Future Internet for real-time planning and monitoring of multimodal trip

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Abstract

The EC-funded project Instant Mobility is defining a comprehensive architecture for transport and mobility applications that aim to innovate by introducing future Internet technologies to this domain. A set of core enabling technologies are being developed by other projects in the Future Internet PPP such as FI-WARE, while the transport domain Instant Mobility project will use these generic enablers where available, and is developing its own enablers where necessary. In this paper, we describe an Internet-based “multimodal travel platform” that provides information and services able to support new types of connected transport applications. The considered scenario, a “Personal Travel Companion”, is centred on multimodal travellers (both drivers and passengers). Almost all modes of transport are present in this scenario: private car, public transport modes, car sharing, ride sharing, bikes, etc. The project defines requirements for future Internet technology tools and enablers that can support services available to any Internet-connected traveller, whether using a portable, vehicle-based or fixed terminal. Future Internet technologies offer new horizons for transport information systems and propose for travellers a new experience with means of transport. We are designing and implementing a prototype for multimodal travel assistance taking advantage of these technologies. A demonstration of the application has been shown in the ITS world congress 2012, while the final prototype is due on March 2013.

Keywords:

Future internet, multimodal travel assistance, tracking, online optimization

Introduction

The Internet of networks, the web services, the cloud computing, the social networks and the Internet of Things provide new possibilities for transport applications, which were not imaginable a few years ago. Using future Internet technologies, we should now be able to provide real-time information and up-to-date mobility solutions for multimodal journeys. Travellers should be able to access up-to-date information on transport modes, their availability, ticketing, operation situation, etc., allowing the planning of an optimized and up-to-date itinerary following a great number of criteria. It is possible to connect all transport modes and vehicles whenever needed to assist a traveller during a multi-modal journey, informing him about any disruption and delivering a choice of alternative solutions. The *Instant Mobility* application guides the traveller to the needed transit stops/stations or directs the car driver along the best route. It also provides ticketless mobile payment via the traveller's mobile handset for mobility services such as public transport, parking, congestion charging, ride sharing etc. In this paper, we present the "multimodal travel platform" (MMT) that supports the provision of the essential subset of these services.

Scenario and assumptions

In the scenario that we consider, online services offer a traveller a wide range of personalised travel and transport options, according to his preferences. The trip may use various modes including public transport, bike, car, and ride sharing. When planning a given journey, the traveller receives a number of alternative integrated itineraries which are the optimal plans that respect his preferences and take account of the latest real-time information from all relevant modes such as transit routes, timetables, vehicles positions, fare costs, available ride sharing opportunities, etc. Once it receives confirmation of the chosen itinerary the travel assistant application books the corresponding services, and delivers an integrated ticket receipt while requesting a single payment from the traveller's account. The traveller receives his chosen itinerary via Internet, and throughout the journey is helped to get off at the right stops, walk through a complex terminal or interchange, find the next transport link, etc. During the journey, the itinerary is continuously monitored in real-time, and the traveller is alerted whenever conditions or options change. The current itinerary is then updated according to his choice.

The traveller is charged at the end of his trip. That means that if there is a problem with the planned journey, it is taken into account, and the user won't have to ask for a refund in case something changes. He also only pays for the service he has asked for. That means that a traveller that uses only one means of transport would only pay for that service.

We make two main assumptions in the context of the MMT platform. On one hand we assume that every traveller's mobile Internet device is aware of its location and every transport vehicle (public and private) is tracked continuously, outdoors and indoors. On the other hand, the platform must be able to work with both pre-trip reservations as well as to fulfil its primary objective, to manage changes to the itinerary in real time, incorporating any new traveller requests as well as traffic incidents and transport service deviations.

The scenario is formalized with the use case diagram of Figure 1.

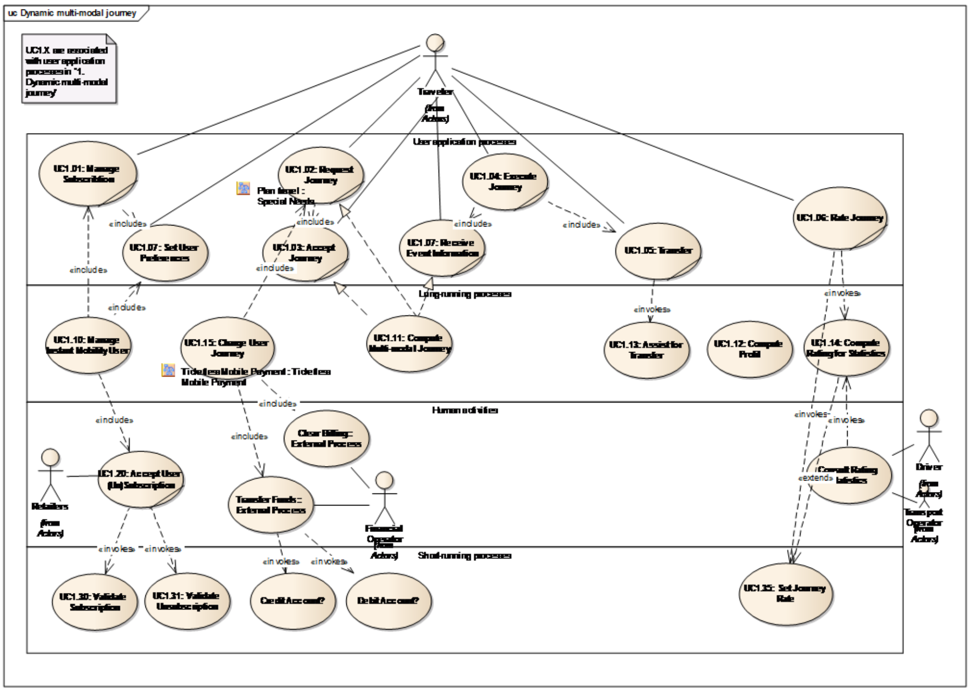

Figure 1 Scenario

The main challenge with this scenario and these assumptions is twofold:

- From a technological perspective, to find the right architectures and system functionalities to take full advantage of the future Internet technologies, while respecting travellers' preferences and data privacy needs;
- From an algorithmic perspective, to find the right procedures and balancing mechanisms to keep each traveller on what is for him the optimum and preferred itinerary while avoiding adding to traffic congestion and overcrowding on public transport.

Public interface of the service

Figure 2 presents a view of the multimodal travel platform from an external point of view. It specifies the requirements for a specific region to set an *Instant Mobility* service and the different exchanges that should take place with the platform.

The platform interacts with three types of actors: the public transport operators, the road transport operators and the travellers.

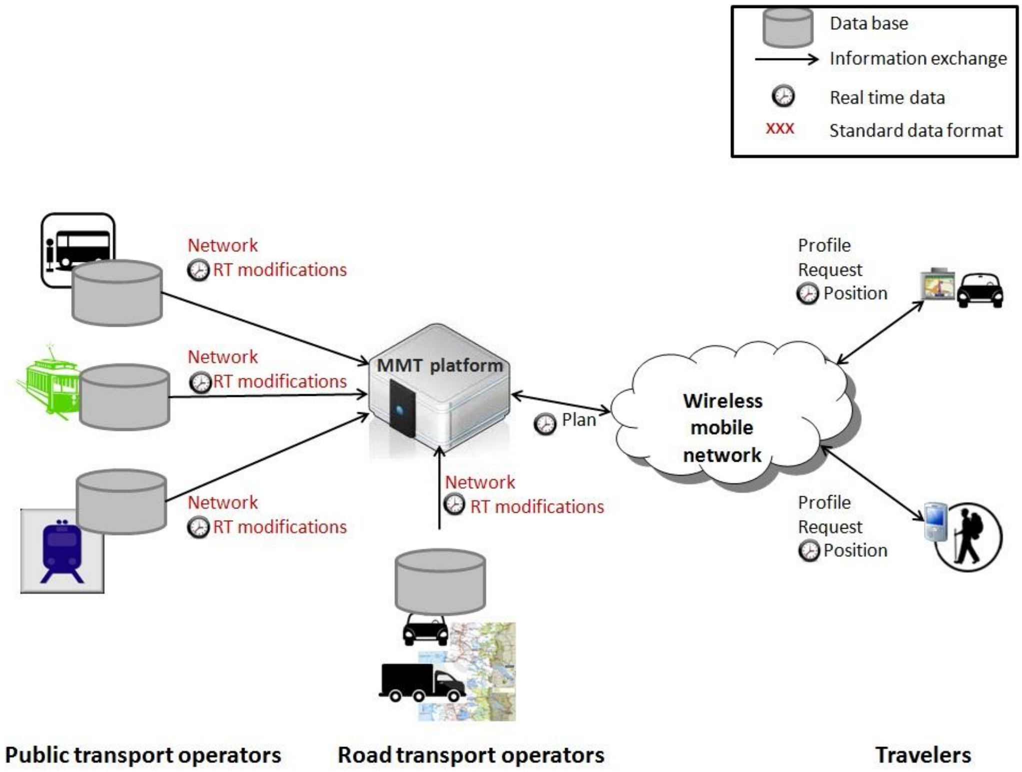

Figure 2 - Multimodal travel platform public interface

Each public transport operator has to provide the platform a description of their network and theoretical timetables. As depicted in the figure, we do not require the public transport operators to have a common database that integrate all the public transport means and networks. Each transport mode operator might have its own database, and the platform has to integrate them and manage them simultaneously.

Each public transport operator has to provide 3 types of data:

- The description of the transport offer
- The position, the advance/delay of all its fleet
- The events that cause transport services disruptions

As for public transport operators, road transport operators have to provide the MMT platform with a description of their network, together with all static information related to it. They also have to provide 3 types of data:

- The description of the road network
- The speeds, densities, occupancy rates or status
- The events which impacts the transport offer

All these exchanged data have to conform to the latest European standards.

The travellers interact with the platform using standard communication protocols. Each traveller provides the system with his profile, which includes detailed information regarding his properties and preferences. Once a plan is received from the platform, the mobile device of the user dynamically sends his current position to the platform. If the difference between the actual position of the traveler and the planned position (i.e. the expected position following the plan that was proposed to the traveler) is big enough, following the traveler's preferences, the traveler receives a new plan taking into account his new context.

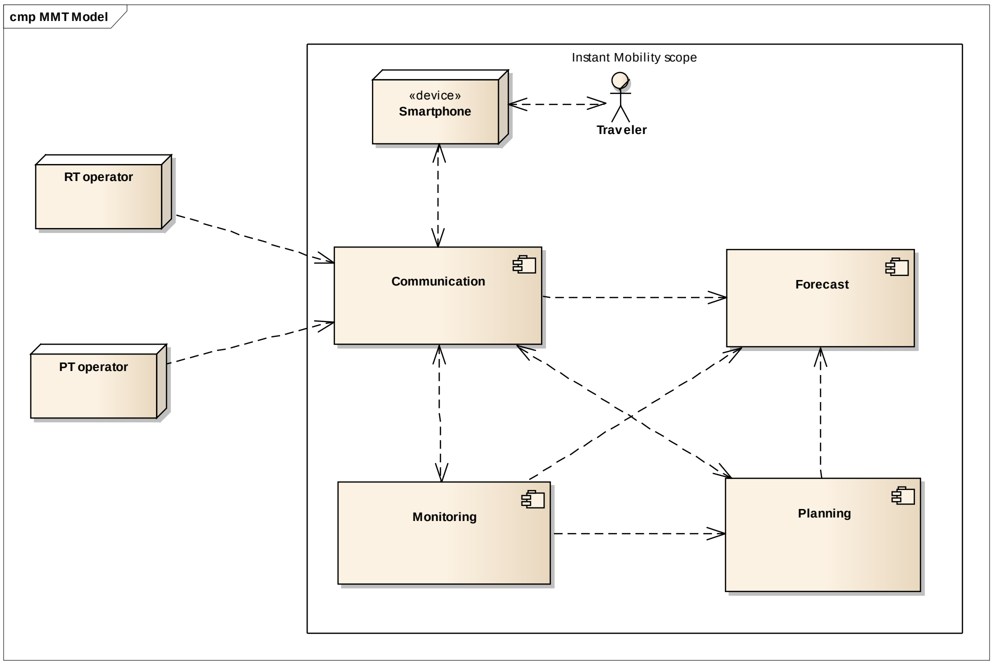

Figure 3 – The MMT platform model

Model

We define a high-level representation of MMT from a functional point of view. It comprises four modules designed as independent and loosely coupled components (cf. Figure 3):

- The communication module is responsible for the interaction of MMT with the outside world (road transport operators, public transport operators, and travellers);
- The planning module is responsible for planning and re-planning of travellers' itineraries (see Figure 4);
- The forecast module maintains the best possible vision of the future status of the networks. The planning module bases its calculation on the outcome of this module;

Finally, the monitoring module monitors the execution of the travellers' plans.

The mobile device of the traveller could store information that would speed-up the calculation and/or improve the quality of the solutions provided to him. For instance, it could store information about users' travel habits. This would save a lot of users' time by immediately making suggestions and recommendations to him.

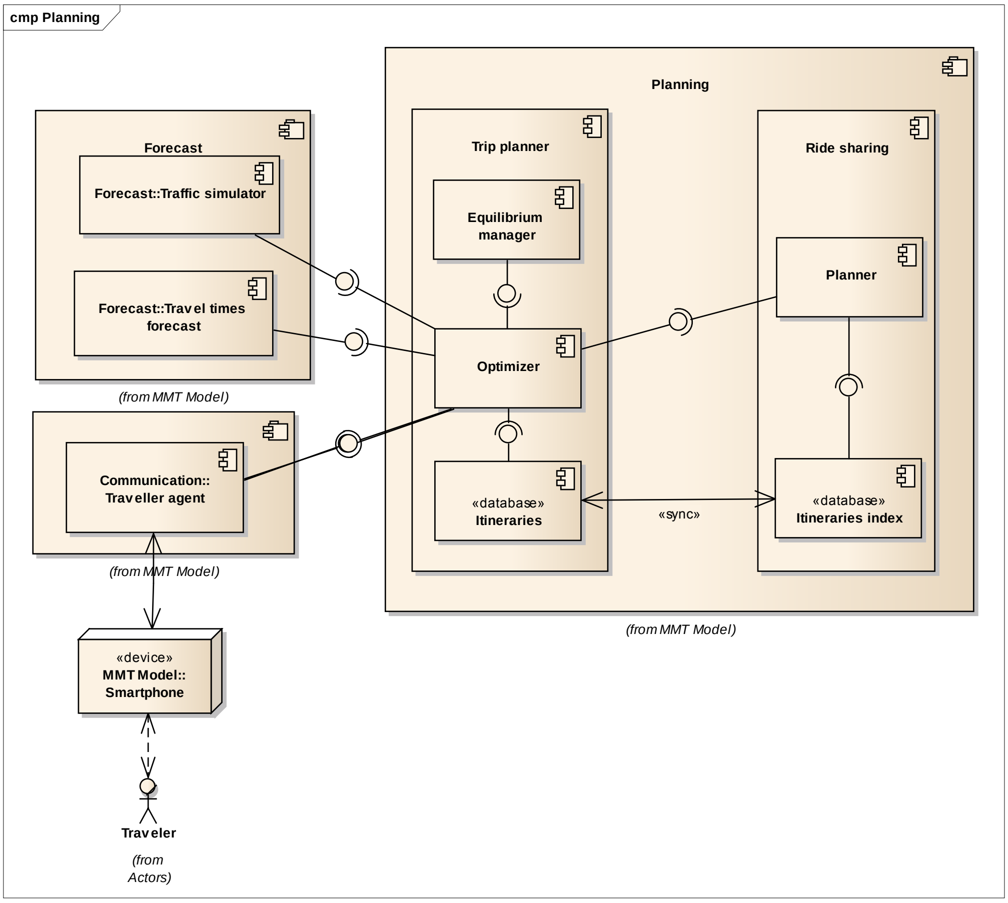

Figure 4 – The planning model

Experiments and results

The multimodal platform has two deliverables. The first is a demonstration with a visual tool allowing for the follow-up of ongoing individual trips. The second is the project prototype that will provide the final implementation of the project enablers, aligned with the FI-Ware project enablers.

The demonstration that we have set up assesses the impact of the platform use on the multimodal traffic quality, notably under unusual traffic conditions (breakdowns, accident, etc.). The continuous tracking of travellers and transport means provides better solutions and consider load balancing between concurrent itineraries. The demonstration also validates the effect of the platform on the actual use of ride-sharing service. By making it easier for travellers and car drivers to meet and share rides, we predict that users would have more incentives to use this service.

Figure 5 shows the demonstration configuration. The platform and the simulator run in a dedicated server. The platform interacts with the server that matches drivers' itineraries and passengers' requests. If a driver accepts to share his vehicle with a passenger, the server verifies the compliance of their preferences and proposes to both actors to share a ride.

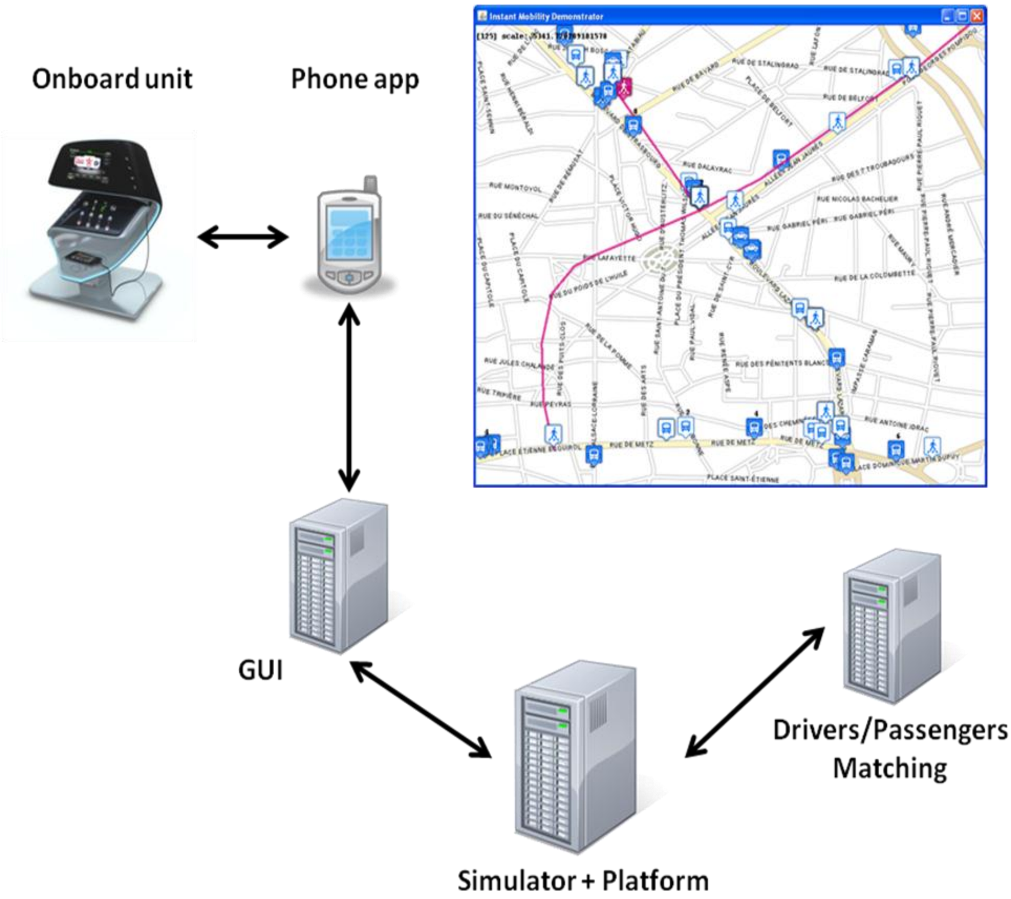

Figure 5 – The demonstration configuration

The GUI runs on a server and shows all the current passengers, drivers and private and public vehicles. When we click on a passenger, we get his itinerary and all the modes he is planning to use.

A mobile application[1] and an onboard unit[2] also interact with the GUI server[3]. When we click on a specific passenger, the mobile application connects to the server and gets his itinerary. If the passenger has a ride-sharing leg that is planned, the onboard unit application also connects to the server and gets the itinerary of the private vehicle. The profiles of the driver and the passengers are shown in each other's devices; both actors either can accept or decline. This scenario replays what happened between the driver and the passenger to plan their common ride. Finally, the passenger will be able to track the real-time position of the driver until they meet.

Implementation

[1] Developed by Telecom Italia

[2] Developed by Valeo

[3] Developed by Thales

We demonstrate the use of the platform for the city of Toulouse, for which we have detailed data, including urban travel demand models. We have considered the main roads of the transport network of Toulouse with 13,226 roads. We also have considered the public transport network of Toulouse, with 80 lines, 359 itineraries and 3,887 arcs. In our current simulations, our multi agent system is made of 118,270 agents: 28,720 buses, 30,000 cars, 30,000 drivers and 30,000 passengers.

The simulation of travellers (pedestrians, bikers, transit travellers, etc.), car drivers, cars, and transport means movements is fulfilled with the Repast multi-agent simulation platform (Tatara *et al*., 2009). This Java based platform is equipped with GIS tools that allows for a relevant representation of transportation applications.

The distribution of processing over several hosts is realised via the Terracotta middleware (Terracotta Inc., 2008), an API that performs distribution at the level of JVMs. The interaction between the simulator, the platform and the different services (GUI, mobile application, and onboard unit application) is realised through Restful Web Services (Richardson *et al*., 2007).

Perspectives

One important issue when developing the multimodal travel platform is to assess its ability to handle a very big number of travellers and transport means. Furthermore, it should keep a high responsiveness when dealing with big networks and big geographical regions. In the near future, we plan to develop scenarios with hundreds of thousands of passengers and drivers to verify that our implementation is actually scalable.

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