Title

Transport4You: an intelligent public transportation manager

Abstract

One of the key challenges faced nowadays by public transportation authorities is to offer personalized services to citizens. This requires the new Information and Communication Technologies (ICT) to be massively exploited.
The goal of this project is to develop some of the core features of a system that can help a Metropolitan Transportation Authority improve the services offered to citizens. At its core, the system should offer the following basic functionalities:

- allow a citizen to register into the system and pre-pay for a certain number of trips;
- recognize when a registered citizen gets on a bus and determine the journey he/she performs, calculating the fare he/she has to pay, and detracting it from his/hers credit;
- when the citizen's credit is finished, allow him/her to pay the bus fare through the cell phone;
- provide registered citizens with information about changes in the lines they use most frequently.

Possibly, the system should be able to offer suggestions to registered citizens for alternative paths, for example because it determines that there are routes that are more optimized than the ones they usually take, or because there is a problem on some line that affects their intended path.

Introduction

Public transportation is one of the main services offered by municipalities, sometimes with the help of private companies. From the end user point of view, the service is perceived favorably when it is reliable and on schedule, when it covers the entire city, possibly with direct and fast connections that fulfil the needs of the various users, and when it is easy to use, e.g., to buy valid tickets and access the service.
Thus, a key challenge is to address all above needs and to offer personalized services to citizens. This requires the new Information and Communication Technologies (ICT) to be massively exploited.
The goal of this project is to develop some of the core features of a system that can help a Metropolitan Transportation Authority (MTA) improve the service offered to citizens.
While the Transport4You project does not refer to a specific city, many municipalities around the world (including Milan) are either developing, or considering to develop systems of similar nature. In fact, Transport4You applications developed by SCORE participants could be used to evaluate the features being considered for such prospective systems.

For the sake of simplicity, we can assume that the vehicles of the MTA are exclusively buses.
At its core, the system should offer the following basic functionalities:

- allow a citizen to register into the system and pre-pay for a certain number of trips;
- recognize when a registered citizen gets on a bus and determine the journey he/she performs, calculating the fare he/she has to pay, and detracting it from his/hers credit;
- when the citizen's credit is finished, allow him/her to pay the bus fare through the cell phone;
- provide registered citizens with information about changes in the lines they use most frequently.

Every bus of the MTA is equipped with a computer with both bluetooth and WiFi. We assume registered citizens have modern cell phones that are also equipped with either a bluetooth or a WiFi connection (or both). The system recognizes when a registered citizen boards the bus when it detects his/her cell phone on the bus. The registration phase happens through the system website. In this phase the citizen inserts the Bluetooth and/or WiFi identifier of its cell phone so that it can be used during the recognition process.

Registered passengers can either pre-pay for trips through the website or they can provide their credit card number and buy the ticket when they access a bus. In the first case, users charge money to their account. When the system detects that a passenger has boarded a bus, it automatically charges the ticket cost to the user's account, and, in case the user has enabled this feature, notifies the passenger through an SMS. The amount of the bus fare, T_COST, is a configurable parameter of the system. If the credit on the pre-paid account is smaller than T_COST, the system notifies the user through an SMS and detracts the unpaid amount from the next money recharge he/she performs. Should the passenger start other trips without recharging the account, the city police will be notified.
In case the registered passenger has chosen to pay by credit card, the system charges T_COST on the credit card whose number has been provided at the time of the registration (for the purpose of the project the interaction with the credit card payment system can be simulated). After it is purchased, a ticket is valid for T_VAL minutes from the time it is stamped (with T_VAL a configurable parameter of the system), even if the passenger gets on and off several buses during the interval of validity of the ticket.
The system infers the journey performed by a registered citizen by keeping track of the stop he/she is using to get in and out from buses. The journey can be obtained as the combination of the buses the citizen takes in the T_VAL amount of time, assuming that this time is enough to cover the entire trip.
The information gathered about the citizens' journeys are used to provide alerts in case a line is interrupted for any reason. In this case, in order to avoid citizens to be flooded with too many data, the system has to direct the alerts to those citizens that are most likely to be influenced by the problem. For instance, in the case a line is stopped from 8.00 to 9.00, someone who usually takes it at 10.00 should not be informed of the stop.
Possibly, the system should be able to offer suggestions to registered citizens for alternative paths, for example because it determines that there are routes that are more optimized than the ones they usually take, or because there is a problem on some line that affects their intended path.

Application domain and scenarios

The buses of MTA are provided with a computer that has both bluetooth and WiFi capabilities. These are used to detect the presence of the passengers' cell phones, which are assumed to be equipped with either bluetooth or WiFi connectivity (or both).
One can assume that the bluetooth/WiFi devices are positioned in the buses in a way that guarantees that cell phones are detected anywhere on the bus. As a drawback to be considered during design and implementation, the bluetooth/WiFi signal is strong enough to detect cell phones also in the immediate vicinity of the bus, but outside it.
Every bus has a GPS, through which the application can determine its geographical position and the speed of the bus. Moreover, it features a GPRS (or higher quality protocol) connection that allows the bus computer to interact with the central mainframe. Due to the cost of this connection and its limited bandwidth, it usage should be minimized. Finally, buses are able to detect when they have arrived at a bus stop in a way that has been already implemented (for the purpose of this project you can simulate the component that informs the other parts of the system about the arrival at the bus stop).

The following scenarios illustrate **some possible** interactions between users and system concerning the core functionalities described above.

Scenario 1: user registration
Jane Doe uses a web interface to activate an account with the Transport4You system. For this, she chooses a username and password, then she provides her personal data (name, address, etc.), and the data of her cell phone: phone number, bluetooth address (if any), WiFi mac address (if any). After having activated the account, she logs onto the system and adds 20€ to her account (which she pays by credit card through an online transaction system).

Scenario 2a: the system detects a registered passenger entering the bus
The system detects that Jane Doe has boarded bus 35 at stop "Central Station" by sensing the bluetooth or WiFi device of her cell phone. It looks for the address of the device among those that are registered with the system and stores the information about the bus stop, the line she boarded, and the time of the boarding for future purposes.

Scenario 2b: the passenger leaves the bus
Jane Doe decides to get out of the bus number 35 at stop "Main Square". After that stop, the system detects that Jane's phone is no more on board and therefore infers that she has left the bus. It also updates the data concerning the trip with the information about the stop where she has left.

Scenario 3: payment of the bus fare
When Jane Doe enters the bus at stop "Central Station", the system recognizes her (see Scenario 2a) and then checks the status of her account. As she has more than T_COST Euros on it, the system updates the account by subtracting the bus fare. The system sends Jane Doe an SMS informing her of the purchase; the SMS notification includes the information about the bus stop at which the system determined Jane boarded the bus, the line she boarded, and the time of the boarding.

Scenario 4: citizens are informed about changes in the lines
A major accident has occurred on the path of line 35. The police decide to block all streets entering "Central Station" for one hour. Therefore, MTA is forced to redirect bus number 35 on an alternative path passing close by "Central Station". The operator John Brown enters the new path into the Transport4You system. The system collects the information about all passengers that are likely to be affected by the problem and sends an SMS to them with the new path and schedule of the bus.

Project goals (requirements)

Details on the functional and non-functional requirements will be elicited by the development team through interactions with the project proposers or with some domain expert. In this last case, the domain expert will have to be explicitly mentioned in the documentation and could be contacted for clarifications by the project reviewers during the project review process. Thus, he/she will have to be available for such interaction (the communication load will be kept to a minimum).
Here we only remark that a very important requirement concerns the usability of the system. In particular, the actions the passenger should proactively perform during the journeys should be limited, very simple, and suitable to situations where the bus is crowded, the passenger is standing, he/she may have to handle children or luggage, he/she may be impaired.

Intended output of the process (process focus)

The development team is free to adopt any development process suitable to the nature of the problem being considered, provided that it will pay special attention to the elicitation of requirements from proper stakeholders (either the project proponents or any expert of the application domain). The following artifacts are expected to be produced, even though the development team is free to define their structure according to the selected development process:

- *Requirement analysis and specification document* (RASD): this should document the result of requirement elicitation and modeling in terms of scenarios/use cases and any other documentation aiming at clarifying and modeling requirements and constraints.
- *Design document* (DD). This document must contain a functional description of the system, and any other architectural view the development team finds useful to provide. Clearly, the information in this document has to be coherent with what is reported in the RASD.
- *Test plan* (TP): TP should identify the test cases that are used to exercise the system, as well as indications on the criteria used to derive them and on the tools (if any) that are used to execute the tests and/or assess the results.
- *Implementation*. This should be a package containing source code and executables, installation and user manuals, and the test report. For the implementation you can select the programming language and middleware infrastructure you like. We do not expect your implementation will cover the whole range of cellular device available on the market. You are free to refer to a single device of your choice, provided that the high level design structure can remain stable when adding a new type of cell phone.

Interaction between stakeholder and developing teams

The authors of this project description are willing to serve as stakeholders of the system to be built. They can be reached at the email address transport4you.score@gmail.com. Other communication channels with teams (e.g, a blog) might be set up in the future. Registered contestants will be notified by email if/when this happens. Development teams can expect a reply to a query within one week (usually sooner).

At their option, development teams might choose instead or in addition to find local domain experts to act as stakeholders. Interaction and requirements elicitation with other stakeholders should be documented to explain how those interactions lead to particular choices in the product design.