik. Now when we show the vehicle's position we take the distance between two stops and place the vehicle in the middle. You could use the time-table information about the time it takes to travel between two stops and compare this with the arrival time to the next stop. Instead of dividing the difference between the positions with two, you divide it with the total time between the stops divided with the time until the vehicle reaches the next stop. This seems promising on paper but implementing it would surely be problematic. Mainly because that the time between different stops in the time table isn't exact, for example there are stops, which according to the time table it takes no time to travel between. For this to be possible a new table would probably have been created with more accurate times between the stops.

The next specification on the list, to get real-time information during a travel is implemented to some degree. The user will get real-time information, and the position of the vehicle, during the travel. What the user don't get, that was planned during the early phases is information about future

vehicles, while at a vehicle. In other words, if you're sitting on a vehicle, and have an upcoming transfer, it would be useful if you could get information about the arrival of the vehicle that you should change to. The reason why this isn't implemented is because that we wanted to limit the number if searches done in the API, that's the bottleneck of the application as it is now. It would also make the algorithm much more complex. Now in the application the user will get information about future vehicles once he or she arrives at the transfer stop.

That we wanted to have more map features than the current application is perhaps a vague specification, but we believe that we succeeded with it. We think that the current iPhone applications didn't utilize maps enough. We've tried to have maps in as many places as possible. Perhaps the biggest reason why we think that we succeeded with this goal is because that our maps will change according to the current journey, they aren't static as the maps in the current applications.

One feature that was listed as: could be implemented, was to make the application automatically detect which vehicle the user is travelling with. This was perhaps mostly wishful thinking. To implement it would involve making a search for the nearest stops based on the GPS position, then do a call for the departures from those stops, narrow down the list to some possible vehicles, then repeat this procedure until the list is narrowed down to just one vehicle. We haven't tested this but it's probable that the search would take a considerable amount of time to complete; it would also most likely be hard to implement. You could ask yourself what the use of such a function would be, besides the fact that it would be an innovative feature. The only benefit that we can think of is that the user can see the upcoming stops and the arrival time. This is the exact same information that can be found if the user selects a real-time departure. So the only benefit would be if the feature would be faster than doing it manually, which it almost certainly wouldn't, which wasn't enough for us to even try to implement it.

6.3. Future work

One useful feature that we never implemented was the alarm feature. The idea was that the users could set an alarm, and get notified before the vehicle reaches the destination or before the vehicle reaches the start stop. We decided not to implement it mainly because that we didn't have any more time to implement, but also because that we feel that for this to be really useful you can't expect the users to have the application running. The availability to run programmes in the background is currently not available as is mentioned in section 4.1.

Another idea on this topic was to give the user continuous feedback about the arrival of a vehicle. Say that the user wants to go into a store while waiting for a bus, instead of running around and looking at the phone the entire time, you could give the user the feedback in some other way, for example vibrations. The vague idea is that the intensity of the vibrations increases as the vehicle approaches the stop. Since the idea isn't even close at being implemented it's impossible to guess what users would think of it.

During the development we got an idea to take the feature to use the GPS to search for closest stops one step further and build a feature that would allow the users to specify both the start and end from a map. This could be done both by using the iPhone's GPS and by sensing presses on a map. This could also be incorporated in the map under real-departures that shows the position of a vehicle. There isn't any possibility to do a trip search from this view at the moment. However it wouldn't be

easy to implement since it involves combining a system that uses real-time information, with a system that only uses time table information.

Developing new applications that utilizes the new smart phones platform would be a lot easier with a new API from Västtrafik. Many of the problems that we've encountered in the development and described in this report can be traced back to short comings in the API. Or to be more fair, that we're trying to implement functionality with an API that isn't designed to support such functionality. The current system is divided into three parts, with no interaction with the different parts. What you would want is one system with a trip-planner that continuously updates its time-table with real-time information and changes according to disturbances.

6.4. Our work

We managed to keep the initial plan for the development that can be seen in the Gantt chart in Appendix B. The biggest difference is that we introduced an expert evaluation during week 13 because of this we rescheduled the final evaluation to week 18 and finished the application during week 19. These changes were good because that we managed to conduct one more user study in the middle of the project that gave us some useful feedback.

We didn’t do a big plan in the beginning of the development phase and in retrospect we’re glad that we didn’t. Since we didn’t really know in the beginning what was possible to accomplish, it probably would have been hard if we would have had a detailed and concrete list of requirements. Letting the design evolve throughout the development process enabled us to attack the problem with an open mind and made it possible for us to adapt the application once that we realized what was feasible.

Even though we’re happy with our development process there’s one thing that we’re regretting, and that is that we didn’t start with the trip planner at an earlier stage of the project. The last view of the trip planner was, as is mentioned a few times in this report, the toughest view to design. In the beginning we made the decision to implement the departures in real-time first, to try out whether we could locate a vehicle or not. Once that we could locate a vehicle we took that functionality and built the trip planner around it, this lead to that we spend a rather short time developing the hardest view. It’s hard to say if it would have been better to do it the other way around but it would have been good to have had more time with development on that view.

As is already mentioned the reason why we choose to develop for the iPhone platform was because we had earlier experiences from developing iPhone applications. We also had access to an iPhone so that made the testing easier. Another option would have been to develop an Android application, but that would have required a longer pre-study to learn how to develop Android applications. The end result would have probably been similar if we would have chosen to develop for Android, although the graphical appearance would have been adapted to the Android platform. There’s also a risk that we wouldn’t had time to develop all the features since we would have been forced to learn a new platform.

We’ve worked together at all stages of the project, even if the work at some points has been divided we’ve still been sitting together and both have been involved in all parts.

7. Conclusion

In the early stages of the project we sat up some objectives for the project, those were to: "Investigate the problems that users have with the current real-time system, and try to come up with solutions for those problems". On the first part we would like to say that we've succeeded. As already mentioned we didn't manage to include representatives from the entire target group. Perhaps the list of problems with the current real-time system would have been longer if other types of users would have been involved. Since the decision was made to develop an iPhone application it's better to say that the user group for this project was the potential users of smart phones, and we think that user group is represented in our studies.

It's hard to state whether we managed with the second part of our objective, to come up with solutions for those problems. We definitely build an application that has the potential to be useful for people, and we've received great feedback on it. But during the testing we realized that to fully evaluate the application a longer study should be done, a study where the participants tries the application, in their daily lives. In any case, we're satisfied with the result of the project and hopefully it will be used by a lot of people on their own iPhones in the future.

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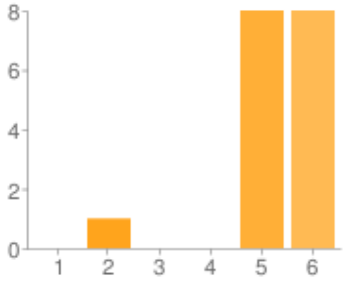
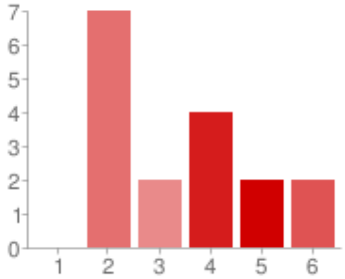
Appendix A: Questionnaire

A total of 17 people answered our questionnaire; they were in the age of 23 – 39, four women and 13 men. They all lived in the central parts of Gothenburg and all except one travelled with public transport at least a few times a week. 11 of the participants had Västtrafik's iPhone application and they were fairly satisfied with it. Västtrafik's application is mostly used to search journeys and to check departures in real-time. The participants were asked to grade six features from one to six, one is not at all useful and six is very useful. The results of the six questions are presented below.

Question 1: Disturbance information that's adapted to your needs

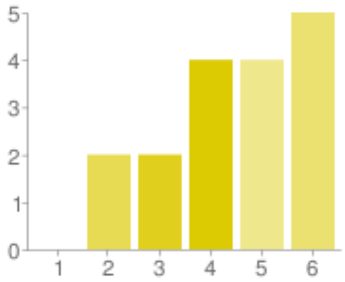


Question 2: Ability to personalize the application



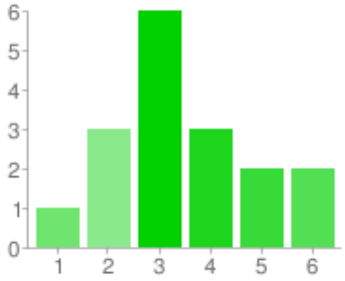
Question 3: Help with a transfer part a

To have the ability to get real-time information about vehicles at upcoming stops



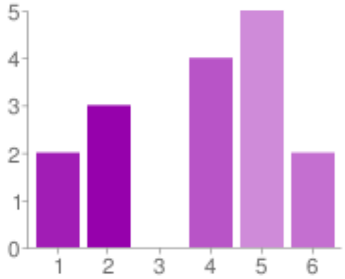
Question 4: Help with a transfer part b

To get guidance between different traffic islands at a stop during a transfer

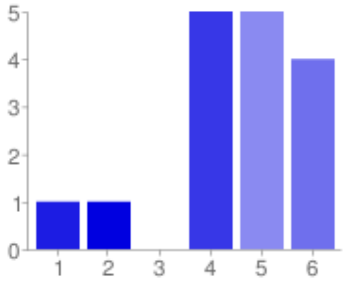


Question 5: Help when to leave the vehicle

That the application tells you when your destination is approaching

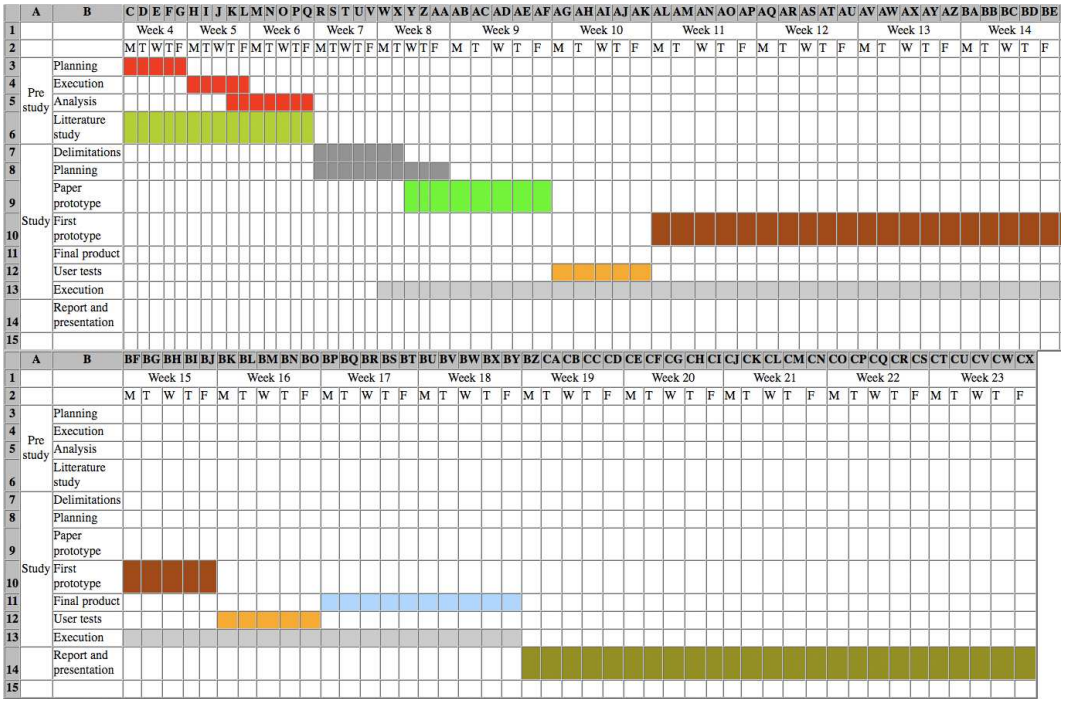


Question 6: Map with a vehicle's position in real-time



Appendix B: Gantt chart

The Gantt chart done in the beginning of the development process



Appendix C: Interview guide

The interview guide used in the final user test

- How old are you and what are you doing for a living?
- Do you have any experience using an iPhone?
- How often do you travel with public transport?
- Task 1: In disturbance information, set the application to only show disturbance information for Göteborg.
- Task 2: Do a trip search from Majvallen to Chalmers as soon as possible
- Check out the stops between start and stop.
- Watch the route on a map.
- Take a look at the stop-map during the change.
- Task 3: When is the next bus 16 to Eketrägatan leaving from Chalmers, and where is it now?
- Task 4: Add a favourite journey and a favourite stop, and then remove them from the system again.
- How was the application to interact with?
- Is there any functionality that you think are missing?
- How do you reflect on the position of the vehicles, is it real-time or not?

Appendix D: Poster 1

The poster used to recruit participants to the focus groups done in the pre-study

västtrafik

Vill du vara med och påverka morgondagens buss och spårvagnar, och samtidigt få gå på bio?

Vi söker nu ett antal personer för gruppintervjuer. Intervjuerna kommer att behandla realtidsinformation som distribueras av Västtrafik och hur den kan förbättras. (ex. skylten till höger) Intervjuerna kommer att ta plats på Chalmers Johanneberg, Onsdag-Fredag nästa vecka (vecka 5).

Tiderna som finns är:

Onsdag 3/2 - kl. 17:00
Torsdag 4/2 - kl. 14:00
Fredag 5/2 - kl. 10:00

Intervjuerna beräknas ta ungefär 1 - 1.5 timma.

Skicka ett e-mail, innehållande Namn, Ålder, Postadress, Vilken/vilka tider som du kan komma på, till exjobb.vasttrafik@gmail.com.

Kan du inte dessa tider men ändå önskar att hjälpa till vid ett senare tillfälle så går det också bra att höra av sig.

Alla som blir kallade och hjälper till får varsin biobiljett!

Detta är ett examensarbete på Chalmers i samarbete med Västtrafik.

Appendix E: Poster 2

The poster used to recruit participants to the final user study