Multimodality for people and goods in urban areas

FP7 . CP 284906

WP4 – D4.2 Multimodal Journey optimization enablers specifications - iteration 1

December 2011

Project funded by the European Commission under the 7th European Framework Programme for RTD - ICT theme of the Cooperation Programme.

Instant Mobility WP4
D4.2 Multimodal Journey optimisation enablers specifications -iteration 1

WP4	D4.2 Multimodal Journey optimisation enablers specifications -iteration 1
Authors	Mahdi Zargayouna - IFSTTAR
Short Description	This document is a draft description of the multimodal travel platform. It describes the public interface of the platform and a description of the application in terms of modules and data.
Dissemination level (select)	PU
Date	31 December 2011
Status	Deliverable (final version 1.0)
Contributions by:	Cedric Andry (THALES) Patrick Constant (PERTIMM) Fabienne Gandon (PERTIMM) Mustapha Tendjaoui (IFSTTAR) Gérard Scemama (IFSTTAR) Marco Bottero (MIZAR) Cristina Peña (TID)
Internal review by	Michael Boc (CEA)
Internally accepted by	Patrick Gatellier (WP4 leader)
Date of acceptance	19 january 2012

Document history

Version	Date	Author /Reviewer	Description
1.0	18.11.2011	Mahdi Zargayouna	Initial document
2.0	12.12.2011	Mahdi Zargayouna	First enablers specification
3.0	23.12.2011	Mahdi Zargayouna	For internal review
4.0	19.01.2012	Mahdi Zargayouna	After internal review

Abstract

This document contains a description of the multimodal travel platform, which is addressing scenario 1. The platform offers services for transport operators and human travellers to provide and receive up-to-date information and to be guided in consequence. This document is divided in 4 sections. The first section is the introduction, setting the context of the deliverable. The second section describes the use cases functional decomposition (based on the work of WP3). Section 3 describes the public interface of the platform and its interaction with external services. It defines the environment in which the platform will be deployed and the requirements of these external actors to interact and take advantage of the platform. It is the outside view of the platform. Section 4 provides the enablers description. It is the inside view of the platform. It presents a description of the application in terms of systems and components.

Table of Content

Table of Figures

1. Introduction

1.1 WP4 objectives in Instant Mobility

The objective of the “Future Internet Enablers” work package is to derive from the use case scenarios analysis and the Future Internet technologies roadmap produced by WP3, the detailed technical specifications of the components necessary to implement these scenarios. These components can be the proposed Future Internet enablers (either generic or domain-specific) or services build on top of these enablers.

1.2 Objectives of Deliverable D4.2

The purpose of D4.2 “Multimodal journey optimization Enablers Iteration 1” is to identify and describe both the generic enablers and the domain specific enablers necessary to implement the “Multimodal travel made easy”-scenario described in D3.1.

D4.9 will review and update the set of requirements by month 15 (June 2012).

1.3 Impact on the other Work packages

This document will serve as input to the prototype implementation in WP5 and the second iteration of the WP2 “Program collaboration” deliverable, which provides input to the FI-WARE project.

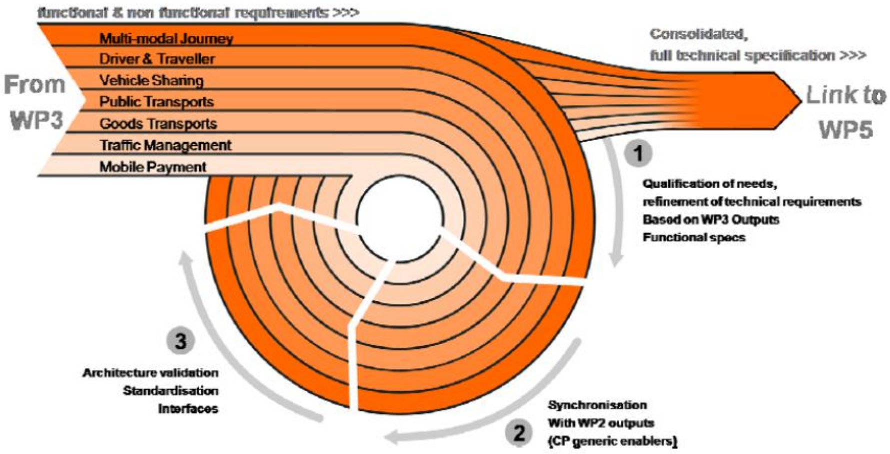

Figure 1: Iterative specifications of enablers in WP4

1.4 Context and assumptions

1.4.1 Scenario 1 summary

In this scenario, online services offer a traveler a wide range of travel and transport options, according to the user’s preferences, for all the stages of a trip that may use various modes including public transport, car, and trip sharing. The ideal scenario would be that, for a given journey, the traveler receives a list of integrated itineraries which are the optimal plans respecting his preferences, and based on up-to-date information from all relevant modes such as time table, frequency, conform level and cost etc. Corresponding tickets would be booked and delivered as an integrated ticket together with the chosen itinerary. During the journey, the traveler is supported by online service to get off at the right stops, walk through a complex terminal or interchanges, find the next mode, etc. During the journey, the itinerary is continuously monitored in real-time and is adjusted whenever conditions or options change.

1.4.2 Assumptions

1.4.2.1 Tracking

In the context of Instant Mobility (IM), we assume that every traveler and every transport means (public and private) are tracked continuously, outdoor and indoor. Now, we do not claim from the system to use these locations at the same cadency and adjust itineraries whenever location information is received. Indeed, the system is free to ask for specific locations when needed. The system can also introduce optimizations with regards to the positions sending from the mobile device to the cloud. In a nutshell, the mobile device and every transport means can send locations based on a specific algorithm.

1.4.2.2 Equipment rates

The ultimate objective of IM is to interact with all the travelers that use the transport network. This being said, the evaluation of the proposal should integrate a progressive equipment rate. For instance, a first experiment should consider that 10% of the travelers are equipped and connected to IM. Then progressively, the experiments consider 20, 50, 80 then 100% of equipped travelers. Since the system will be guiding the equipped travelers, the impact of its use, in terms of time, distance and emissions savings should remain positive for all these equipment rates.

1.4.2.3 Scalability

The system to be developed should be scalable. The increase in the number of travelers, the increase in the number of networks and the enlargement of the covered geographic zones should not have a too big impact on the performance of the system (the performance criteria are to be defined).

1.4.2.4 Instantaneous requests

Even if the system to be proposed should be able to work with trip reservations, the primary objective of IM is to handle instantaneous transport requests. All along this document, we will only refer to requests that are submitted to the system, and that are expecting a real-time answer.

1.4.2.5 Evaluation

The basic evaluation of the system should be a comparison between the current situation and the envisioned one with the use of IM. A specific system should then be designed and implemented, that simulates the current situation.

1.4.3 Issues

- It is difficult especially during a journey to find information and to be assisted on journey choices, on making connections, on real-time services; little is available on portable devices, or is poorly integrated
- Car users often are unaware of collective transport alternatives
- Separate ticketing: a multimodal trip is often involved with booking many tickets with different operators
- Users have bad experiences with finding the right stops to change, right directions in an interchange, etc.
- Users have bad experiences to find information on available transport modes and purchase tickets or make payment , particularly in an unfamiliar area

- Users have bad experiences with unforeseen problems, e.g. accidents, congestion, interrupted transport services.
- Guiding in parallel a high proportion of the travelers using the system could lead to a unbalanced distribution of the travelers on the networks and to congestion. Meaning that using the system would lead to a worse situation than without it. This is the reason why the system should address "equilibrium issues" specifically

1.4.4 Rationale: how Future Internet solution could address the above problems

Future internet would be able to provide the following solutions:

- Provide up-to-date information on transport modes, availability, tickets, operation situation etc., which will allow planning of the optimised itinerary;
- Connect all transport modes, vehicles and travellers all the time to assist a traveller through a multi-modal journey;
- Connect the traveller with various services to provide real-time information through the entire journey, inform traveller with any disruption and deliver alternative solution
- With help of location information to guide traveller to find stops/stations, and provide location based information;
- Provide ticketless mobile payment to enable integrated ticket via mobile handset and allow traveller to buy tickets en-route using mobile handset when disruption occurs.

1.5 Abbreviations

IM	Instant Mobility
CP	Core Platform
FI	Future Internet
PT	Public transport
RT	Road transport
MMT	Multimodal travel
SIRI	Service Interface for Real Time Information
OMA	Open Mobile Alliance
GDF	Graphic Data File
IFOPT	Identification of Fixed Objects in Public Transport

1.6 Glossary

Driver: a person owning and driving a car.

Passenger: a person using one or several means of transport to travel from one point to another, but doesn't drive a car during his trip.

Traveler: a driver or a passenger.

Pick-up point: an ID, geographical position, and an associated period of time (start time, end time). It represents, for a given travel, a point in space and time where a certain vehicle will pick-up passenger(s)/traveler(s). The associated period represents an estimate of the moment when the vehicle will be at the considered location.

Preferences: a list of attributes that represent what a given traveler prefers. They are set explicitly by the traveler.

Context: a list of attributes that represent the context of a given travel. These are preferences that are inferred from the user behavior (rating, acceptance of a trip, etc.)

Parameters : preferences and contextual elements

Itinerary : a bag of pick up associated with a list of parameters.

2. Use case decomposition

2.1 Dynamic multimodal journey

The dynamic multimodal journey use case addresses the default case of a traveler asking for a multimodal travel. The traveller/user first subscribes to the service, then sets up his preferences, before requesting for a journey. When he receives the information about his journey, he either accepts the offer or declines it. When executing his trip, he can make a transfer if his trip concerns several transport modes, he receives information about the events happening all along his trip and he finally can rate his journey. The user is charged with the amount of money necessary for his the eventually completed journey.

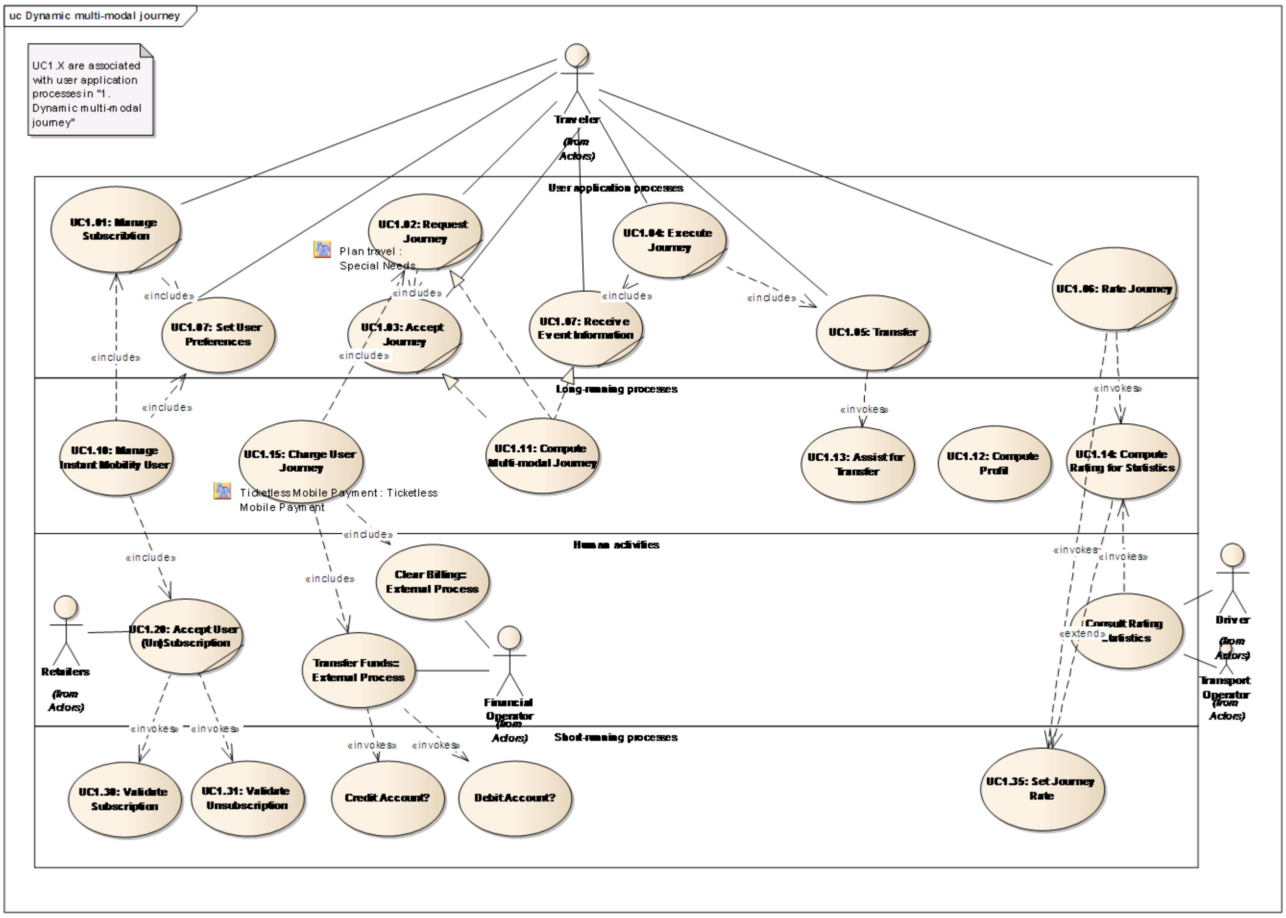

Figure 2 Dynamic multi-modal journey

The service operations related to this use case are defined in **Figure 3 Service Model**. The services are-: Manage user, Manage rating and manage account.

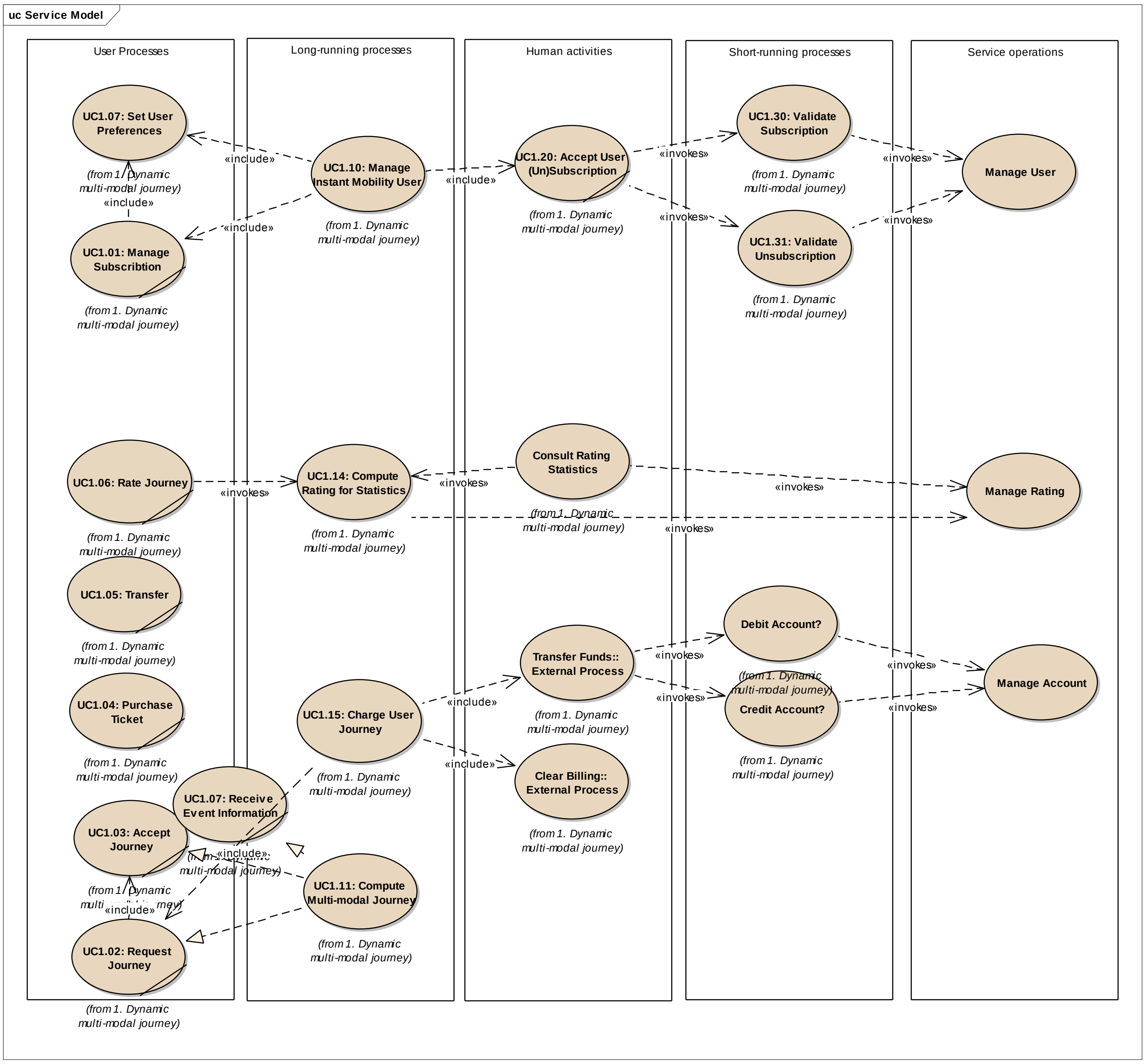

Figure 3 Service Model

The ticketless mobile payment use case details the processing that are relative to the payment of the trip.

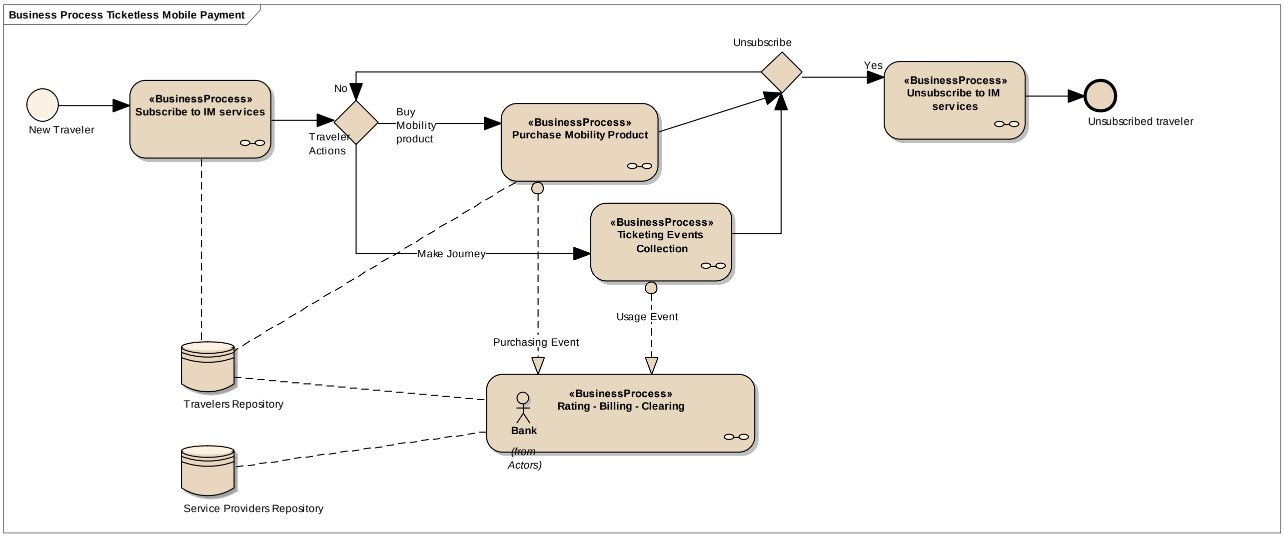

Figure 4 Ticketless mobile payment

2.2 Dynamic private & professional ride sharing

The dynamic time/place pick-up point - Organize a shared travel use case addresses the case where a traveller accepts to share his ride. This driver receives information about the time and location proposal for a traveller that desires to share his ride. He can accept the itinerary change and the traveller and may receive compensation.

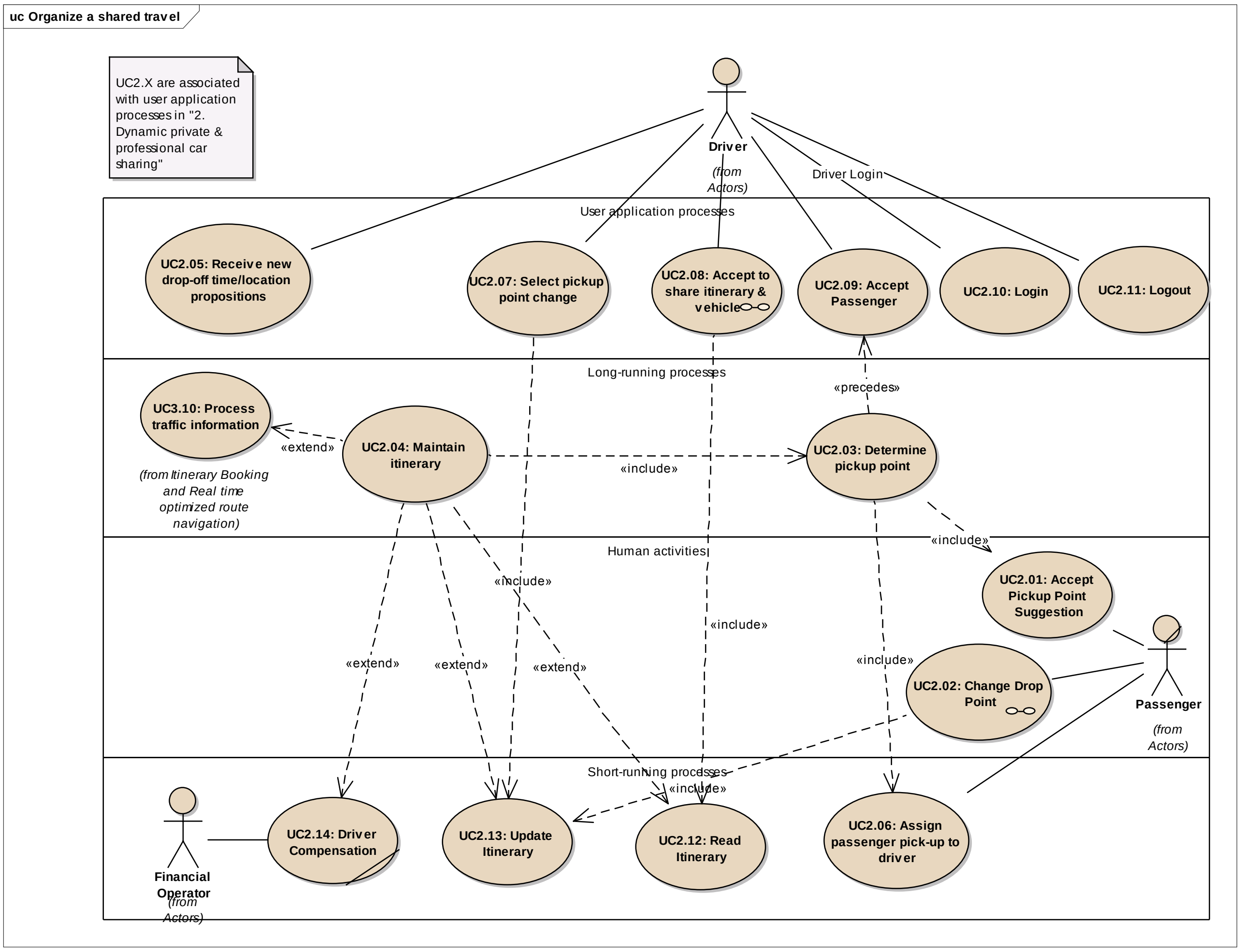

Figure 5 Dynamic time/place pick-up point - Organize a shared travel

The service model related to this use case is reported in **Figure 6 Service model.**

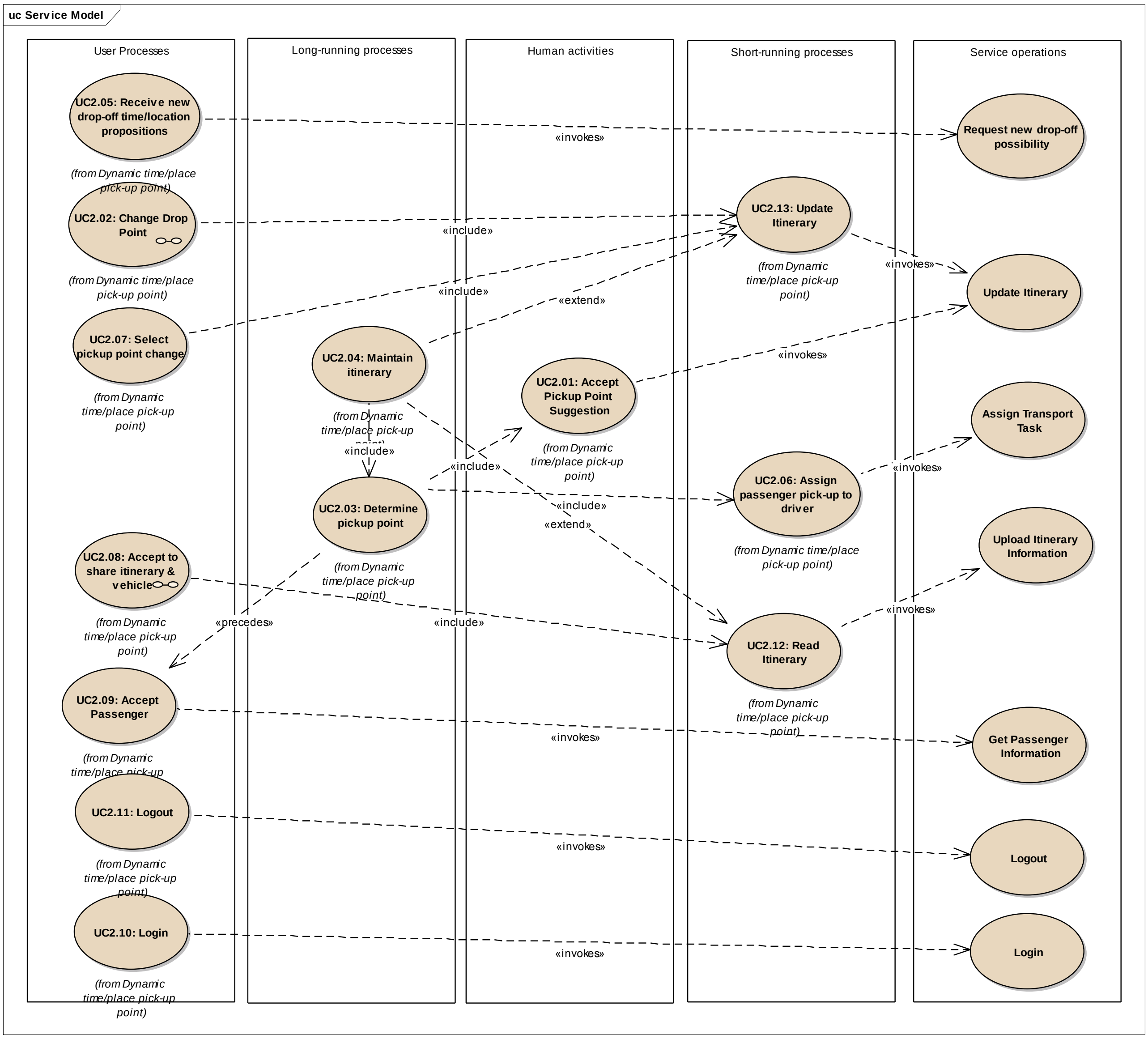

Figure 6 Service model

The use case related to the passenger point of view of this use case is reported in **Figure 7 Itinerary Booking and Real time optimized route navigation - Travel in sharing mode**, and the corresponding service model in **Figure 8 Service model.**

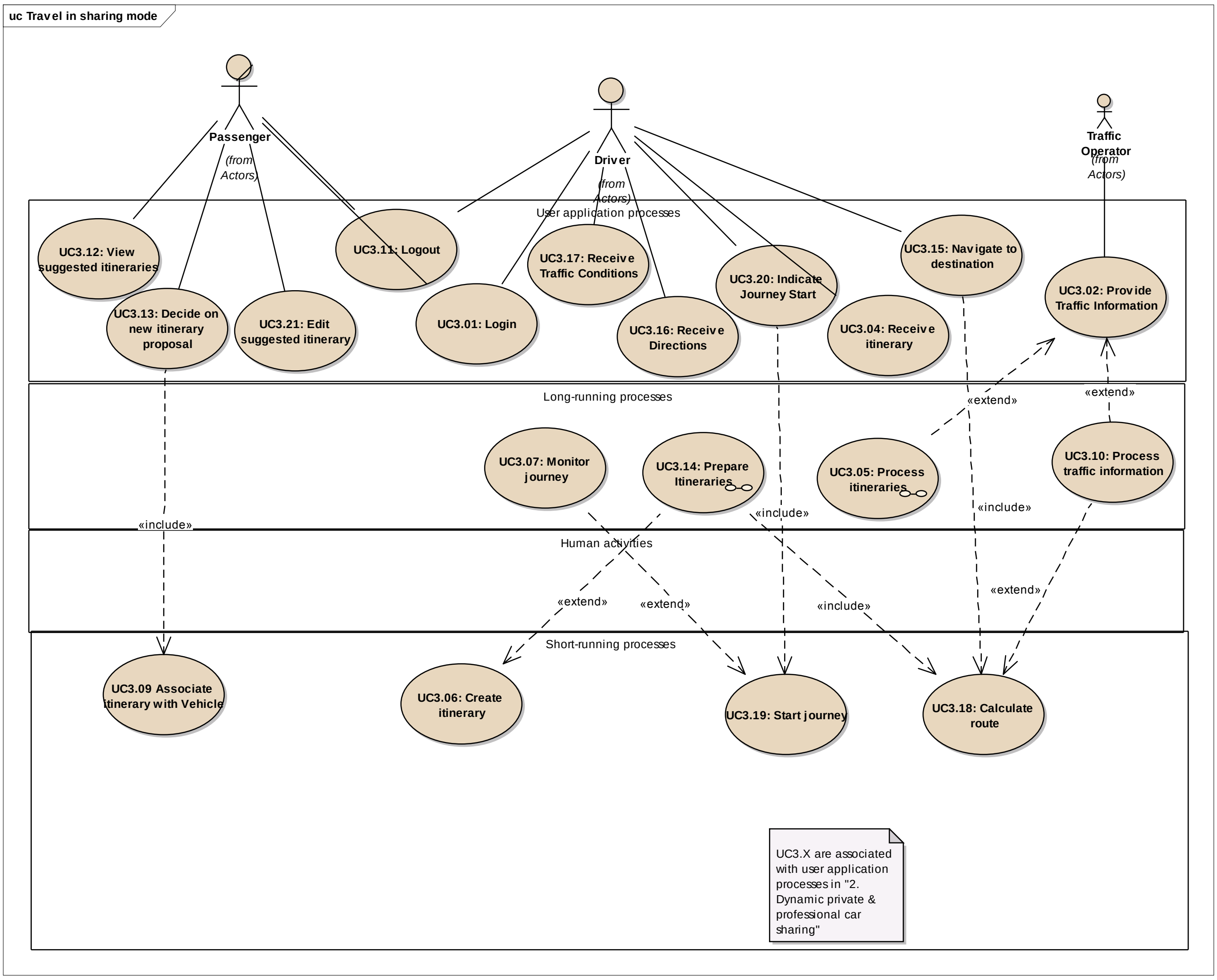

Figure 7 Itinerary Booking and Real time optimized route navigation - Travel in sharing mode

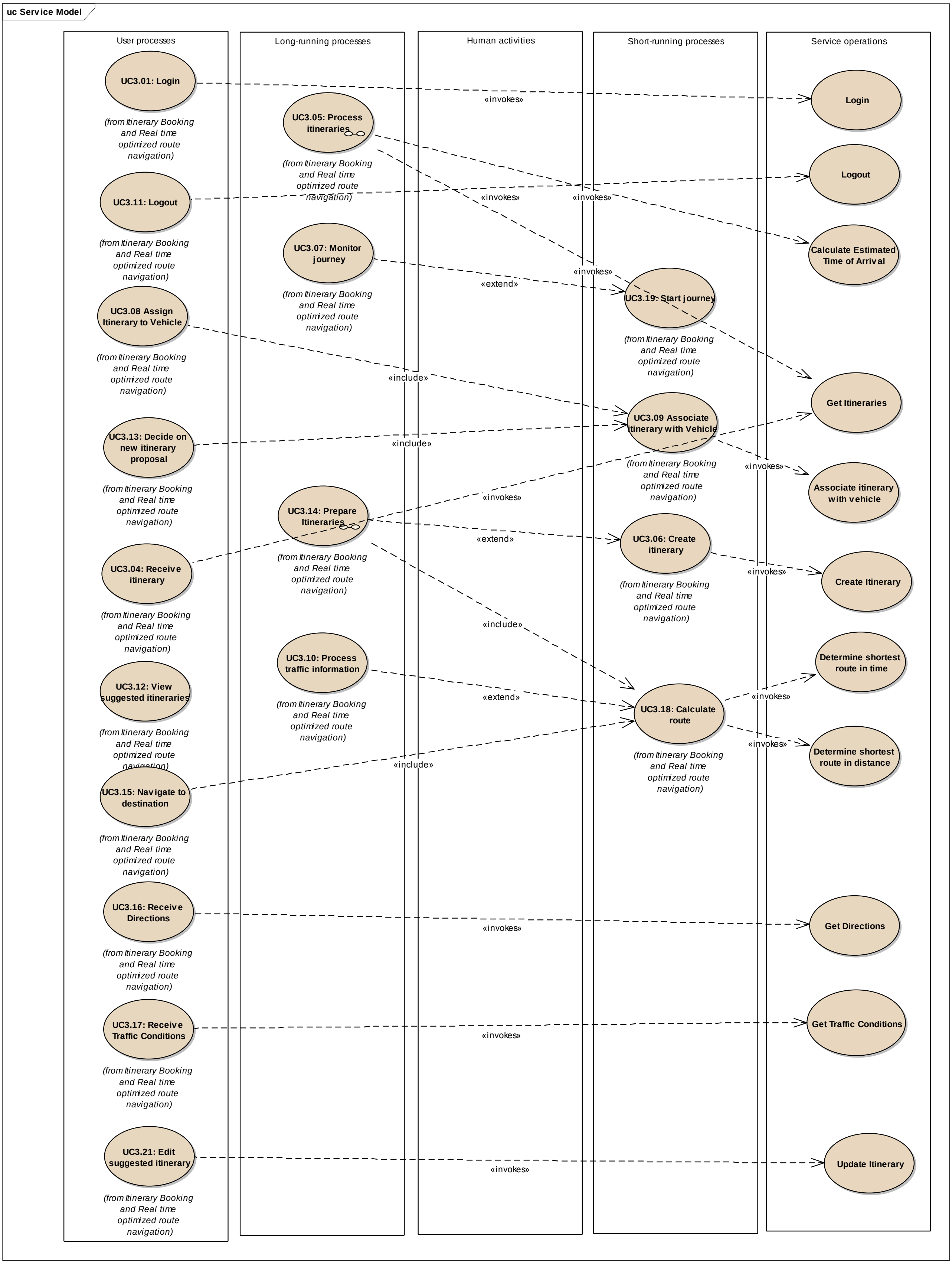

Figure 8 Service model

2.3 Optimized public transport usage

The optimized public transport usage use case (cf. **Figure 9 Optimized public transport usage**) addresses the optimization of public transport means including itineraries changes and ratings. The corresponding service model is reported in **Figure 10 Service Model**.

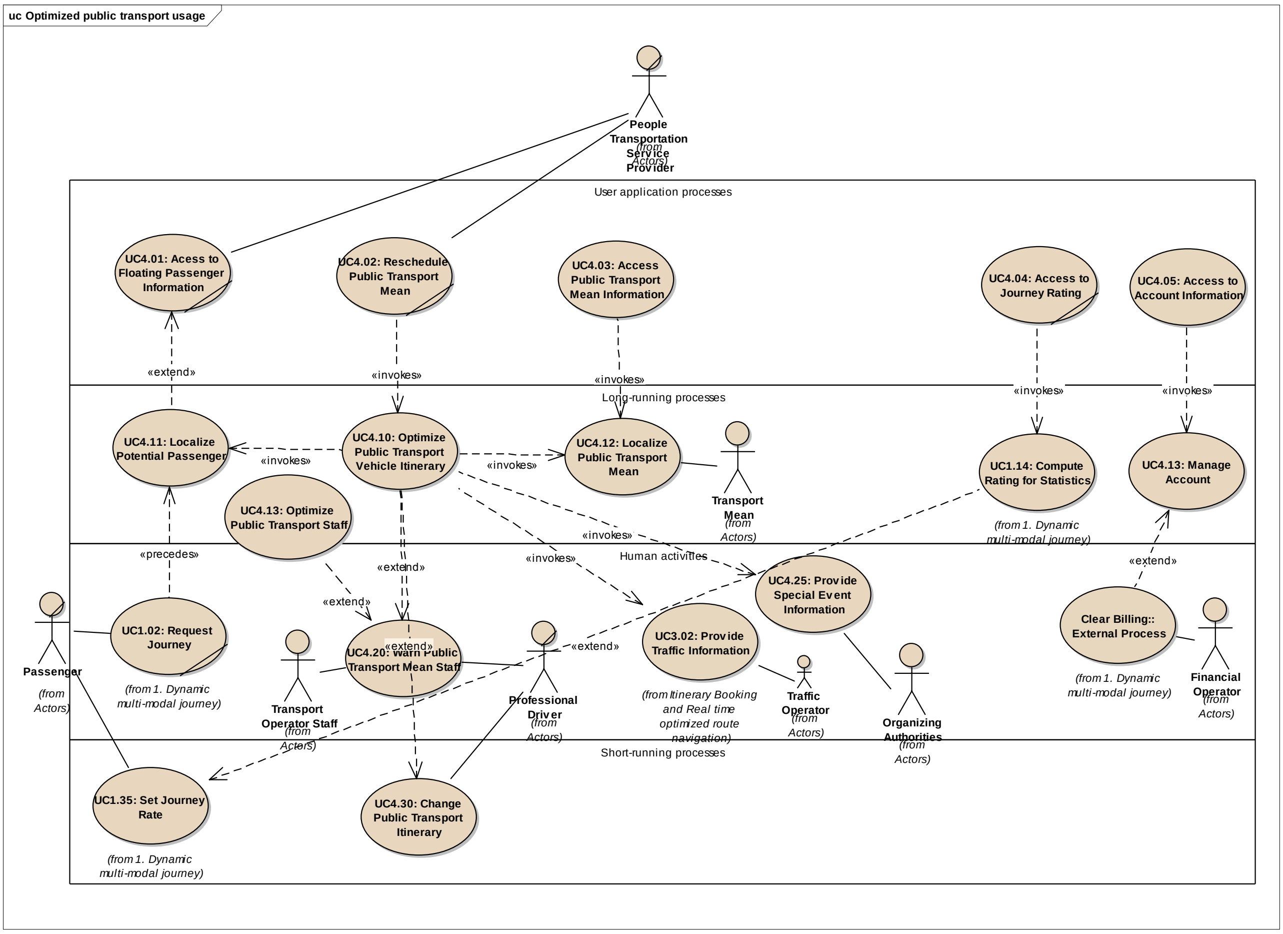

Figure 9 Optimized public transport usage

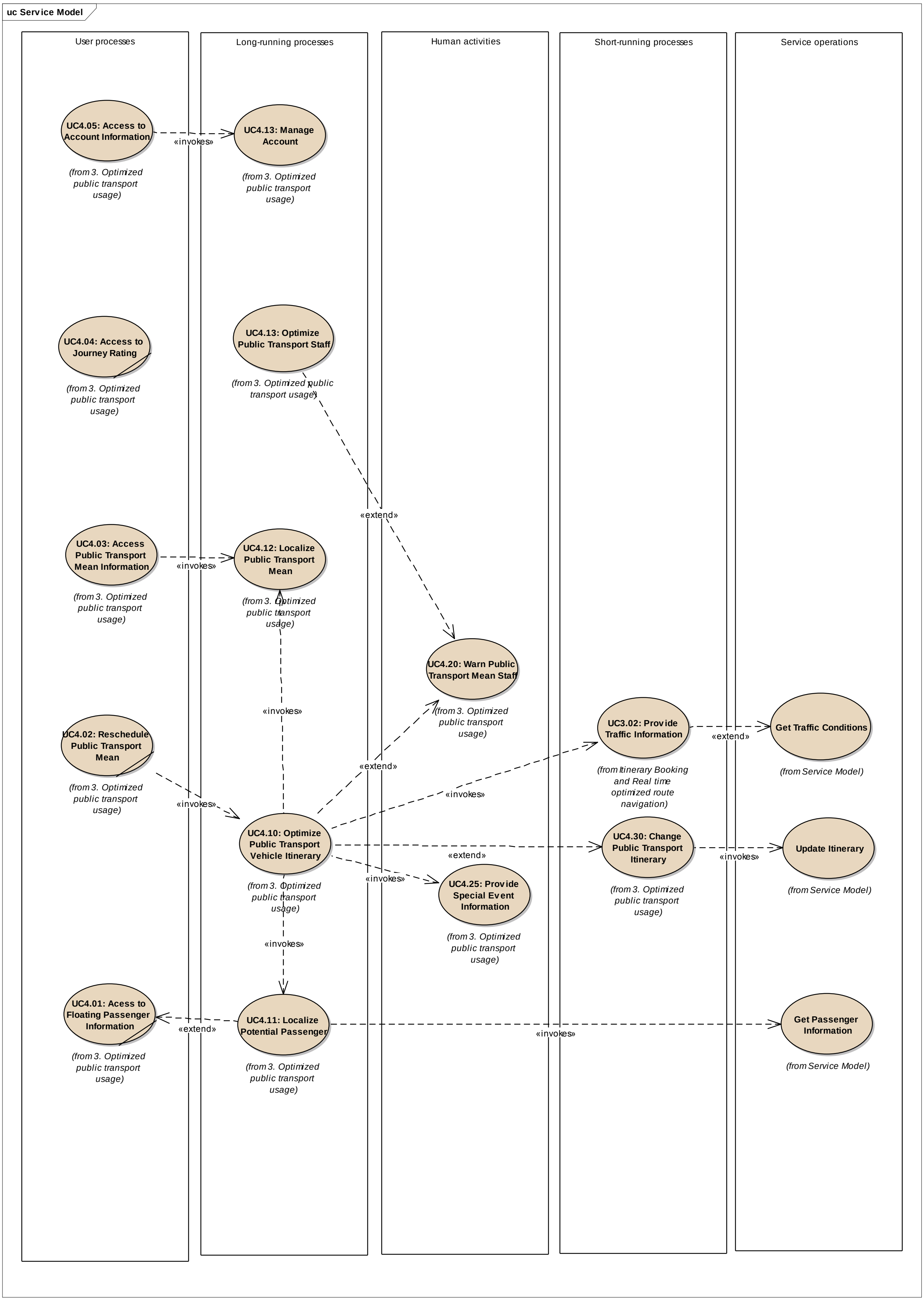

Figure 10 Service Model

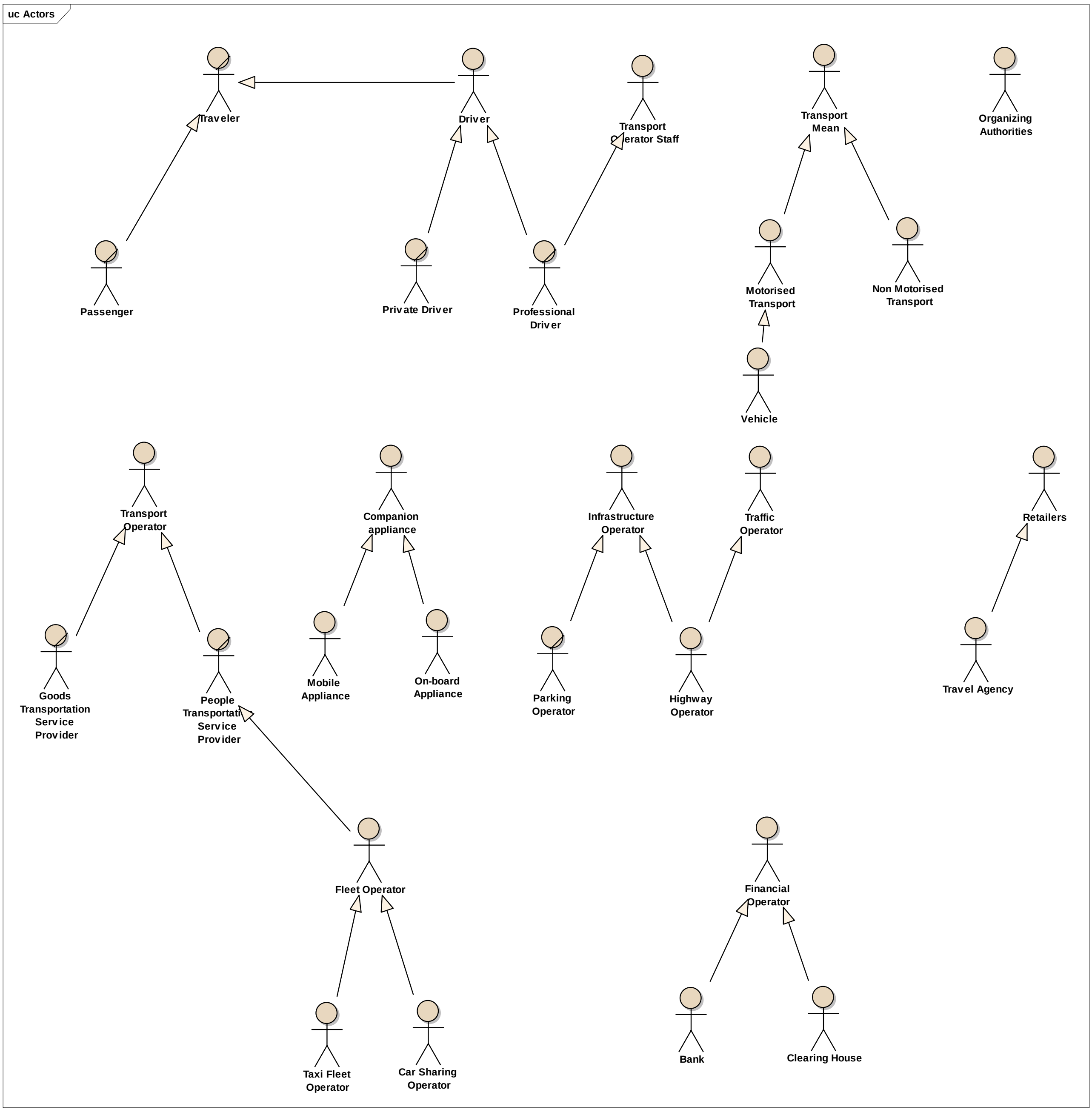

Figure 11 Actors

2.4 User experience flows

The following BPMN flows detail specific user processes, related to the update of his itinerary, the transfer and En-Route assistance, his travel execution, the itinerary setup and the consideration of his specific needs.

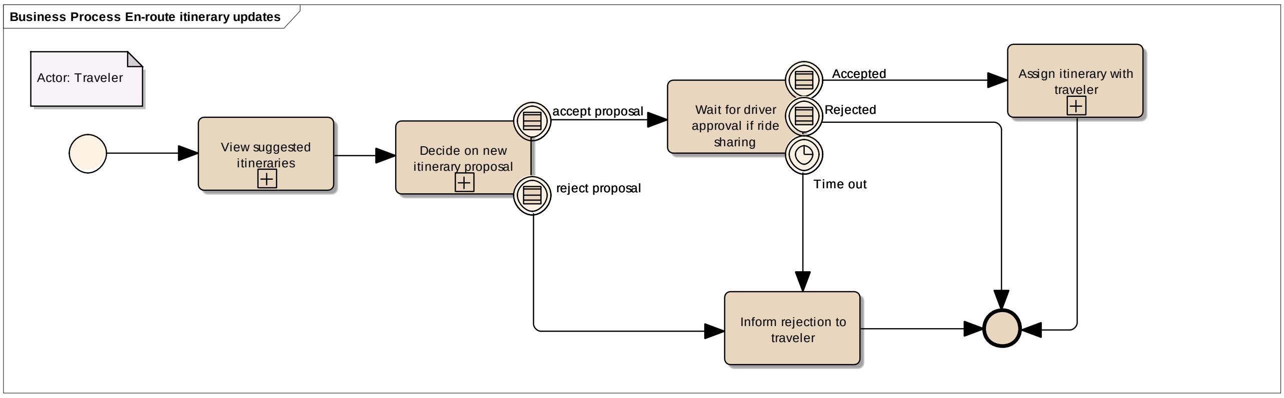

Figure 12 En-route itinerary updates

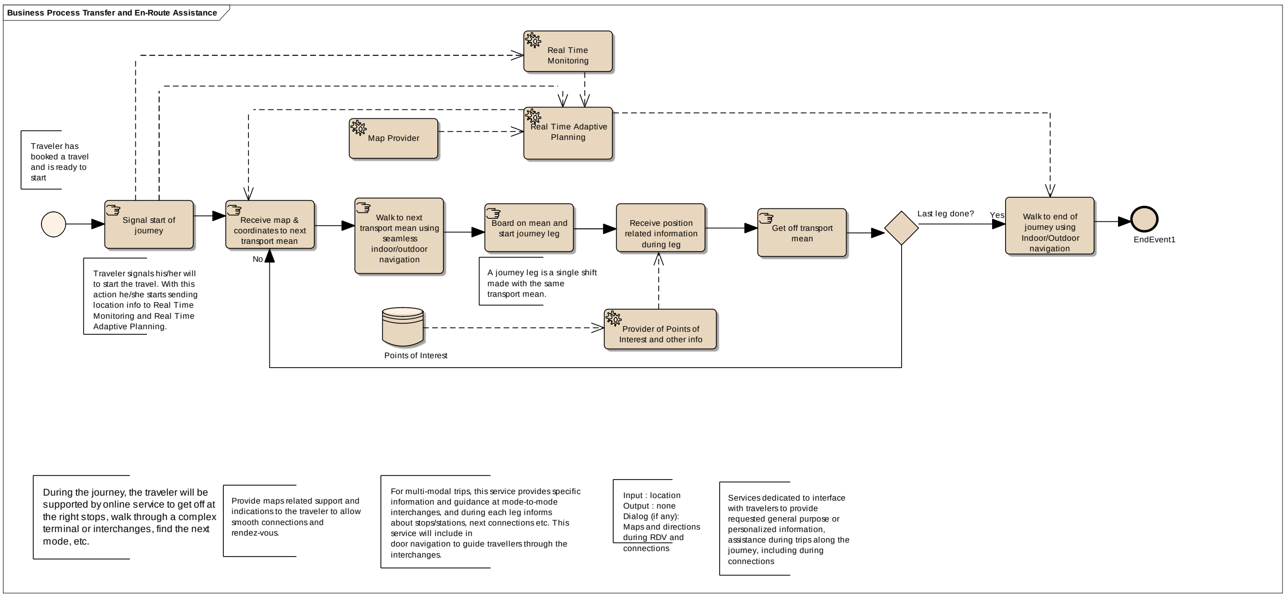

Figure 13 Transfer and En-Route Assistance

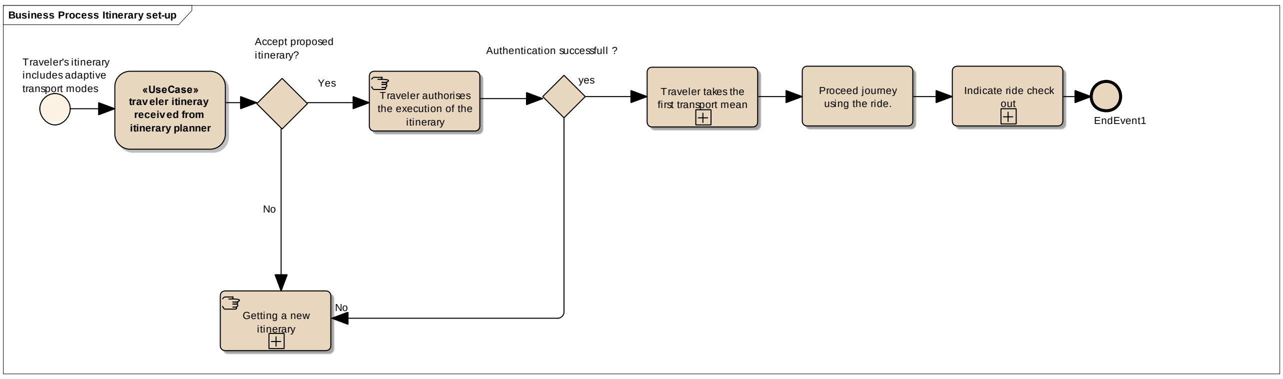

Figure 14 Itinerary setup

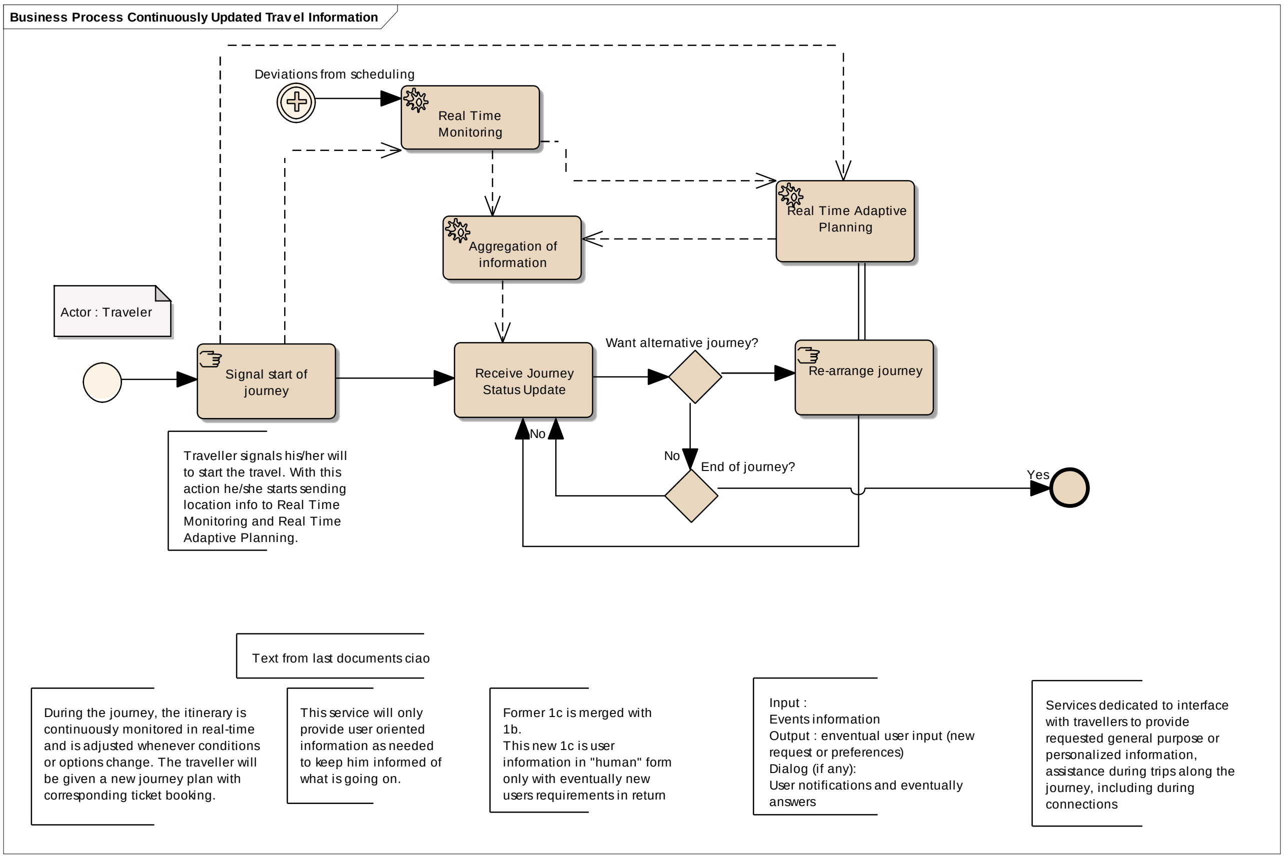

Figure 15 Execute travel

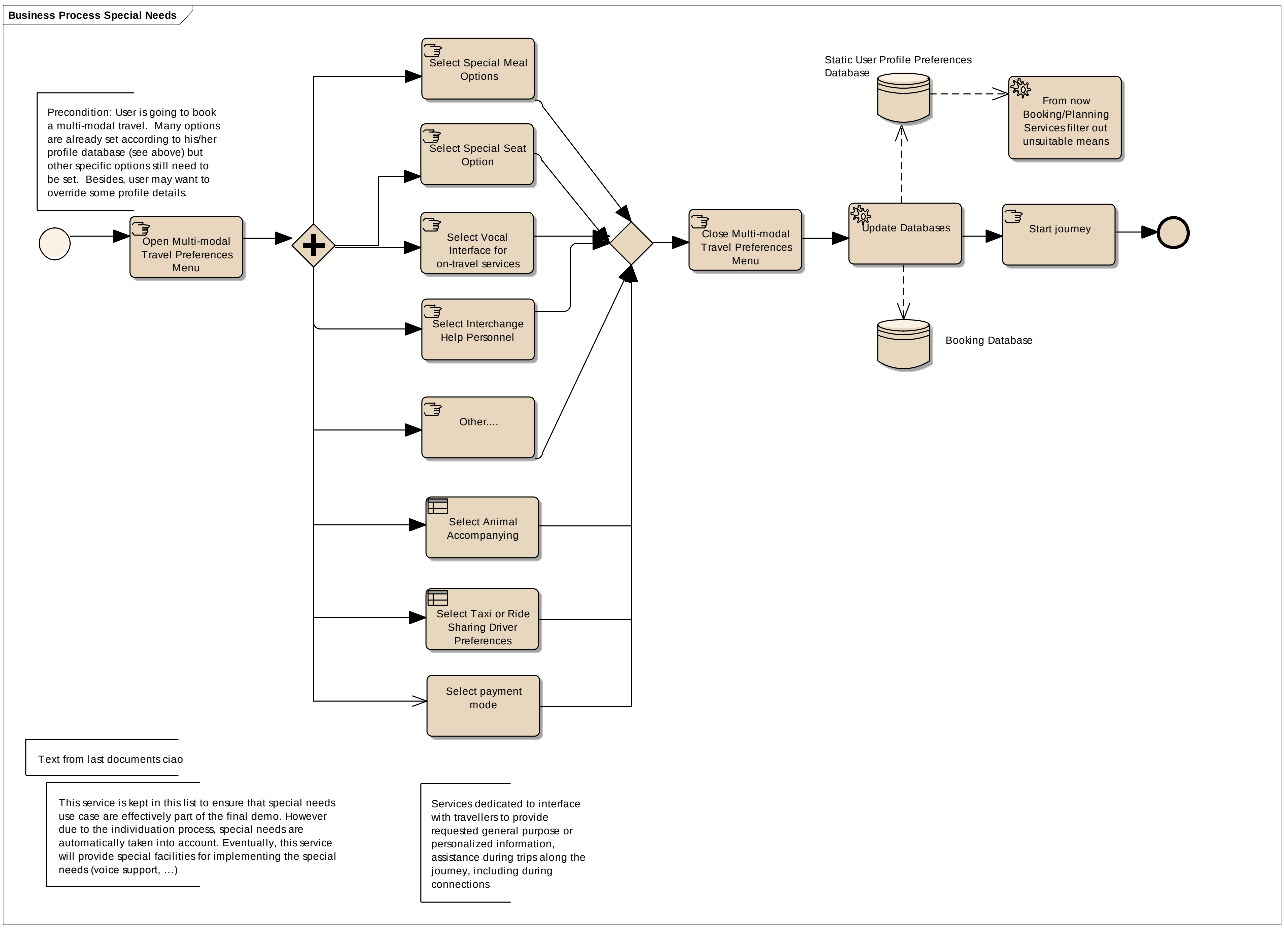

Figure 16 Special needs

3. Public interface and interaction with external services

The next figure presents a view of the multimodal travel platform from an external point of view. The purpose of this figure is to specify the requirements for a specific region to set a "multimodal travel made easy" service and the different exchanges that should take place with the platform.

The multimodal travel (MMT) platform is located in the center of the figure. It interacts with three types of actors: the public transport operators, the road transport operators and the travelers. For each actor, we define the language with which it can interact with the platform. When the exchanged information is very dynamic, we place a clock on the left side of the concerned exchanged element. When the format of the element is standard or based on a standard, it is colored in red. More details follow about each actor and the exchanged information.

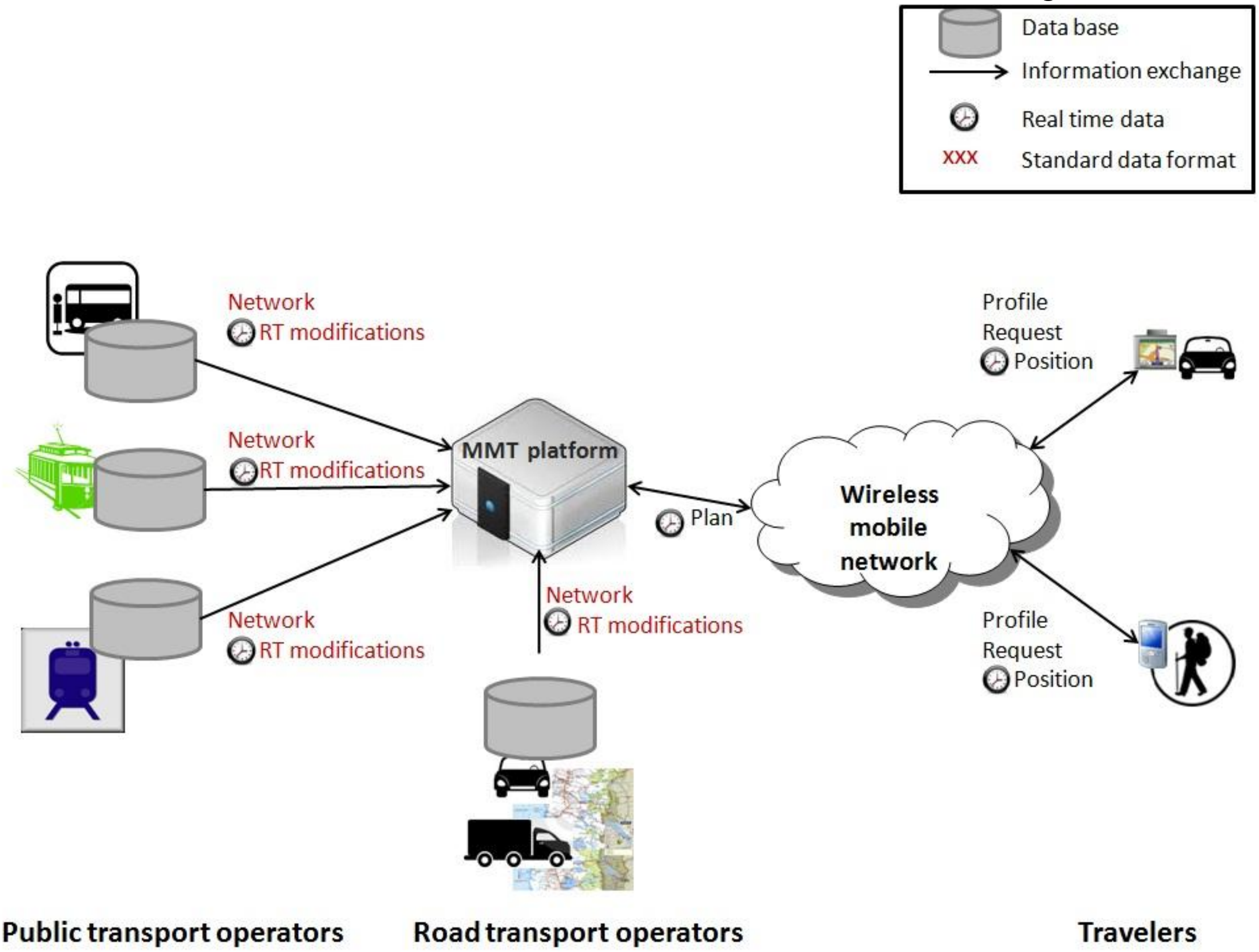

Figure 17 Multimodal Travel public interface

3.1 Public transport operators Main structure of the webpage

Each public transport operator has to provide the MMT 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 his own database, and the platform should 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

For each of these data types, there might exist a standard exchange format or not. Here follows the most important among them.

Standard	Description
TRANSMODEL[1].(Reference Data Model For Public Transport, EN12896)	The European Reference Data Model for Public Transport Information. It provides an abstract model of common public transport concepts and structures that can be used to build many different kinds of public transport information system, including for timetabling, fares, operational management, real time data, etc.
NeTEx2	A prCEN/ Technical Standard currently in development. The goal of NeTEX is to provide an efficient European wide standard for exchanging Public Transport schedules and related data. NeTEX is intended to be a general purpose format capable of exchanging timetables for Rail, Bus, Coach, and Ferry, Air or any other mode of public transport. It includes full support for rail services and can be used to exchange UIC (International Union Of Railways) data. NeTEx is based on TRANSMODEL which specifies a Conceptual model for Public Transport data, extended with additional concepts for stops and stations from the CEN Technical standard IFOPT (Identification of Fixed Objects in Public Transport).
IFOPT	A prCEN/ Technical Standard in development. IFOPT defines a model and identification principles for the main fixed objects related to public access to Public Transport (e.g. stop points, stop areas, stations, connection links, entrances, etc.).
SIRI (Service Interface for Real Time Information)	When the operators wish to update the timetables that they have provided to the platform, they use standardized SIRI[3] messages. SIRI is an XML protocol to allow distributed computers to exchange real-time information about public transport services and vehicles. The protocol is a CEN standard, developed with initial participation by France, Germany (Verband Deutscher Verkehrsunternehmen), Scandinavia, and the UK (UK Real Time Interest Group). SIRI is based on TRANSMODEL. It allows the exchange of structured real-time information about schedules, vehicles, and connections. It is also possible to use SIRI to provide general information about the operation of the services.

We make the choice to base our external interface on both TRANSMODEL and SIRI because they are the most mature European standards. There is however still a need to define a more precise format both for TRANSMODEL representations and SIRI exchanges. Indeed, TRANSMODEL is a generic and very rich model that can fit virtually any type of public transport use case. But it still needs to be optimized for the type of service that is planned. Also, it is always necessary to

[1] The TRANSMODEL specification can be found in http://www.transmodel.org/
[2] http://www.kizoom.com/standards/netex/overview.htm
[3] The SIRI specification can be found in http://www.siri.org.uk

define an "exchange profile" or local agreement for SIRI messages when developing a specific service. The SIRI technical specification has to be defined more precisely to be concretely applied: certain classes might prove useless, others might need to be specified and their attributes qualified (id, type, unit, time calculation, methods and protocols taking place, etc.) In future versions, we will have to choose a local agreement based on SIRI (for instance, we can think of the STIF local agreement) and a sub-model of TRANSMODEL that are optimized for the specific context of Instant Mobility.

3.2 Road transport operators

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

These data are described using the European standard GDF[4] (Geographic data file). GDF is an interchange format for geographic data, used to describe and transfer road networks and road-related data. It provides rules on how to capture the data as well as how the features, attributes and relations are defined.

Again, together with theses quasi-static information, road operators have to provide dynamic information about traffic related data (traffic status, disturbances, dynamic speed limits, weather conditions, etc.). To this end, the operators should use the European standard Datex II[5] to interact with the MMT platform.

DATEX II is a multi-part Standard, maintained by CEN Technical Committee 278, CEN/TC278, (Road Transport and Traffic Telematics). The first three Parts of the CEN DATEX II series (CEN 16157) have already been approved as Technical Specifications. These three Parts deal with the most mature and widely used parts of DATEX II: the modeling methodology (called Context and framework) as Part 1, Location referencing as Part 2 and the most widely used DATEX publication for traffic information messages (called Situation publication) as Part 3. A fourth Part of CEN DATEX II series, VMS publications, is currently being prepared for standardization to CEN/TC278 and a fifth part on measured and elaborated data is currently proposed as work item. More parts are to follow as new content requirements emerge.

Besides, all exchanged information has to respect the “Inspire” European directive[6], which objective is “to ensure that the spatial data infrastructures of the Member States are compatible and usable in a Community and transboundary context. The directive requires that common Implementing Rules (IR) are adopted in a number of specific areas (Metadata, Data Specifications, Network Services, Data and Service Sharing and Monitoring and Reporting). These IRs are adopted as Commission Decisions or Regulations, and are binding in their entirety.”

3.3 Travelers

[4] The specification of GDF can be found in http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=30763

[5] The specification of DATEX II can be found in http://datex2.eu

[6] http://inspire.jrc.ec.europa.eu/

The travelers interact with the platform using standard communication protocols from the Open Mobile Alliance (OMA[7]). Each traveler provides the system with his profile, which includes detailed information regarding his properties and preferences. There is obviously no standard format for the definition of a traveler's profile, and this definition has to be done in collaboration with WP3 partners.

Information that has to be defined in a travelers profile will deal with (non-exhaustive list):

- position, a pick-up station / timestamp
- destination, a pick-up station
- constraints : baby, children, several persons, luggage, animal, handicap
- the preferred transport modes: pure ride sharing route, mix public transportation and ride sharing, no underground, route criteria: minimum time, minimum number of changes, experienced driver, driver already known by the user and validated by the user.
- affinities : grey list, spoken language, M/F, age, musical preferences, hobbies, rating …
- the itinerary choice criteria,
- the budget,
- the possession of a car or not,
- the acceptance of ride sharing or not,
- the accepted delay before to ask for a new plan,
- his specific needs,
- his interest in POI,
- his account information for billing,
- For the driver, availability
- real time positioning of the vehicle,
- current destination and route,
- contextual data such as: not lacking of fuel(!), no alert on the car
- vehicle data: type of vehicle number of available seats, baby seat availability, luggage space,
- driver data: spoken language, M/F, rate from the website,
- the driver expressed preferences : animal accepted/not
- Some data can be captured from sensors within the vehicle (video, audio, technical alerts, …)
- Contextual preferences (e.g. meteo: if it rains, then I prefer the mode X, etc.)

Once a plan is received from the platform, the mobile device of the user will dynamically send 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

[7] For Open mobile Alliance protocols, please visit http://www.openmobilealliance.org/

to the traveler) is big enough, following the traveler's preferences, the traveler should receive a new plan taking into account his new context.

The mobile devices of the travellers have to provide their position to the system. For this purpose, Mobile Location Protocol (MLP) protocol is used. This is an application-level protocol for receiving the position of Mobile Stations (mobile phones, wireless devices, etc.) independent of underlying network technology. The MLP serves as the interface between a Location Server and a location-based application. Basic MLP Services are based on location services defined by 3GPP.

4. Enabler overall description

In this section, we zoom in the MMT platform and define a first version of the different modules envisioned to propose the multimodal travel made easy service. Figure 18 Multimodal Travel platform modules depicts a high-level representation of the multimodal travel platform from a functional point of view. It is made of a set of modules that are designed as independent and loosely coupled components. A more detailed specification of each module follows.

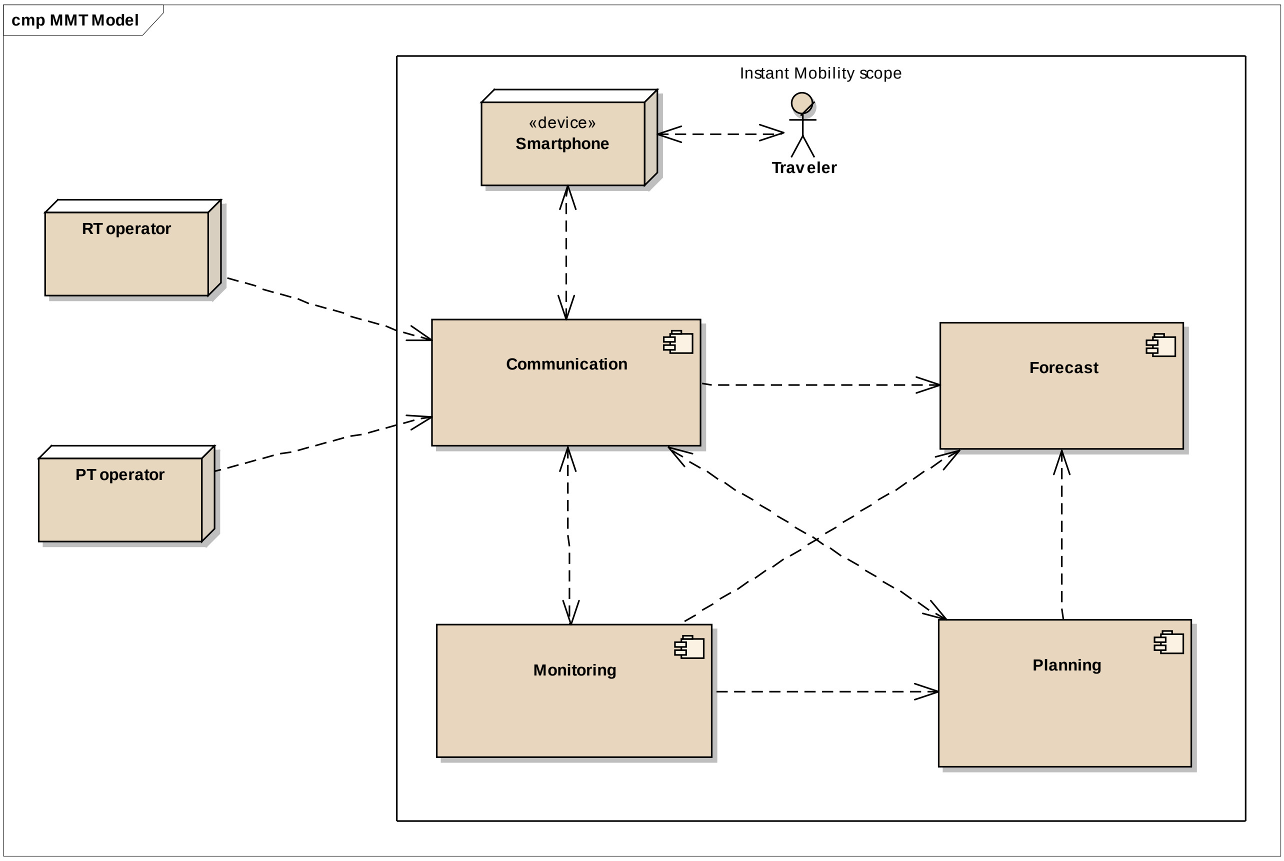

Figure 18 Multimodal Travel platform modules

The figure is divided in four packages. In the left side, we have the communication package, responsible of the interaction with the outside world. On the top, we have two packages: planning, which is responsible of the planning and re-planning of the travelers' itineraries, and forecast which is responsible of maintaining a correct vision of the future status of the networks. On the bottom, we place the monitoring package, composed of the modules monitoring the execution of the travelers plan as time passes.

4.1 Communication package

The communication package is responsible of the interaction of MMT with the external world as described in the previous section. Each of these modules feed data stores in the system: the travelers' data store and the multimodal network.

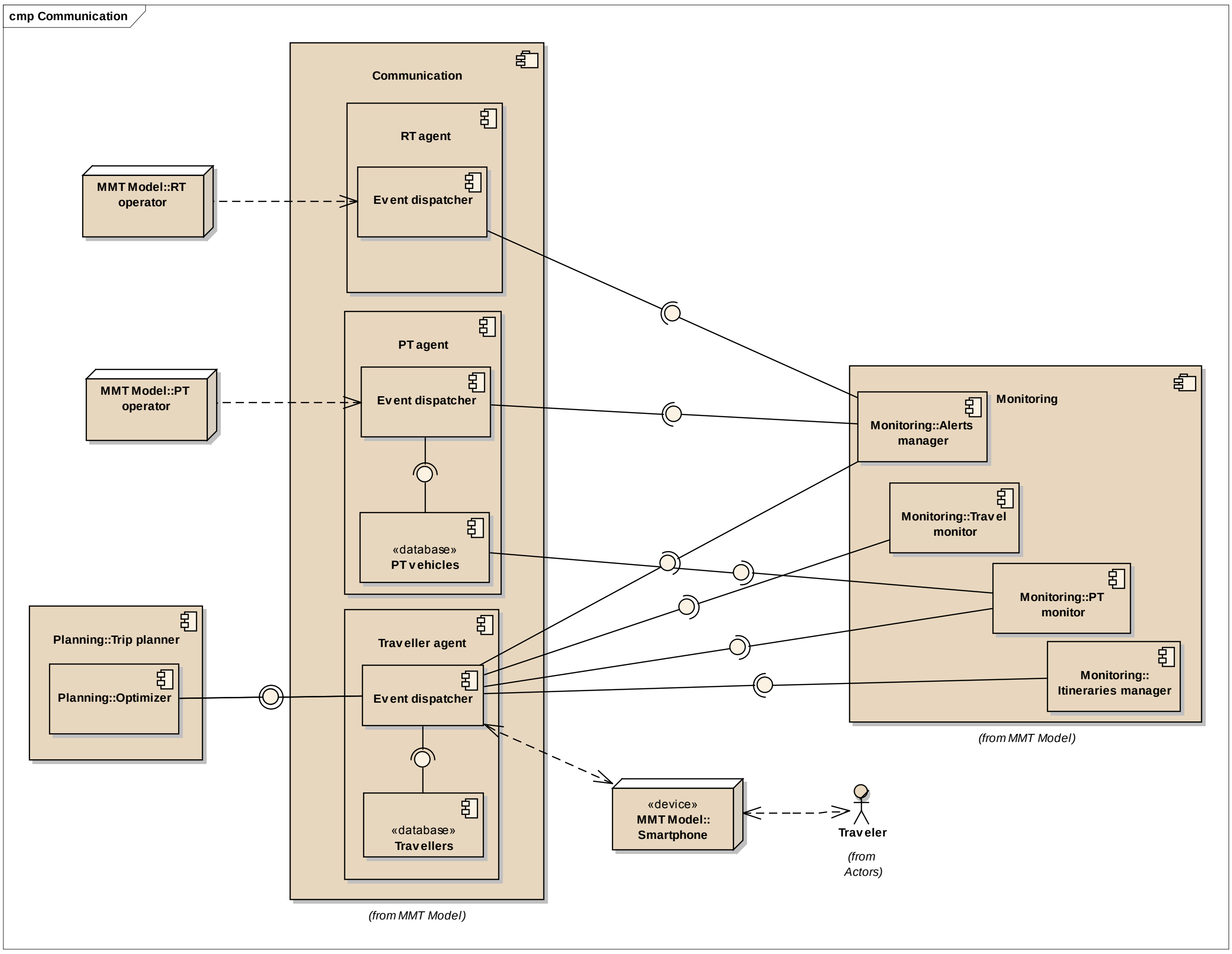

Figure 19 Communication package

4.1.1 PT agent

Input: public transport operators' theoretical data (network, timetables) and real time data (timetables modifications, vehicles positions, alerts).

Output: notifications to the monitoring and the planning packages, PT vehicles store update.

The PT agent module is responsible of the interaction with public transport operators. It is composed of an event dispatcher that dispatches the received information to the concerned module and updates the "PT vehicles" data store.

Indeed, the current public transport (PT) vehicles are placed in a data store, together with their dynamic characteristics: their current capacity, their current position (in the multimodal network), etc. The public transport vehicles include the ride sharing vehicles, which are the private vehicles, which owners accept to share. The presence of a public transport vehicle is related to a vehicle's "mission". That is, we do not considerate all the operating procedures that are related to drivers and their assignments to vehicles. A PT vehicle in the data store is a vehicle with an origin, a destination and an itinerary. If the same vehicle is assigned to another mission, a new occurrence is created in the data store.

4.1.2 RT agent

Input: road transport operators' theoretical data (network, roads characteristics) and real time data (speeds, densities, concentrations, alerts).

Output: notifications to the monitoring and the forecast packages.

The RT agent module is responsible of the interaction with road transport operators. It is composed of an event dispatcher that dispatches the received information to the concerned module: the alerts are sent to the traffic simulator (cf. 4.3.2) and to the monitoring for the alerts and forecast for the simulation.

4.1.3 Traveler agent

Input: travelers' data (request, profile, positions).

Output: alerts (message to the Alerts Manager module), plans and alerts (to the traveler).

The traveler agent module is responsible of conveying the information received from the travelers (profile, request, positions and alerts) and the information that have to be sent to them (alerts and new plans). When receiving an alert concerning a traveler's plan, this module decides whether to request a new plan for the traveler or not, following the preferences of the user. This module manages a Travelers store, which contains all the information related to the travelers. The profiles of the travelers (preferences, request, etc.), their current plans (itinerary) and their current positions are placed in this data store. The latter is fed with the information from the travelers and updated by the planner and monitoring modules with respect to the current decisions that are taken.

4.2 Planning package

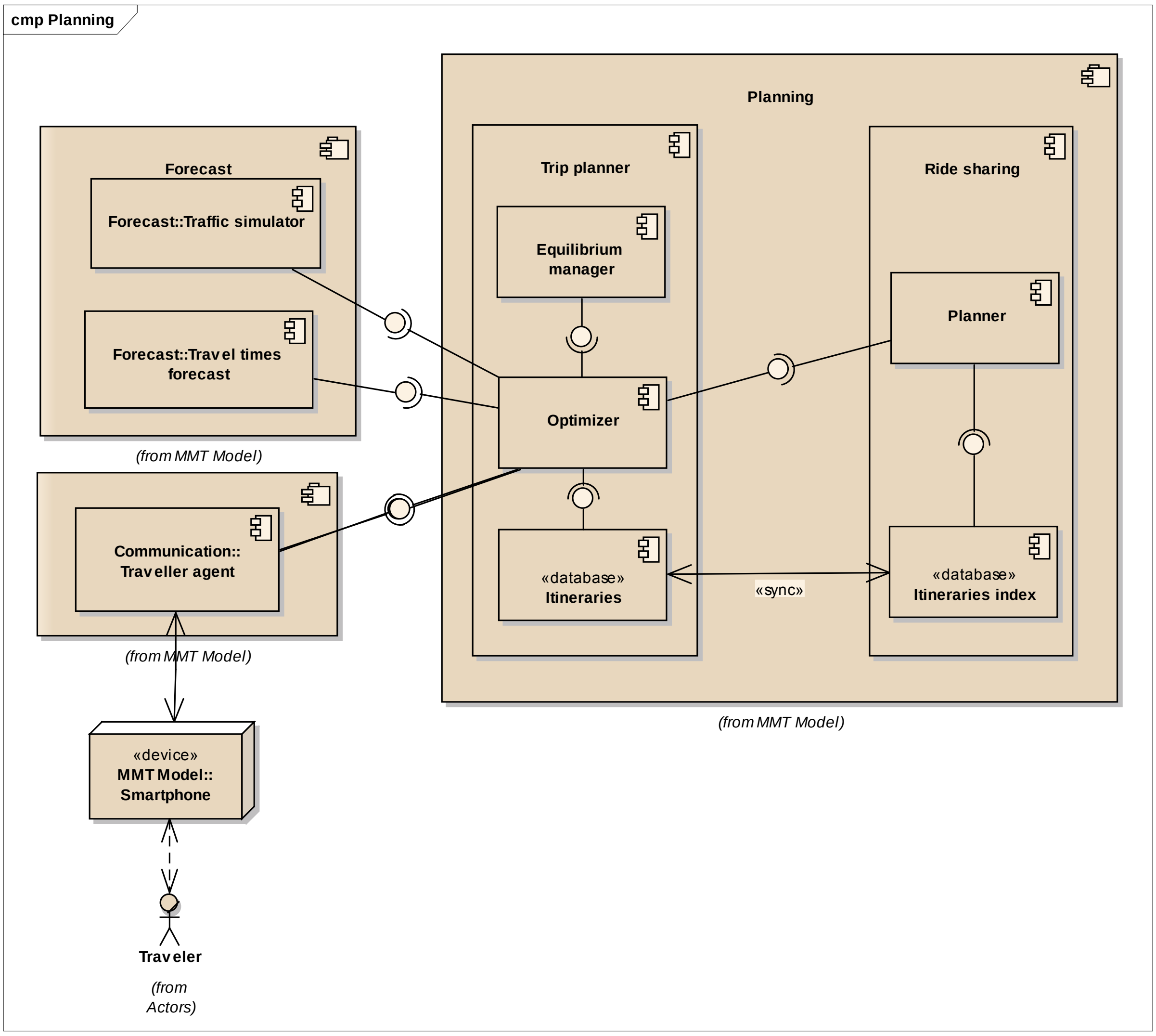

Figure 20 Planning package

4.2.1 Trip planner

Input: travelers' requests, multimodal traffic forecast.

Output: itineraries data store update, travelers' requests (message to the Ride sharing module).

This module is composed of two sub-modules: the optimization sub-module and the equilibrium manager sub-module.

4.2.1.1 Optimization

The planner module receives the travelers' transport requests from the travelers' data store. If the request concerns a driver, it creates a sub-view of the network that fits with its travelers' profile and preferences (only roads wide enough for a truck, no tunnels, no bridges, no highways, etc.). Then, the planner creates a set of "best itineraries" based on the driver's preferences and the output of the traffic simulator. Indeed, the planner will try to propose itineraries that are the most realistic possible, taking into account future -unknown- travelers. The best itinerary will be proposed to the traveler, and if accepted, the itinerary will be added to the itineraries data store. If the traveler is interested in sharing his car, this will be specified in the itineraries data store. The car of this driver will be considered as a PT vehicle. The matching between passengers' requests and PT vehicles (including ride sharing cars) will be fulfilled by the Ride sharing module.

The itineraries are maintained in a data store. They are of two types. The first type concerns the planned itineraries, the ones that are computed by the planner module. They are used by the traffic simulator module to infer their effect on the network status. The second type of itineraries concerns the completed itineraries. They are used to feed the historical map data for future computations.

4.2.1.2 Equilibrium manager

The equilibrium manager is responsible for the maintenance of an equilibrated guidance of the travelers. Indeed, the planner module is expected to be parallelized, since a sequential processing of request would generate a bottleneck.

In this context, a delay could occur between the decisions of the planner modules about the currently processed requests and the impact of these decisions on the space-time network (via the traffic simulator module). The equilibrium manager module will supervise the parallel execution of the planner modules and influence them to avoid sending travelers on the same network arcs and creating congestions.

4.2.2 Ride sharing

Input: passengers' requests.
Output: passengers' itineraries.

The ride sharing module is responsible of finding a multimodal itinerary for the travelers. It maintains an index for the ongoing itineraries. This index contains a list of tuples *<coordinates, vehicle ID, time window>*

- Coordinates might be an ID referring to a directory of pick-up stations;
- The vehicle which will be present at this pick-up station;
- The time window defining when the vehicle will reach the pick-up station.

The time windows associated with the pick-up points are the estimation of the time at which the concerned vehicle will be at that pick-up point. These times are continuously updated with the very last estimations. This is the reason why this data store is synchronized with the itineraries data store on the trip planner module. The latter are in turn updated by the simulator module, based on the predicted future status of the networks.

To summarize the mutual work between the planner module and the ride sharing module, consider the following scenario. Let a driver that desires to travel from point A to point B, and that accepts to share his ride. His itinerary is calculated by the trip planning module and his itinerary will be added to both the itineraries data store and the itineraries' index data store. Now, when a passenger asks for a plan, the trip planner module simply transfers the request to the ride sharing module which will reason about the itineraries index and the travelers' profile to find the best multimodal itinerary and sends it back. Later on, this itinerary will be continuously updated following the traffic status and the simulator module predictions.

4.3 Forecast package

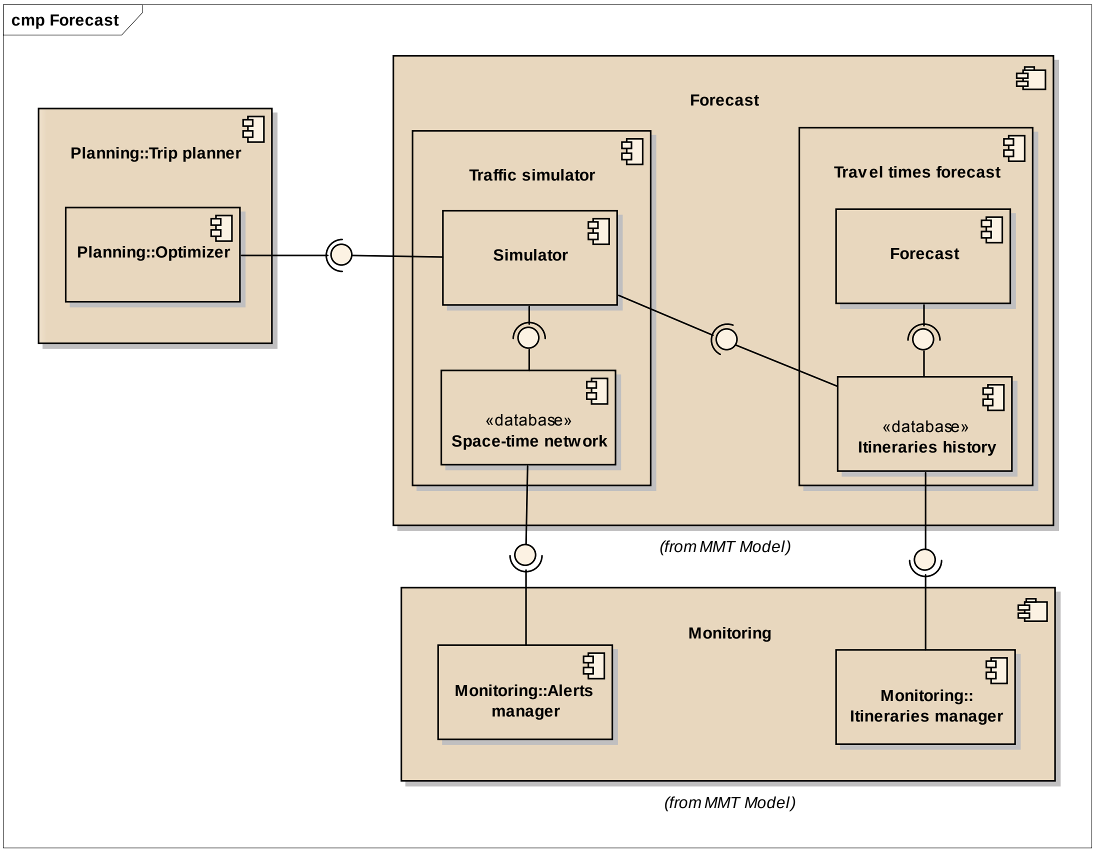

Figure 21 Forecast package

4.3.1 Travel times forecast

Input: Alerts, itineraries history.
Output: space-time network update.

Even if we assume that every single traveler and every transport mean is tracked by our system, these information are not enough to provide a realistic guidance to the travelers. Indeed, future transport requests might completely change the status of the network and make current planning decisions wrong. This is why the travel times forecast module is defined. This module bases its predictions on the history of itineraries, which in turn are fed by the itineraries that are taken by the travelers. This way, the planner module would base its calculation, not on the current known travels only, but also on expected future travelers. The Itineraries history are fed by the itineraries data store and associate with every arc of the multimodal network and with every time period, the number of travelers using the infrastructure and their effect on the traffic status. These data are of great importance in the planning and monitoring phase, to provide plans that are the most realistic possible.

4.3.2 Traffic simulator

Input: itineraries, space-time network, travel times prediction
Output: space-time network update
The traffic simulator is a central piece of the platform. It reasons about the current status of the space-time network, and merges the information from the current itineraries and the travel times forecast module to infer the future state of the network. It listens also to the alerts, which are inserted in the space-time network by the alerts manager module. The latter feeds the space-time network with the expected consequences and the duration of disturbances and accidents.

The result of the continuous calculation of this module is a space-time network that best reflects the expected network status in the near future.

The space-time network is a representation of the network with a projection on the future. Indeed, the multimodal network provides a vision of the current situation of all the travelers and all the transport means, but it provides no information on the dynamics of the system and its future state. However, this kind of projection is very important since the planning and monitoring decisions concern the future state of the network, not the current situation.

4.4 Monitoring package

4.4.1 Alerts manager

Input: alerts (messages from PT agent, RT agent and Traveler agent modules).
Output: space-time network update.

The alerts manager interacts with the travelers and with the PT and RT agents and listens to the notifications of disturbances and accidents occurring in the networks. It interprets the alert, computes the expected consequences on the network and informs the traffic simulator and the itineraries manager about these effects.

4.4.2 Itineraries manager

Input: space-time network, itineraries.
Output: alerts (message to the traveler agent module).

The itineraries manager is responsible of the correctness of the currently executing itineraries with respect to the real status of the networks. To this end, it maintains a continuous awareness about the space-time network status (future status, provided current information and travel times forecast). Once there is a change in the space-time network, it calculates the impacts on the current itineraries and changes their expected arrival times. That is, even if the current position of the traveler matches his plan, this module would alert the traveler about future expected gap between them.

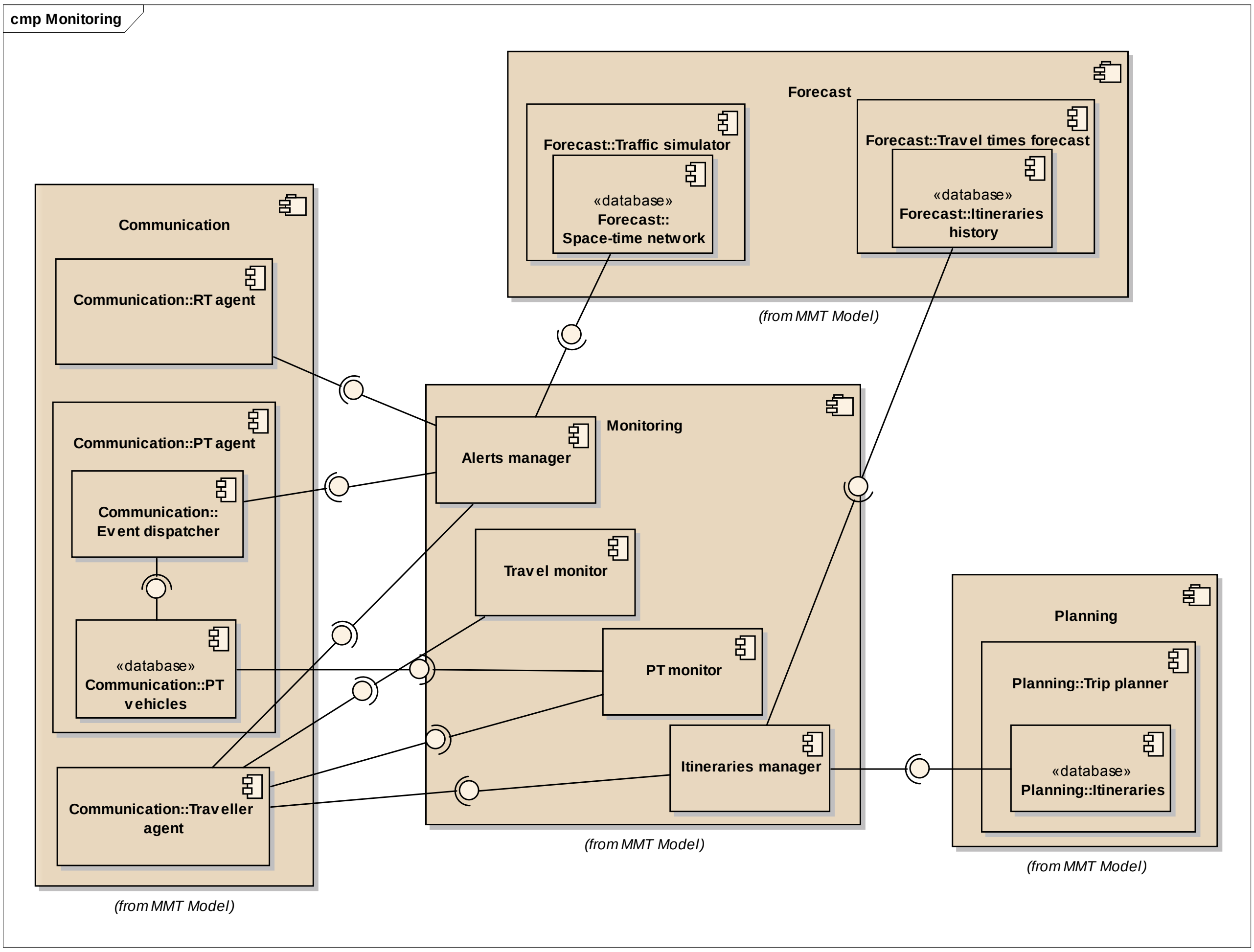

Figure 22 Monitoring package

4.4.3 Travel monitor

Input: travellers, Positioning data (GPS/EGNOS/GALILEO), Speed/odometer, Direction, Status: travelling/stop/rest/...

In the road sector, the DATEX standard was developed for information exchange between traffic management centres (see subsection 3.2), traffic information centres and service providers and constitutes the reference for applications that have been developed in the last 10 years. The second generation DATEX II specification now also pushes the door wide open for all actors in the traffic and travel information sector.

Output**:** alerts (message to the traveller agent module), First level alert, Second level alert (may lead to new plan request)

Remark: we could possibly consider other alerts, related to real-time info about traffic events in the surrounding of the traveller (e.g. incidents, road works, congestion).

The travel monitor module is responsible of monitoring the trip of the travellers. It maintains continuously a listener on the itineraries and on the travelers' current positions and preferences. If the current position of the traveler deviates from the planned position more that what is tolerated in the traveler's profile, the travel monitor alerts the concerned traveler, via his representative: the traveler agent module. The latter would request a new plan from the planner module.

Non-functional requirements: as regards performance, the communication network is the key for the deployment of this module. The need to continuously monitor and update the information on the traveler (position, direction, speed) requires a robust communication network. Attention should by paid also to privacy issues, setting up a strong encrypting protocol.

4.4.4 PT monitor

Input: travelers, PT vehicles.
Output: alerts (message to the traveler agent module).

The public transport monitor is responsible of continuously checking that the PT vehicles are moving following their plan. If they don't, it is responsible of alerting the concerned travelers that their itinerary is impacted by a delay or incident in the vehicles they are taking or are supposed to take in the near future, following their plan.

5. Conclusion

This document has provided a high level description of the enablers identified from the scenarios belonging to the multimodal journey optimization enabler set. The next step after this deliverable will be harmonization between the enabler sets described in D4.2 to D4.8 to ensure consistency and completeness, followed by development of detailed specifications of all enablers.