FlexTrans

Demand Responsive Transportation Support Solution

João Tiago Ferreira Coutinho Arez da Cruz

Universidade Técnica de Lisboa
Instituto Superior Técnico
Av. Rovisco Pais
Portugal
joaotiagocruz@ist.utl.pt
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Abstract. The Demand Responsive Transportation Services (DRT) are becoming more active in our lives. There are the services that take the older people to their nearest health center, or the ones that transport workers from home to their job location, or the services that take people from a town to the train station on the outskirts of the town. There's a growing expansion of DRT services, following by a growing urge to have systems capable of managing those services. This thesis is about exploring the concept of flexible transportation services, understand what are the main operations that these type of services requires, and to explore visualisation techniques that could provide an operator the right tools to manage his fleet accordingly and also answer for travel requests from customers. The study presented in this document focused on many case studies and currently working systems, to see where they fail in terms of visualisation of the main management operations. This thesis ends with the implementation of a prototype application, that is focused on solving the problems found on previous studies. This prototype, we'll call it FlexTrans, will provide the operator a set of tools and visualization techniques so that he can manage the fleet and travel requests efficiently and easily, and also to allow a fast response from him when needed.

1 Introduction

Connecting people to different locations in a pleasant and simple way was always an objective to accomplish. Nowadays we are facing many types of public transportation services, like boats, planes, buses, subways, and many other, but in spite of having this growing diversification, all of them have their limitations regarding fixed scheduling and routing. There are other problems regarding social aspects that limit the mobility of the people: economic difficulties with the prices growing every time (Enoch [2]), physical limitations that difficult the arrival to the Medical Center for example, or work (Sara [6]). The population is getting older, and there are almost no transportation offers in the most rural areas. There is also the problem where we find ourselves using excessively our own vehicles to travel, contributing to more pollution (Katzev [3]).

To face these problems, the Demand Responsive Transportation Services or DRT services were created in order to complement the current public transportation network by providing flexible schedules and routes to all the people that need them (Brake [1]), allowing a better social inclusion and sustainability of communities (Mageean [5]).

But since these type of services is relatively new, there are just a few systems that supports them. Most of these systems are capable of accomplish some of the main tasks of fleet management, but they all lack the proper visualisation techniques that supports those tasks efficiently.

So we designed a prototype that will handle this topic face on. With this prototype we propose an alternative way to interact and manage a group of DRT services and answer travel requests in a way that is more appealing graphically, by providing visualisation tools that makes the operator feel like he is really in control of what he is doing.

This prototype is called FlexTrans, and is a web-based application that can run in any computer with an internet connection. The operator will only need to open the browser and access the application.

2 Related Work

Different DRT services management systems have been explored and implemented in the last years. Each one of this systems has its unique features, and we will now proceed to analyse some of them.

2.1 Related work

Reservation, Scheduling, and Navigation System for a Checkpoint DRT Service Li [4] proposes a web-based system to automatically manage a DRT service. It allows only one bus to be scheduled to answer trip requests. This bus has a looping fixed route but with optional stops. The operator has only one function here: to provide a configuration file with the route, optional stops, stop hours and loop frequency. During this part, he is able to see the route in the map Then the backend system will use that information to answer the customers about their options, leaving the operator with little work to do. Even when the bus starts its service, the operator has no way to monitor its state. This system proved to be very limited, because there are almost no tasks that the operator has to do and no way to monitor the service status.

An Intelligent Model for Urban Demand-responsive Transport System Control Xu [7] proposes an architecture for a simulated DRT system, including backend functionality and an interface for service monitoring. In this study the author divides the system into logical layers: One regarding the architecture of the various entities that interact with the system, the agents, another regarding the services provided to those agents, like directory, communication and location services, and finally the last one that is regarding to the interface to the operator. This interface is divided into two parts: the simulation interface and the monitoring interface. The first provides controls to add or remove agents of the system, and the second one shows a map in a satellite view where the operator will be able to see the agents location and status, like the number of passengers or its service status. This system in terms of visualisation lacks features, allowing only monitoring the services without any kind of interaction, but in the other hand gave us a better notion of a backend that supports a DRT service.

PASS Pass[1] is a system developed by Trapeze that gives support to the management of DRT services. This system is more robust than the previous one, because it gives more information regarding the status of the services that are running. The customers can be registered into the system, so that the system can track their route history to better handle future requests. The operator can create trips, using a form and a map to preview the route. The monitoring screen is presented with detailed lists of services and a map view to see a specific service route. In spite of its feature rich application, the PASS system has a big flaw: the interface cluttering. There seem to be infinite buttons and lists when it is needed to create a trip or just see the status of a service, turning the monitoring a not so elegant task to do. Also the system does not allow viewing more than one service at a time. If the operator needs to see the vehicles on service on the map, we will need to select one by one and then see their location.

NOVUS The NOVUS[2] system is an upgrade to the PASS system made by the same company (Trapeze). This system shows a more polished application that allows monitoring and answering trip requests, computes the best trip to satisfy a request, and allows to view some statistical information. Its configuration capabilities allows the system to be robust as intended by the services company. This system allows also viewing more than one vehicle at a time, but there are still some visual problems that need to be addressed: there are still many forms to be filled to answer a request, and the global state of the system is seen through a big coloured list without the help of a map.

[1] `http://www.marintransit.org/pdf/Trapeze_PASSProductDescription.pdf`
[2] `www.nds.org.au/asset/view_document/979318782`

Schedulling-Routing System (SRS) The Schedulling-Routing System is a DRT services manager that has absolutely no monitoring interaction with the operator. There is no UI where the operator can see the state of the buses. The goal was to provide a backend system that allows to generate trips running in background, which can be used by another application that has the UI capabilities to show that information. The system answers trip requests based on the request characteristics and operation preferences. The system may choose one or more vehicles to fulfil a request, and may choose a specific bus having in account the passengers number or the proximity of a bus to the origin of the request, or if the passengers are students, it will choose a school bus. These decisions are made by a set of rules or policies that are configured at the beginning of the execution.

Acces Another system that is used nowadays in many places is the Acces[3] from GIRO[4]. This system enables trip requests either by phone, or via internet, so that the operator doesn't need to make the initial interaction with the customer. This system is very similar to the NOVUS system, the biggest difference lies in the inexistent of a map view to see the vehicles or the requests. Everything runs by filling forms and watching a colourless list with the detailed status of each active service. However there is one big advantage to use this system: the possibility to define time windows to answer the requests, so the trip remains in standby mode unless there are the required number of reservations done.

Mentor Streets Transit The Mentor Streets Transit[5] application from the Mentor[6] company was the most visually polished application we studied among all the other systems. This application uses the map view a lot to check the status of the services, the real-time information of a specific bus, allows communication with the vehicle anytime with a 2 click distance. It allows also the access to all the trips a vehicle has done in the past, with a simple yet powerful slider bar. We can filter our viewable vehicles to just the ones that interest at the time. Also this system allows to see some points of interest in the map, in case there are requests to those points, easily found in the map. However this application lacks of requests functionality. There is no notion of passengers neither can the operator answer trip requests. But there were some nice ideas with this system, that were used in our final solution.

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[3] `http://www.giro.ca/en/products/giro-acces/index.htm`

[4] `ttp://www.giro.ca/en/`

[5] `http://info.mentoreng.com/MentorStreetsTransitandAutomaticVehicleLocation.html`

[6] `http://www.mentoreng.com/`

SAEIP and XTRAN - The Carris Study We were able to be at the transit operations department at the Carris transport company. Although Carris operates under the common public transport system, with fixed routes and schedules, we could extract many indicators of how can they monitor a huge set of vehicles and how they solve problems regarding accidents, transit and communication.

They use two major applications: The SAEIP and XTRAN. The first one gives detailed information about vehicles and vehicle services in real time, allowing communication with the drivers, and allowing access to activity logs of the buses. The second one gives geographical information of the buses in a map, and allows access to the history of location of each bus.

The major problems identified included the fact that they need two completely distinct applications to be running at the same time. There is also lack of traffic information that could allow prevent delays in the service. At last we could also see interface cluttering along the application. There were many buttons that occupies a significant part of the screen, leaving less for the important content.

3 Solution Requirements

All the studies shown before gave us many hints on what to do next. We identified many issues regarding visualisation and interaction between the systems and the operator that needed more attention.

3.1 Solution Goals

We planned FlexTrans so that it could allow an operator to experience DRT management tasks in a way he couldn't before. We provided the application with a set of tools that will allow the operator to be able to interact with the information more intuitively and naturally, forgetting about the filling of forms.

We wanted to make the operator feel like he is in control of the whole operations, so that he can take decisions without doubts or hesitation.

The FlexTrans solution must allow the execution of the basic flexible transport services management tasks. These tasks include monitoring all the services and trip requests with ease, answer trip requests anytime, change trip routes if needed, have traffic feedback if may affect the correct function of any service, it should allow viewing many types of statistics that allow having different indicators for taking decisions in the future and access vehicle history.

3.2 Implementation Requirements

Not only the FlexTrans must implement the referred goals, but it should also implement them having in account design, performance and interaction mechanisms that simplify the execution of the tasks and boosts the user experience overall. Therefore we identified a set of non-functional requirements that Flax-Trans should meet: simplicity, efficiency, and extensibility.

4 FlexTrans

The FlexTrans is our solution to most of the visual problems found in the earlier systems, is the product of this thesis. It is a web based application that allows monitoring a fleet of DRT services, allowing answering trip requests, changing routes, replace damaged vehicles, and to get statistical information regarding the system over time.

4.1 Overview

The FlexTrans system has two major components: the backend, which manages and provides all information regarding vehicles, services, clients, routes, transit and communication, and the interface, the component that displays the backend information to the operator, being the bridge that connect both operator and the system. For this solution we assumed that the trip requests are made through an external entity that connects to the backend, and it won't be considered in the implementation of our solution.

4.2 Backend

The backend is the core of the system. It's the entity of the FlexBus that does all the processing tasks, and it's the central component that connects to operators and vehicles. It also has the necessary components that allows getting the location of the vehicles, to generate the best route for a given group of trip requests, and to connect to external sources to get transit feedback. It has also capabilities for communication between the vehicles and the operator, either using SMS and Voice calls. The backend is also responsible for persisting the system state every time.

Architecture of the Backend The backend has several components that operates a different set of entities. It has the *Trips Manager*, which deals with all services attributes and routes, there's the *Client Manager*, that have information regarding all the customers in the system. There's also the *Vehicle Manager*, which deals with both communication between the operator and the driver, and provides the location of the vehicle to the system. It has a component that is responsible to fetch traffic information from the Internet, the *Traffic Manager*,and there's also a *library component* that persists all this information into a database, so it can be provided anytime.

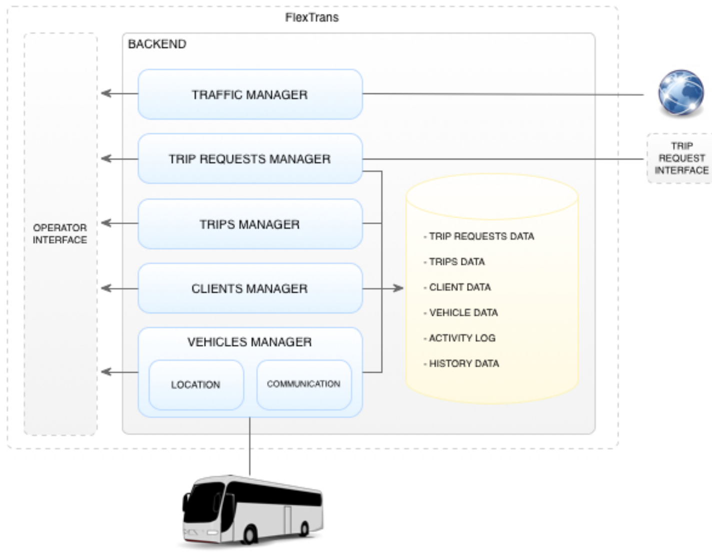

Fig. 1. FlexTrans backend architecture

Trips Manager This component is capable of managing both trips information, and trips routes. Anytime the operator wants to find information like the what are the points that one specific trip needs to stop to leave passengers, or just to know the current state of the service, this component has ways to answer that request. It also is responsible to generate the best path having in account the requirements of all the trip requests made from users. The Trips Manager is also capable of getting past trips when needed.

Client Manager The Client Manager manages information regarding clients. Every time a client uses a service, it will be recorded in his history sheet, so the application can use that information to answer the next similar request from that user. This component also knows the status of the clients, their personal information and physical limitations.

Vehicle Manager The Vehicle Manager has the job to supply information regarding vehicle characteristics and to provide mechanisms to allow communication between the operator and the vehicle either via SMS messages or voice calls. When there is the need to get one available vehicle to satisfy one trip request, one of the factors that needs to be considered is the vehicle capacity and special seats or accesses. The Vehicle Manager knows all this and provides it to the interface.

Traffic Manager The Traffic Manager is responsible for fetching traffic information on the Internet. In many occasions the system will need to know traffic information to check if there are any road accidents that can have negative impact in the correct services behaviour.

Library The library stores all the information in the previous components so that can be accessed anytime.

4.3 Visualisation

The biggest challenge of this thesis was the creation of the interface that would satisfy the requirements found. We had to think outside the box and leave behind the standard interaction to find another way to interact with the system that would boost the user experience of the operator when managing his fleet. Next we will talk about how we reach those goals.

Overview We can divide the visualisation in two major blocks: the monitoring and the statistics. It's in the monitoring section when almost everything happens, starting from getting the state of the elements of the system, to answer trip requests or replace damaged vehicles, establish communication between the operator and the vehicles, route edition and history visualisation. The statistics section provides some visualisations that give the operator important indicators in long term decision making regarding trips and requests.

Main Window The spine of the interface was the starting point in the definition of the whole interface. It was necessary to understand what types of information we would need to display and what would be the best way to display it to the operator. So in the FlexTrans implementation we divided the whole window into five regions: the upper panel which contains the navigation, the center panel that contains all the main visualisations and it's where the operator mostly interact with. It will have either a map or a diagrams panel. The left panel is where the vehicle and request lists are, so they can be selected quickly. The right panel will contain the major information regarding the item that is selected, which would be either a vehicle or a request. The bottom panel complements the right panel, giving another set of information that suits better its horizontal nature, like logs and trip spines. The communication is also located at the bottom panel.

Monitoring the monitoring is the major group of features of the FlexTrans. The operator can follow the state of all the active services in the system by looking at the lists in the left panel, or by watching the entities in the map view or diagram view. The map view brings location context to the monitoring whereas the diagram view gives a sense of relative position of the vehicle in his route.

The monitoring includes answering to trip requests, where the operator will just need to select the specific request and then drag the vehicle from the list to the bottom panel. The system will then generate the route and display it on the map and in a diagram visualisation at the bottom panel.

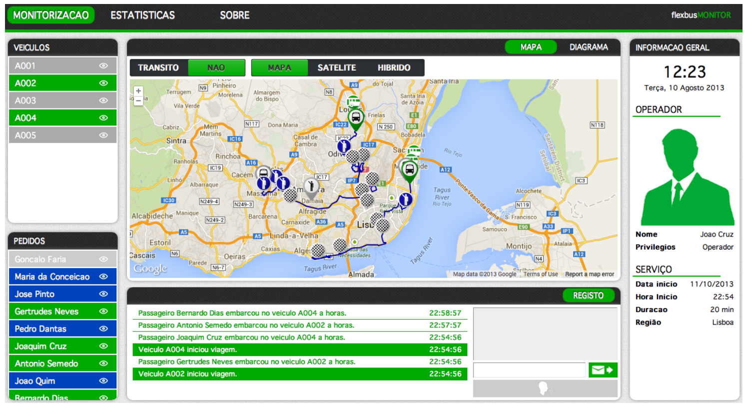

Fig. 2. FlexTrans main window

Switching vehicles because of an accident is processed the same way as answering a trip request, and editing any trip path is as easy as dragging the route path along the map. Also simple is switching requests order in a path. Just drag one into another in the map to make the switch.

The operator can select a vehicle to check its history log. When the history tab is selected, the user will be able to choose a date from a calendar and then scroll a draggable selector until he reaches the desired hour.

Statistics The statistics panel was designed thinking of statistics correlation. We implemented a mechanism that allows visualisation of up to 4 different statistic visualisations at the same time with different sizes between them, so that the user could compare two or more types of information in a better way, because some visualisations are better seen horizontally or vertically.

We thought of 3 different statistic visualisations: Number of requests per unit of time, map based location of trip requests and a heatmap that highlights the zones in a map where the vehicles are mostly active.

5 Evaluation

We did user testing with the FlexTrans. In total there were 17 people that were asked to perform a serious of tasks representatives of the major tasks in DRT services management. In the end they were asked to complete a survey regarding usability (System Usability Scale) and about specifics of the FlexTrans.

Most of the users loved the way they interacted with FlexTrans, and liked the fact that they don't need to go through a serious of steps to accomplish the tasks. In spite of having good feedback, there were also cases when some mechanisms proved to need to get more attention because they lead into misunderstanding.

The SUS scale we obtained from the surveys was of 71 points, a value considered above average, putting FlexTrans in a good place in terms of usability.

6 Conclusions

We were very satisfied with the end product. FlexTrans met almost every requirement with good results. We provided a tool that went against the monotony of the traditional fleet management visualisations and interactions.

Even taking into account the relative young age of the DRT services managers, there hasn't been much studies regarding visualisation techniques applied to them. So we took that and conceived a system that is different from the others in almost every way.

We left the forms out, we left the popup windows, and we left the overcrowded toolbars to let the main features of the FlexTrans breathe and let the operator focus on his task.

The result was an application that gives the operator the sensation of control of the fleet and flexibility to solve typical management problems easily.

6.1 Future Work

Unfortunately there wasn't much more time to implement all the features we had planned to, but we leave it as future work. We made the FlexTrans in a way that can be added more visualisations and more information about services, vehicles and trip requests. Some users left us hints of what we could improve regarding specific interface elements that could be made better, and suggested more features that could fit into the application.

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