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D2.2 Use case analysis and priority application scenarios

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Summary
The purpose of this deliverable is to provide a comprehensive overview of the use case definitions within the frame of the MOVESMART project, as well as the priority application scenarios, which shall be used for project demonstration and evaluation purposes. Given that use case analysis is a critical task for software engineering projects, the present document aims to facilitate the system developers by describing in detail, both in tabular format and by using Unified Modeling Language (UML) diagrams, all the use cases that adhere to the user requirements and can be realised by the foreseen MOVESMART applications and services. The use cases are categorised into three distinct groups according to the innovative features/services of the project, namely "Renewable Mobility on Demand Feature", "Incentivised Vehicle Sharing Feature" and "Integrated Personal Mobility Service". Each use case is assigned a specific priority level based on the significance of the user requirements involved as well as the importance of the envisaged innovative system applications and services, as an intermediate step towards the selection of those use cases that shall be deployed at the two pilots of MOVESMART in the form of priority application scenarios.

Contents

1 Introduction

The aim of deliverable D2.2 is to precisely describe all the use cases that adhere to the user requirements and can be realised by the foreseen MOVESMART applications and services, and select a sufficient range of innovative application scenarios, among the defined use cases, through which the results of the project can be demonstrated and evaluated during the pilots. The present document comprises the outcome of task T2.2 and builds upon the user requirements reported in the deliverable D2.1, following a structured software engineering methodology based on well-established best practices. The work undertaken in this task is a very critical step for the successful culmination of the project, given that the definition of use cases and the selection of priority application scenarios provide input to the task that details the technical specifications of the MOVESMART subsystems and modules (i.e. T2.3), as well as the task related to pilots planning and preparation (i.e. T6.2).

1.1 Description of WP2

The key objective of work package WP2 is to provide the system architecture and technical specifications of the overall MOVESMART renewable mobility platform. The focus of WP2 is to identify the end users (target groups) of the MOVESMART end product and services and define appropriate use cases for each one of them. At the same time, the definition of MOVESMART functional and non-functional user requirements is conducted within the frame of WP2. Based on the functional requirements, the overall design of the MOVESMART system architecture is examined and the technical specifications are provided for the description of the various modules and system components.

More specifically, WP2 first gathers, prioritises, and analyses the end users of the MOVESMART project. Based on the hands-on-experience of the consortium members from previous and ongoing relevant R&D projects, an integrated user requirement analysis is performed to collect the user requirements for the project. This work package also exploits the outcome of user-requirement analysis for proceeding in the specification of the MOVESMART representative use cases and pilot scenarios. Use cases are defined in terms of the general context of use, the participating actors, inputs (triggers), preconditions, outputs (effects), etc. Thus, the primary goals of this work package are:

- To identify the end users (target user group) for the MOVESMART project.
- To define use cases for each of the proposed mobile web services.
- To follow a formal user requirement analysis procedure in order to capture the user-related parameters and constraints and, hence determine the UI functionality and expected output of the envisaged services.
- To derive the detailed specifications of the MOVESMART system architecture.
- To specify the user-perspective technical requirements, as well as the measurable functional and non-functional criteria that will need to be satisfied by the envisaged schemes.
- To define the MOVESMART architecture and determine the positioning of the architecture entities.

1.2 Scope of this deliverable

The present deliverable, D2.2, is the output of the task T2.2 and describes the second phase of the work carried out within the frame of WP2 with the purpose to define the use cases of MOVESMART and extract the priority application scenarios that shall be deployed during the pilots of the project. The precise definition of the use cases is based on the user requirements document (deliverable D2.1), following a structured software engineering methodology according to well-established best practices. The use cases are described using a customised template in tabular format, developed specifically for the needs of MOVESMART, along with the corresponding Unified Modeling Language (UML) use case diagrams.

For the sake of clarity and coherence, the use cases are divided into three distinct groups on the basis of the innovative features/services of the project, as follows:

- Use cases for "Renewable Mobility on Demand Feature"
- Use cases for "Incentivised Vehicle Sharing Feature"
- Use cases for "Integrated Personal Mobility Service"

The flow of work in the task T2.2 followed an iterative approach for the further refinement of the initially defined use cases and the finalisation of their structure and content. Then, a prioritisation process was applied to select the most appropriate priority application scenarios among the set of all MOVESMART use cases that shall be deployed during the pilots. Given the interdependencies between the tasks within WP2, the present deliverable provides input to task T2.3 for the definition of the technical specifications of the MOVESMART subsystems and modules. Moreover, in the course of the project it shall provide basic input to WP6 for the pilots planning and preparation, i.e. task T6.2.

1.3 Structure of this document

The rest of the present document is structured as follows: Section 2 details the methodology for defining the MOVESMART uses cases, based on the user requirements and the envisaged innovative system applications and services, and gives the general overview of the process for extracting the priority application scenarios. Section 3 provides the precise descriptions of the use cases, both in tabular format and by using UML diagrams, while the subsequent section presents the selected priority application scenarios that shall be deployed during the pilots of the project. Last, Section 5 summarises the findings of the work undertaken in the frame of task T2.2 and draws the main conclusions.

2 Methodology

This section describes the process followed for the definition of the use cases of the MOVESMART project. It surveys existing best practices for extracting use cases from user requirements and needs, presents the methodology adopted within the frame of the MOVESMART project, specifies the template for the detailed description of the use cases in tabular format, and explains the required notation for their graphical representation in the form of UML diagrams. Moreover, it presents the prioritisation process to apply in order to extract the priority application scenarios, through which the results of the project can be demonstrated and evaluated.

2.1 Best practices in use case extraction from user requirements and needs

Use cases are an effective technique for capturing, organising and communicating the functional requirements of a system [4]. A use case typically represents a subset of functionalities of the system towards the achievement of a specific goal, with the key characteristic that these are considered from the user's point of view. They show how the system responds to the outside world, the responsibilities and behaviour of the system, without revealing how the internal parts are constructed [4]. In other words, a use case lists a number of possible sequences of interactions between the system and external actors to accomplish a goal, describing a flow of events where the system fulfils one or more user's requirements. The term "actor" is used to specify an external role that interacts with the system, implying that it is not necessarily a person, but it can also represent any element outside the system, such as an organisation, device or even a software package. The system is treated as a single entity, which interacts with the actors [2]. A use case ends with the completion of the flow of events and the fulfilment of the corresponding goal, while satisfying the imposed constraints and producing the expected results.

The first step for the definition of the use cases consists in the identification of the actors involved, which is a straightforward process typically based on the functional requirements of the system. The identification of the various roles that interact with the system can often reveal other use cases and/or requirements that would have gone unnoticed [7]. An iterative approach is often followed to further refine the initially defined use cases and/or determine any missing ones. At this point, it is important to note that actors and users are not always the same, since a user can play one or more different roles, whereas an actor is an external entity to the system that plays one specific role.

Use case analysis is a critical task for the development of the system and generally involves the description of use cases, both in textual form and diagrams. The latter are usually constructed using UML that provides a standard notation for visualising, specifying, constructing, and documenting the artefacts of software systems [1]. Use case diagrams represent graphically distinct pieces of functionality for a system, a component, or even a class [7]. Thus, such UML diagrams facilitate system developers to verify the requirements specified by the end users, or to discuss a design with domain experts [1].

The elements that a use case should contain and describe, among others, are the following:

- The goal to be accomplished

- The actors involved
- The conditions under which the use case occurs
- Any constraints that may apply
- The flow of events/interactions between the actors and the system
- The expected system output

A good use case is characterised by the extent to which (i) the flow of the process is detailed in the form of easy to follow steps, and (ii) the goal, trigger event and preconditions are clearly specified. Moreover, the description of a use case should be relatively brief, e.g. 1 or 2 pages, and the set of use cases must clearly cover the function space, in other words, all the functionalities that the system provides must be described [5]. Furthermore, a relevant aspect is that the description of a use case should be comprehensible by an heterogeneous audience, ranging from people with a non-technical background to system experts.

There are different techniques that can be applicable to the specification of the use cases. Among the possible best practices, it is typically recommended to determine the use cases after the elicitation of the requirements of the system. However, this procedure can also be applied in the other way round, since use cases are the description of a specific scenario or situation, in other words, a trace of actions and messages between the different actors and the system, from the trigger event to the completion of the goal or its abandonment. A scenario is a sequence of interactions happening under certain conditions, to achieve the primary actor's goal, and having a particular result with respect to that goal [2], which can serve to raise the remaining necessary requirements to complete the objective of the functionality described in the use case [5]. It shall be noted that scenarios are separated according to the conditions encountered, and grouped together as they have the same goal [2].

2.2 Adopted methodology

Figure 1 illustrates the approach followed within the frame of the MOVESMART project for identifying and detailing the relevant use cases. In this context, the envisaged functionalities and services along with the initially identified user groups provided the required input to a brainstorming session, where representatives of all partners contributed to the identification of the innovative features that the MOVESMART system should implement, a process that led to the definition of the high-level use cases. On the other hand, the user requirements document (deliverable D2.1), as the output of task T2.1, specified the exact user groups and classified the user requirements into functional and non-functional ones. During this task, the user groups and needs were extracted through surveys with questionnaires, based on telephone and personal interviews, for the two pilots of the project.

Upon the completion of the deliverable D2.1 and the determination of the actors (i.e. the external entities to the system that play specific roles), the functional requirements were matched with the high-level use cases and a number of iterations were launched between the contributing partners for the further refinement of the use case definitions. The purpose of this process was to divide complex use cases into simpler ones (if and when needed), identify any missing use cases and

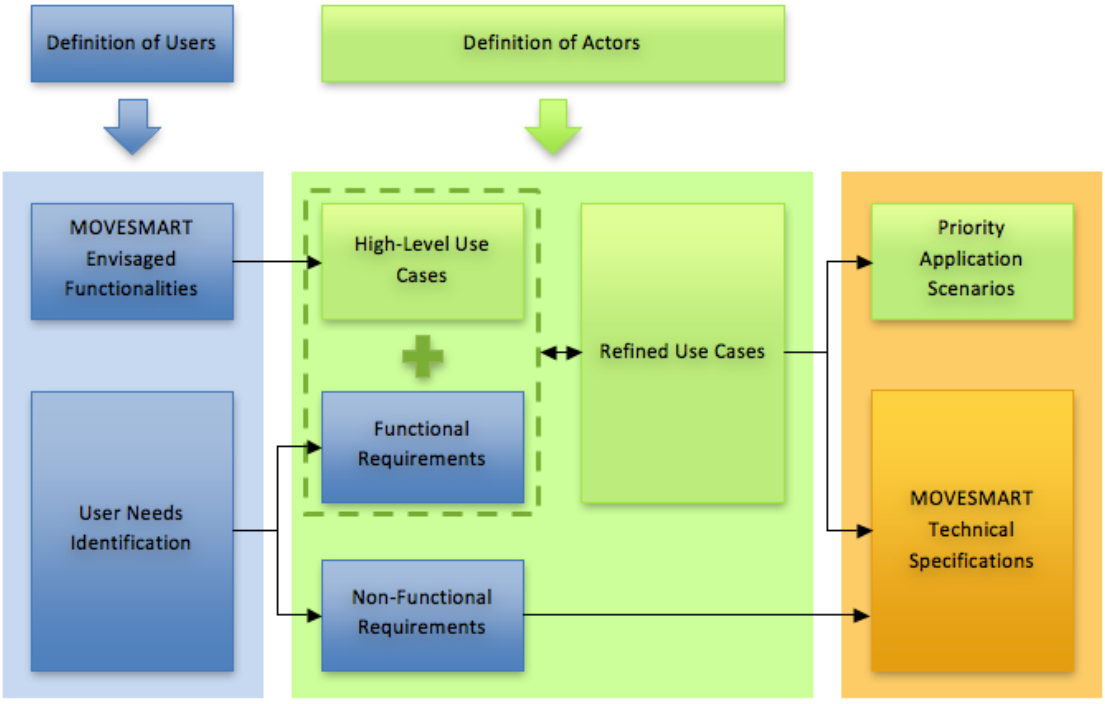

Figure 1: Workflow of requirements engineering methodology followed for task T2.2

revise the existing ones according to the user requirements.

Taking also into account the priorities assigned to each use case, the overall process finally led to the definition of the priority application scenarios that shall be implemented during the pilots of the project. Last, the non-functional requirements combined with the refined use cases provided input to the relevant task of the project that involves the determination of the technical specifications of the system, i.e. task T2.3.

2.3 Use case priorities - Prioritisation process for extraction of priority application scenarios

The selection of a sufficient number of use cases in the form of priority application scenarios to be deployed at the pilots of the project requires the definition of a proper prioritisation scheme. To this end, the defined use cases shall be prioritised in terms of importance and innovation of the foreseen MOVESMART applications and services, as well as significance of the user requirements involved. The priority levels employed are listed below in descending order:

- Essential

- Secondary
- Supportive

In this framework, the devised use case description template in subsection 2.5 includes two relevant fields for assigning a priority level and providing the required reasoning respectively. The use cases with assigned priority level "essential" or "secondary" are the main inputs that shall be considered for structuring the priority application scenarios, through which the results of the project can be demonstrated and evaluated. The "supportive" use cases are the ones that supplement the main goals of MOVESMART and shall be included in the priority application scenarios to the extent that practical issues allow for their testing during the pilots.

2.4 UML notation

The complementary process to the textual definition and specification of the different use cases is their visual representation using the UML, a visual language for capturing software designs and patterns [7]. This process results in a series of diagrams, each one referring to a single use case or a group of use cases, while showing the relationships and associations among actors, modules and actions that have been previously identified within each use case. The main purpose of UML is to provide a common technique for capturing and expressing relationships, behaviours, and high-level ideas in a notation that is easy to learn and efficient to write [7], allowing the readers to obtain a more complete comprehension of the interactions with the system.

UML diagrams are generally divided into two broad categories in terms of the different views of a system model, namely structural and behavioural. Structural diagrams (e.g. class diagrams and composite structure diagrams) focus on the static structure of the system using objects, attributes, operations and relationships. On the other hand, behavioural diagrams (e.g. sequence diagrams, activity diagrams and use case diagrams) focus on the dynamic behaviour of the system by showing collaborations among objects and changes to the internal states of objects.

For the purposes of the MOVESMART project, use case diagrams are the most relevant, since they represent situations where the system is used to fulfil one or more of the stakeholders' requirements [6]. The basic elements of use case diagrams include: (i) the relevant use cases in the form of named ellipses that represent the pieces of functionality of the system, (ii) the actors, usually in the form of stick figures that denote people or things invoking the functionality represented, and (iii) subjects that reflect other elements responsible for implementing the use cases. A typical example that illustrates the different kinds of elements and associations in a use case diagram is given in Figure 2.

2.4.1 Actors

In the context of use case analysis, a use case is initiated by a third party outside the scope of the system, the so-called "actor". This entity is not necessarily a human user; it can also be any external system or element outside the use case, which may trigger it or be the recipient of its results [7]. More specifically, the actors are classified into "primary" and "secondary" ones. A primary actor is defined as the one making use of the system to achieve a specific goal [3], given that a use case documents the interactions between the system and the actors to achieve the goal of

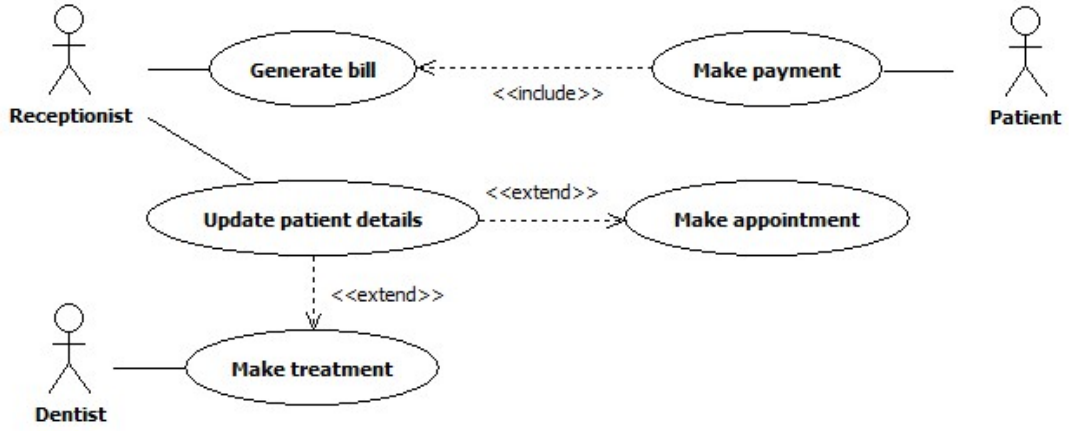

Figure 2: Example of a use case diagram

the primary actor. On the other hand, a secondary actor is one providing assistance to the system in order to achieve the primary actor's goal [2].

In general, there is no theoretical limit to the number of actors that can participate in a use case [6]. Each actor may be associated with one or more use cases, while a relationship indicates whether the actor triggers the use case, the use case provides results to the actor, or both. These associations are graphically represented by lines or arrows to indicate the direction of communication, as shown in Figure 2. Conventionally, the use case diagrams are read from left to right, with actors initiating use cases on the left and actors that receive the use case results on the right [7].

2.4.2 Relationships

As already pointed out, the elements of a use case diagram are associated with different kinds of relationships. The purpose of establishing such relationships is to provide the system's designers with some architectural guidance and facilitate them to efficiently divide the system's concerns into manageable pieces within the detailed system design [6].

Dependency In UML, a dependency is a directed relationship to signify that an element (or group of elements) requires, uses or depends on other elements for specification or implementation, while it is graphically represented as a dashed line with an open arrow that points from the former to the latter.

Generalisation The generalisation relationship is an association that can be applied to elements of the same type, e.g. between actors or between use cases, where a common structure or behaviour can be extracted from them. This type of association is typically used to gather common requirements or characteristics and specify the modelling process of the use case. The purpose of

using generalisation between use cases is the introduction of a specific functionality (it is noted that this refers to the representation of the functionality, not its implementation). This association is represented by a solid line and a closed arrow pointing from the specialised actor or use case to the base one. An indicative example of applying the generalisation relationship is illustrated in Figure 3.

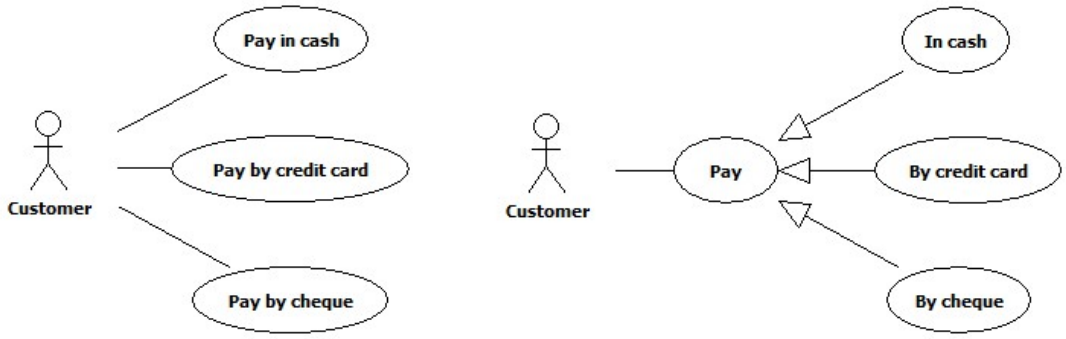

Figure 3: Application of generalisation

Inclusion The activities contained in some use cases can be restructured into different use cases to increase reusability and manageability, in the sense that a repetitive behaviour or sequence of activities shared between two or more use cases can be separated and captured within a totally new use case [6]. In this context, the relationship <<include>> can be employed as a type of association between uses cases that establishes a compulsory fulfilment of the use case included. More specifically, the inclusion of a use case indicates that its fulfilment is not optional, since the use case that includes another use case is usually not complete on its own. It should be noted that this relationship declares that the base case completely reuses all the steps involved in the use case included. The inclusion relationship is graphically represented by a dashed line with an open arrow pointing from the base use case to the use case included, followed by the keyword "<<include>>", as shown in the example of Figure 4.

Extension The relationship <<extend>> is another type of association between uses cases that establishes the accomplishment of the extension use case only if certain conditions are met. The extension use cases are typically smaller in scope and represent additional functionality, thus they may not be useful outside the context of the base use case [7]. The key feature of this type of association is its optional character, allowing for the addition of certain optional functionality to the base use case performed. Therefore, the system can efficiently continue its activity if the user rejects to complete the extension use case. The extension association is graphically represented by a dashed line with an open arrow pointing from the extension use case to the base use case, followed by the keyword "<<extend>>", as exemplified in Figure 5.

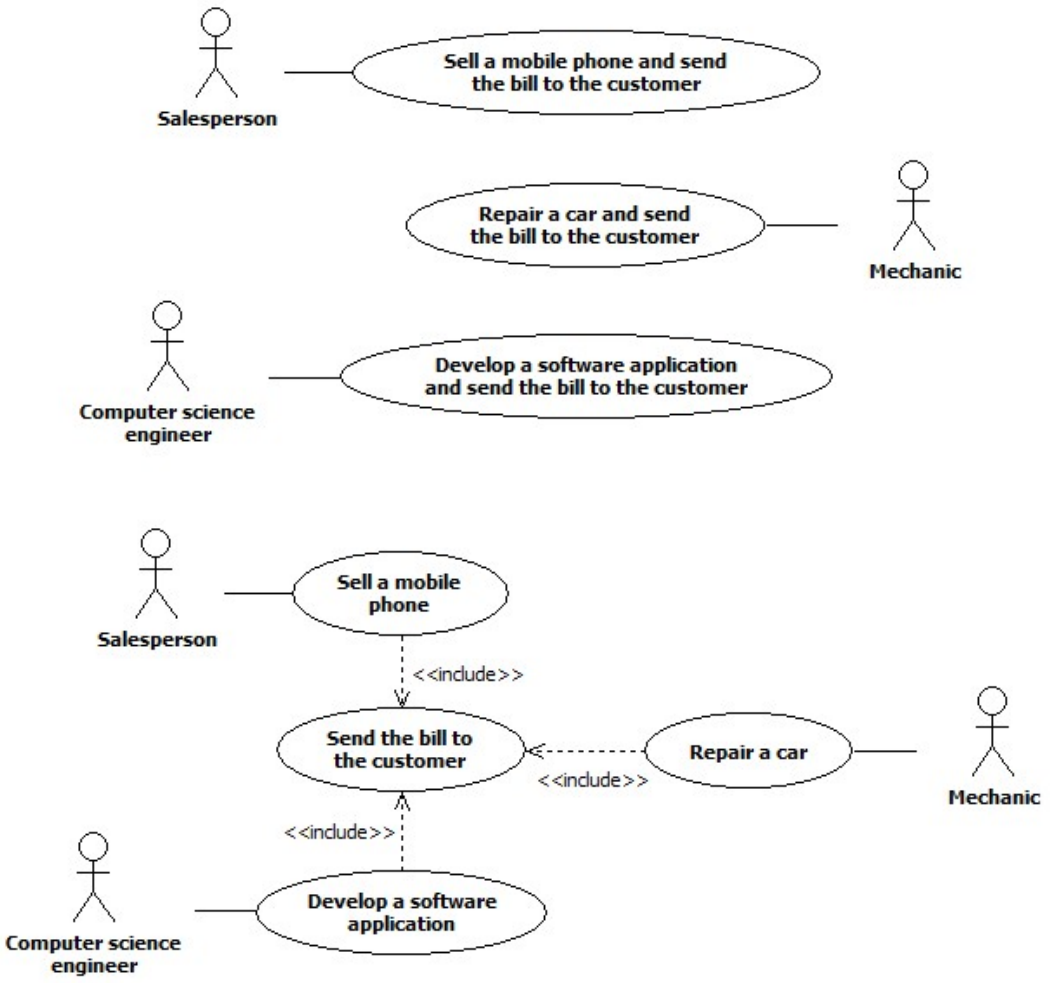

Figure 4: Application of inclusion

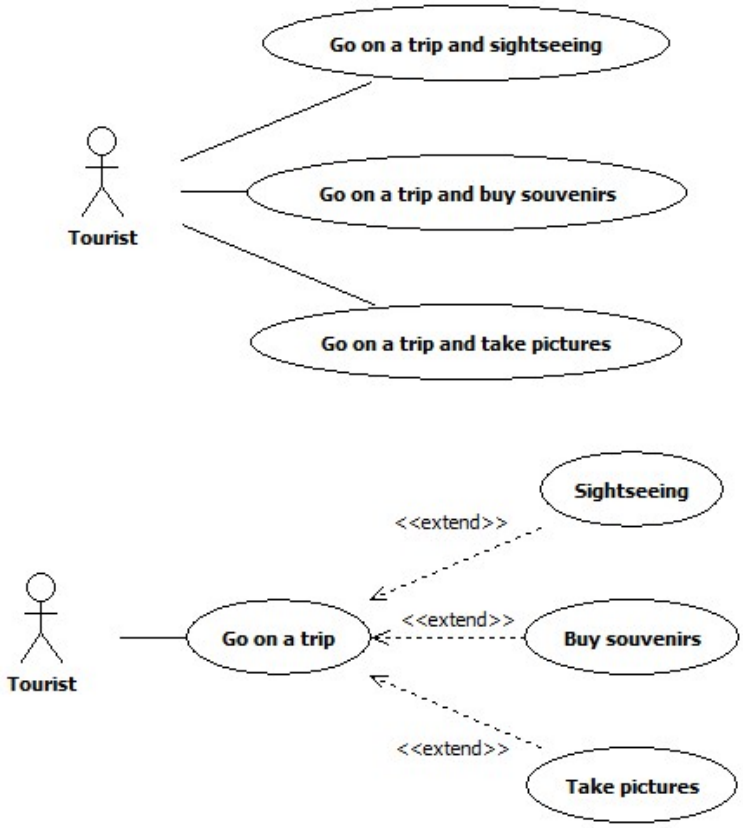

Figure 5: Application of extension

2.5 Template for detailed description of use cases

The following table shows the proposed template for the detailed description of the MOVESMART use cases in tabular format. Each use case is detailed in a separate table and it is identified by a unique ID in the form of UC$x.y$, where x is an integer number from 1 to 3 corresponding to each one of the main MOVESMART features/services (i.e. 1 for "Renewable Mobility on Demand Feature", 2 for "Incentivised Vehicle Sharing Feature", and 3 for "Integrated Personal Mobility Service"), while y is an integer number that specifies each subsequent use case.

Use Case ID **Use Case Name**	**<unique identifier in the form UC$x.y$>** **<brief title that expresses the goal of this use case>**
Description	• Purpose and goal: <intention of the use case> • Scenario of use: <detailed statement describing the context, user's profile, why he/she uses the platform, interaction with the system, interaction with actors involved, benefits obtained, etc.>
Primary actor	<the actor who will be initiating this use case>
Secondary actors	<other actors who interact with the system/participate in completing the use case>
Priority level	<available options: *Essential*, *Secondary*, *Supportive*>
Reason for assigning this priority	<importance of classifying this use case into the specific priority level>
Preconditions	<description of the conditions (if any) that must be fulfilled before the use case can be executed>
Trigger	<events that trigger the actions to be executed>
Main flow	<detailed description of the user actions and system responses (in the form of step-by-step action/event list) that will take place during execution of the use case under normal, expected conditions> Example: 1. The user inputs his/her destination and sends a request for a multimodal route. ... n. The system displays a set of alternative routes, each one consisting of combinations of various means of transportation in an efficient mobility-chain.
System output	<detailed system's functionality as a response to the user's actions>

Alternative flow	<situations that can prevent proper execution of the use case, referring to the corresponding step number k of the main flow, the condition that must hold true and the alternative actions to be taken> Example: k.a. The are no available shared-use vehicles at the user's position. k.a.1. The system suggests the expected time that a vehicle becomes available. k.a.2. The flow continues with step m. where a is the number of each subsequent branch of the alternative flow.
Services involved	<MOVESMART services involved in the implementation of this use case>
Devices	<on which device this use case will operate properly>
Critical success parameters	<identification of key factors for successful execution of the use case>
Constraints	<all constraints to be taken into account, e.g. environmental>
Relevant UCs	<IDs of any relevant MOVESMART use cases>
Relevant functional requirements	<IDs of the functional requirements (according to the notation reported in D2.1) that are used to derive this use case>
Notes and issues	<additional comments about this use case or remaining open issues that must be resolved (if applicable)>
Author	<name of the author of this use case>
Version	<use case version>
Date	<date of last change>

3 MOVESMART Use Cases

This section presents in detail the use cases of the MOVESMART project, both in tabular format and by using UML use case diagrams. The precise description of the use cases is based on the software engineering methodology defined in the previous section. For purposes of clarity and coherence, the use cases are classified according to the innovative features/services of the project, namely "Renewable Mobility on Demand Feature", "Incentivised Vehicle Sharing Feature", "Integrated Personal Mobility Service".

3.1 Renewable Mobility on Demand Feature

3.1.1 User receives renewable routes

Figure 6 illustrates the UML diagram for the use case related to the definition of user's profile and preferences, the detailed description of which is given in the table below.

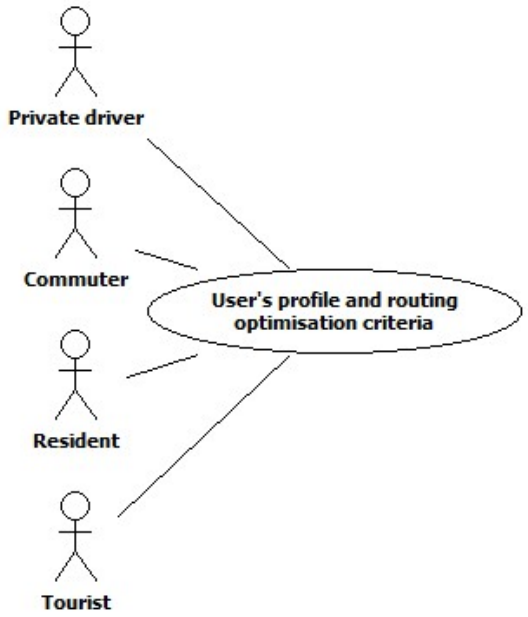

Figure 6: UML diagram for UC1.1

Use Case ID **Use Case Name**	**UC1.1** **User's profile and routing optimisation criteria**
Description	• Purpose and goal: To specify the user's profile, either predefined (e.g. tourist, frequent/occasional commuter, frequent/occasional EV user or private driver) or customised in terms of personal criteria to be taken into account for trip planning. • Scenario of use: Leire is a city resident who wants to commute economically to her work, move around the city for leisure using environmentally friendly options and move fast when she has to pick up her children from school. To this end, she wants to define her preferences on the routing options depending on the case, so she will modify her MOVESMART profile to be able to receive route suggestions optimised for different criteria, such as economical, eco-friendly, and/or the fastest.
Primary actor	Private driver, commuter, resident, tourist
Secondary actors	–
Priority level	Essential
Reason for assigning this priority	Enabling the user to choose a predefined profile (e.g. tourist, frequent/occasional commuter, frequent/occasional EV user or private driver) or create a customised one that allows him/her to specify different criteria for the computation of route suggestions is an essential feature in routing applications.
Preconditions	• Leire has registered to the MOVESMART platform. • A connection has been established with the MOVESMART platform to access Leire's profile.
Trigger	Leire logs into the MOVESMART platform and chooses to modify her preferences on trip planning.
Main flow	Steps: 1. The system retrieves and displays Leire's existing profile with her current preferences. 2. Leire enters or modifies the routing preferences in her profile. 3. The system updates the information.
System output	The system displays a notification to confirm that the update is accomplished.

Alternative flow	Steps: 1.1. There is no access to the MOVESMART platform (communication failure). 1.1.1. The system generates a warning corresponding to a communication error. 1.1.2. The system asks from Leire to choose one of the predefined profiles that are locally stored at her device. 1.1.3. The flow continues with step 2.
Services involved	Pre-trip planning, on-trip routing
Devices	Portable navigation device (PND), smartphone
Critical success parameters	There is easy access to the trip planning preferences, the interface is user-friendly, and the available options are sufficiently rich to keep Leire using this feature.
Constraints	Due to the necessity of monitoring user preferences, the system must ensure that the collected data are protected and anonymous.
Relevant UCs	UC1.2, UC3.1, UC3.2, UC3.8
Relevant functional requirements	FR1, FR12
Notes and issues	–
Author	Yoseba Penya Landaburu, UD
Version	0.3
Date	25/07/2014

Next, Figure 7 presents the UML diagrams for the use cases that enable the user to receive renewable routes based on time-dependent traffic data, as well as detailed route information for each one of them. The use case descriptions are given in the following tables.

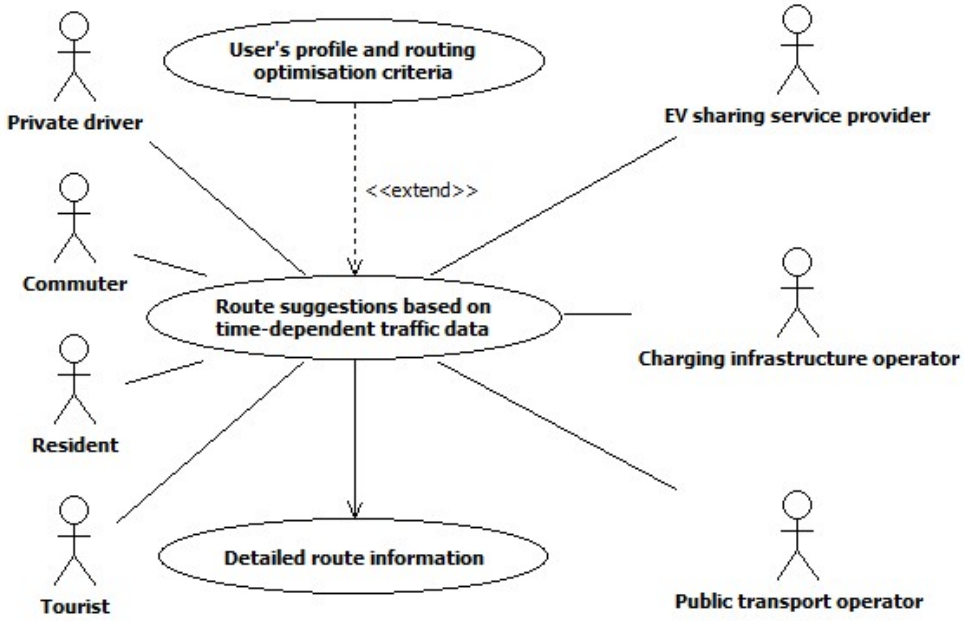

Figure 7: UML diagram for UC1.2-UC1.3

Use Case ID **Use Case Name**	**UC1.2** **Route suggestions based on time-dependent traffic data**
Description	• Purpose and goal: To provide the user with route suggestions optimised for different objectives based on time-dependent traffic data. • Scenario of use: Mattin usually combines shared-use EVs with public transport media for his daily mobility needs. Either pre-trip or on-trip, he wants to receive a number of time-dependent routes optimised for different objectives, as defined in his profile preferences, while taking into account current and predicted traffic conditions.
Primary actor	Private driver, commuter, resident, tourist
Secondary actors	EV sharing service provider, public transport operator, charging infrastructure operator
Priority level	Essential
Reason for assigning this priority	The provision of time-dependent route suggestions is one of the key concepts in MOVESMART.

Preconditions	• Mattin has registered to the MOVESMART platform. • A connection has been established with the MOVESMART platform to obtain historical and/or real-time traffic information.
Trigger	Mattin logs into the MOVESMART platform to request route suggestions in order to plan his trip with a shared-use EV.
Main flow	Steps: 1. Mattin inputs the time and point of departure, as well as the destination point, and requests route suggestions based on his profile preferences. 2. The system requests/retrieves information on the battery SoC of the EV. 3. The system displays time-dependent routes (optimised for different objectives) from Mattin's point of departure to his destination for the time chosen, and their characteristics based on predicted traffic data.
System output	The system outputs a number of routes from Mattin's point of departure to his destination for the time chosen. The characteristics to display for each route include the predicted traffic situation (e.g. time delay and traffic tendency), estimated earliest arrival time (EAT), and its energy efficiency assessment (e.g. consumption and/or emissions).
Alternative flow	Steps: 1.1. There is no access to the MOVESMART platform (communication failure). 1.1.1. The system generates a warning corresponding to a communication error. 1.1.2. The system calculates time-dependent routes (optimised for different objectives) from Mattin's point of departure to his destination for the time chosen, and their characteristics based on the replica of data stored in his device. 1.1.3. The flow continues with step 3. 2.1. The battery SoC of the EV is not enough to complete the trip. 2.1.1. The system: (i) recommends a more efficient route to reach the final destination (if applicable), and (ii) displays information about nearby charging stations (e.g. location, minimum charge level and charging time required). 2.1.2. The flow continues with step 3.
Services involved	Pre-trip planning, on-trip routing

Devices	Portable navigation device (PND), smartphone
Critical success parameters	First, the routes shall be computed by taking into account time-dependent traffic information. Second, the proposed routes shall be appealing enough to Mattin to keep him using this feature.
Constraints	Due to the necessity of monitoring user activity, the system must ensure that the collected data are protected and anonymous.
Relevant UCs	UC1.1, UC1.3, UC1.4, UC1.5, UC1.6, UC1.7, UC1.8, UC1.9
Relevant functional requirements	FR4, FR5, FR6, FR7, FR17
Notes and issues	Loss of connectivity with the MOVESMART platform will probably result in reduced availability of options and accuracy of information.
Author	Yoseba Penya Landaburu, UD
Version	0.2
Date	03/07/2014

Use Case ID	**UC1.3**
Use Case Name	**Detailed route information**
Description	• Purpose and goal: To provide the user with detailed information on a given route. • Scenario of use: Joxe has chosen a shared-use EV for his trip and has received a number of route suggestions (based on his preferences), along with their characteristics. However, he wants to receive more detailed information for one of the suggested routes.
Primary actor	Private driver, commuter, resident, tourist
Secondary actors	EV sharing service provider, charging infrastructure operator
Priority level	Essential
Reason for assigning this priority	The provision of detailed information on a given route is a key feature in MOVESMART.
Preconditions	• Joxe has registered to the MOVESMART platform. • A connection has been established with the MOVESMART platform to obtain detailed information of the selected route.
Trigger	Joxe has selected one of the routes proposed by the MOVESMART platform.

Main flow	Steps: 1. Joxe requests detailed information for the selected route. 2. The system presents the detailed information of the specific route.
System output	Besides the standard route information, such as the predicted traffic situation (e.g. time delay and traffic tendency), estimated earliest arrival time (EAT), and its energy efficiency assessment (e.g. consumption and/or emissions), the system also outputs any traffic incidents and other relevant information (e.g. cost, nearby charging/drop-off stations, and parking space availability).
Alternative flow	Steps: 1.1. There is no access to the MOVESMART platform (communication failure). 1.1.1. The system generates a warning corresponding to a communication error. 1.1.2. The system calculates the detailed characteristics of the route based on the replica of data stored in Joxe's device. 1.1.3. The flow continues with step 2.
Services involved	Pre-trip planning, on-trip routing
Devices	Portable navigation device (PND), smartphone
Critical success parameters	The information provided shall be accurate and appealing enough to Joxe to keep him using this feature.
Constraints	–
Relevant UCs	UC1.2, UC1.10
Relevant functional requirements	FR14
Notes and issues	Loss of connectivity with the MOVESMART platform will probably result in reduced availability and accuracy of information.
Author	Yoseba Penya Landaburu, UD
Version	0.2
Date	03/07/2014

The UML diagrams for the use cases related to the provision of renewable route suggestions based on time-dependent traffic data are shown in Figure 8, while their descriptions are detailed in the following tables.

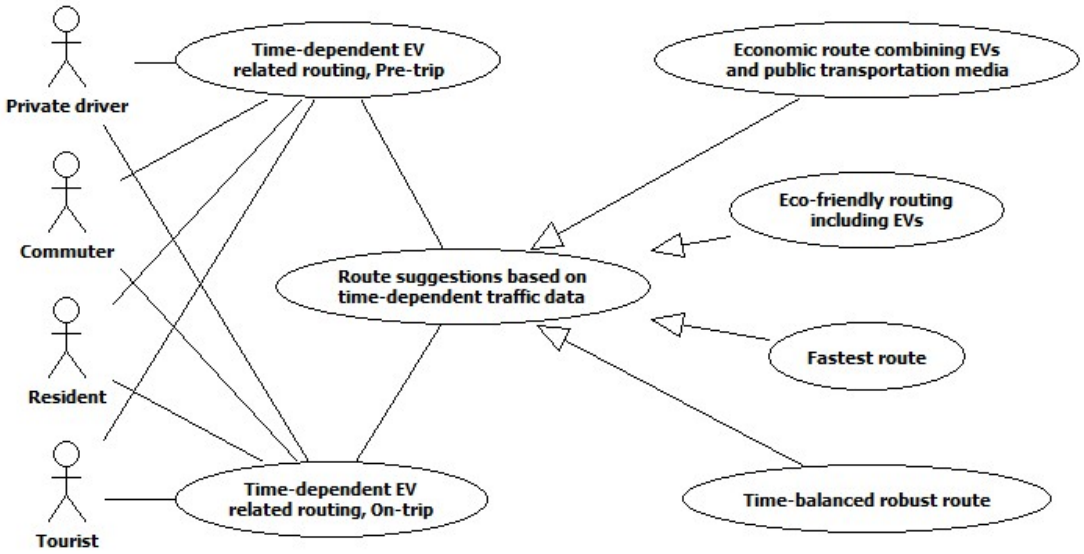

Figure 8: UML diagram for UC1.4-UC1.9

Use Case ID	**UC1.4**
Use Case Name	**Time-dependent EV related routing, Pre-trip**
Description	• Purpose and goal: To provide pre-trip time-dependent routing information for EVs based on historical, live and predicted traffic data. • Scenario of use: Aitor is a driver who wants to plan his trip with a shared-use EV. He wants to receive time-dependent routes optimised for different objectives taking into account current and predicted traffic conditions in order to choose among them.
Primary actor	Private driver, commuter, resident, tourist
Secondary actors	EV sharing service provider, charging infrastructure operator
Priority level	Essential
Reason for assigning this priority	The provision of time-dependent routing information is one of the key concepts in MOVESMART.

Preconditions	• Aitor has registered to the MOVESMART platform. • A connection has been established with the MOVESMART platform to obtain historical and/or real-time traffic information.
Trigger	Aitor logs into the MOVESMART platform and chooses a shared-use EV to plan his trip.
Main flow	Steps: 1. Aitor inputs the time and point of departure, as well as the destination point, and requests pre-trip routing information. 2. The system requests/retrieves information on the battery SoC of the EV. 3. The system displays time-dependent routes (optimised for different objectives) from Aitor's point of departure to his destination for the time chosen, and their characteristics based on predicted traffic data.
System output	The system outputs a number of routes from Aitor's point of departure to his destination for the time chosen. The characteristics to display for each route include the predicted traffic situation (e.g. time delay and traffic tendency), estimated earliest arrival time (EAT), and its energy efficiency assessment (e.g. consumption and/or emissions).
Alternative flow	Steps: 1.1. There is no access to the MOVESMART platform (communication failure). 1.1.1. The system generates a warning corresponding to a communication error. 1.1.2. The system calculates time-dependent routes (optimised for different objectives) from Aitor's point of departure to his destination for the time chosen, and their characteristics based on the replica of data stored in his device. 1.1.3. The flow continues with step 3. 2.1. The battery SoC of the EV is not enough to complete the trip. 2.1.1. The system: (i) recommends a more efficient route to reach the final destination (if applicable), and (ii) displays information about nearby charging stations (e.g. location, minimum charge level and charging time required). 2.1.2. The flow continues with step 3.
Services involved	Pre-trip planning
Devices	Smartphone

Critical success parameters	First, the routes shall be computed by taking into account time-dependent traffic information. Second, the proposed routes shall be appealing enough to Aitor to keep him using this feature.
Constraints	Due to the necessity of monitoring user activity, the system must ensure that the collected data are protected and anonymous.
Relevant UCs	UC1.1, UC1.2, UC1.12
Relevant functional requirements	FR3, FR19
Notes and issues	Loss of connectivity with the MOVESMART platform will probably result in reduced availability of options and accuracy of information.
Author	Konstantinos Genikomsakis, UD
Version	0.2
Date	20/05/2014

Use Case ID **Use Case Name**	**UC1.5** **Time-dependent EV related routing, On-trip**
Description	• Purpose and goal: To provide on-trip time-dependent routing information for EVs based on historical, live and predicted traffic data. • Scenario of use: Ander is a driver who has chosen a shared-use EV for the next leg of his trip and wants to be able to receive on-trip time-dependent routes optimised for different objectives (based on his preferences) taking into account current and predicted traffic conditions.
Primary actor	Private driver, commuter, resident, tourist
Secondary actors	EV sharing service provider, charging infrastructure operator
Priority level	Essential
Reason for assigning this priority	The provision of time-dependent routing information is one of the key concepts in MOVESMART.

Preconditions	• Ander has registered to the MOVESMART platform. • Ander has made a reservation for a shared-use EV and holds a driving licence for the corresponding vehicle category. • A connection has been established with the MOVESMART platform to obtain historical and/or real-time traffic information. • Ander's location is known, either entered by him or through GPS.
Trigger	Ander logs into the MOVESMART platform and gets in a shared-use EV for the next leg of his trip.
Main flow	Steps: 1. Ander inputs his destination and requests on-trip routing information. 2. The system records his current location and requests/retrieves information on the battery SoC of the EV. 3. The system displays time-dependent routes (optimised for different objectives) from Ander's current location to his destination, and their characteristics based on live and predicted traffic data. 4. The system detects the start of the trip and records the time stamp. 5. The system keeps track of the battery SoC of the EV, so that Ander has enough battery to complete his trip. 6. Ander's in-vehicle device anonymously sends real time information and/or emergency reports of disruptions (optional and if applicable). 7. The system provides emergency alerts (if applicable). 8. The system detects the end of the trip and records the battery SoC, EV condition, distance travelled, time used and % of battery consumed. 9. The system requests feedback from Ander on the quality of the suggested route plans. 10. Ander sends feedback for his level of satisfaction.
System output	The system outputs a number of routes from Ander's current point to his destination, optimised for different objectives. The characteristics to display for each route include the current and predicted traffic situation (e.g. time delay and traffic tendency), estimated earliest arrival time (EAT), and its energy efficiency assessment (e.g. consumption and/or emissions).

Alternative flow	Steps: 1.1. There is no access to the MOVESMART platform (communication failure). 1.1.1. The system generates a warning corresponding to a communication error. 1.1.2. The system displays time-dependent routes (optimised for different objectives) from Ander's location to his destination, and their characteristics based on the replica of data stored in his device. 1.1.3. The flow continues with step 8. 2.1. The battery SoC of the EV is not enough to complete the trip. 2.1.1. The system: (i) recommends a more efficient route to reach the final destination (if applicable), and (ii) displays information about nearby charging stations (e.g. location, minimum charge level and charging time required). 2.1.2. The flow continues with step 3. 5.1. The EV runs out of battery, breaks down or is involved in an accident. 5.1.1. Ander sends an emergency report to the system. 5.1.2. The flow continues with step 8.
Services involved	On-trip routing
Devices	Portable navigation device (PND), smartphone
Critical success parameters	First, the routes shall be computed by taking into account time-dependent traffic information. Second, the proposed routes shall be appealing enough to Ander so that he reaches his destination with a high level of satisfaction.
Constraints	Due to the necessity of monitoring user activity, the system must ensure that the collected data are protected and anonymous.
Relevant UCs	UC1.1, UC1.2, UC1.11, UC3.3, UC3.4, UC3.5, UC3.6, UC3.7, UC3.8
Relevant functional requirements	FR3, FR6, FR7, FR9, FR19
Notes and issues	Loss of connectivity with the MOVESMART platform will probably result in reduced availability of options and accuracy of information.
Author	Konstantinos Genikomsakis, UD
Version	0.2
Date	20/05/2014

Use Case ID **Use Case Name**	**UC1.6** **Economic route combining EVs and public transportation media**
Description	• Purpose and goal: To provide an economic route based on historical, live and predicted traffic data, while taking into account a number of cost factors, including EV charging, prices, public transit fare, etc. • Scenario of use: Bidane is a person with diverse and varying transportation needs who wants to be able to receive an economic route suggestion from her current location to her destination, combining EVs and public transportation media in order to decide "on the spot" which transportation medium to choose for the next leg of her trip.
Primary actor	Private driver, commuter, resident, tourist
Secondary actors	EV sharing service provider, public transport operator, charging infrastructure operator
Priority level	Essential
Reason for assigning this priority	The provision of economic routes is one of the key user requirements.
Preconditions	• Bidane has registered to the MOVESMART platform. • A connection has been established with the MOVESMART platform to obtain historical and/or real-time traffic information. • Bidane's location is known, either entered by her or through GPS.
Trigger	Bidane logs into the MOVESMART platform to request an economic route to her destination.
Main flow	Steps: 1. Bidane inputs her destination and requests an economic route that allows combining EVs and public transportation media. 2. The system requests/retrieves information on availability of shared-use EVs and their battery SoC. 3. The system displays an economic route from Bidane's current location to her destination, and its characteristics based on current and predicted traffic situations, public transport fare, EV charging, vehicle sharing prices and incentives.

System output	The system outputs a low cost route from Bidane's current point to her destination. The characteristics to display for the proposed route include the cost, current and predicted traffic situation (e.g. time delay and traffic tendency), estimated earliest arrival time (EAT), and its energy efficiency assessment (e.g. consumption and/or emissions).
Alternative flow	Steps: 1.1. There is no access to the MOVESMART platform (communication failure). 1.1.1. The system generates a warning corresponding to a communication error. 1.1.2. The system calculates the low cost route from Bidane's current location to her destination, and their characteristics based on the replica of data stored in her device. 1.1.3. The flow continues with step 3. 2.1. The battery SoC of the EV is not enough to complete the trip. 2.1.1. The system: (i) recommends a more efficient route to reach the final destination (if applicable), and (ii) displays information about nearby charging stations (e.g. location, minimum charge level and charging time required). 2.1.2. The flow continues with step 3.
Services involved	Pre-trip planning, on-trip routing
Devices	Portable navigation device (PND), smartphone
Critical success parameters	First, the economic route shall be computed by taking into account time-dependent traffic information. Second, the proposed route shall be appealing enough to Bidane to keep her using this feature.
Constraints	Due to the necessity of monitoring user activity, the system must ensure that the collected data are protected and anonymous.
Relevant UCs	UC1.2, UC1.12
Relevant functional requirements	FR9, FR10
Notes and issues	Loss of connectivity with the MOVESMART platform will probably result in reduced availability of options and accuracy of information.
Author	Konstantinos Genikomsakis, UD
Version	0.3
Date	03/07/2014

Use Case ID **Use Case Name**	**UC1.7** **Eco-friendly routing including EVs**
Description	• Purpose and goal: To provide information on eco-friendly routing (including EVs) based on historical, live and predicted traffic data, while taking into account energy consumption and emissions. • Scenario of use: Garbiñe is an environmentally conscious person who is interested in minimising the eco-footprint of her mobility habits and wants to be able to receive information on eco-friendly routes from her current location to her destination, combining EVs and public transportation media in order to decide "on the spot" which transportation medium to choose for the next leg of her trip.
Primary actor	Private driver, commuter, resident, tourist
Secondary actors	EV sharing service provider, public transport operator, charging infrastructure operator
Priority level	Essential
Reason for assigning this priority	The eco-friendly routing functionality is one of the key concepts in MOVESMART.
Preconditions	• Garbiñe has registered to the MOVESMART platform. • A connection has been established with the MOVESMART platform to obtain historical and/or real-time traffic information. • Garbiñe's location is known, either entered by her or through GPS.
Trigger	Garbiñe logs into the MOVESMART platform to request eco-friendly routes to her destination.
Main flow	Steps: 1. Garbiñe inputs her destination and requests eco-friendly routes that allow combining EVs and public transportation media. 2. The system requests/retrieves information on availability of shared-use EVs and their battery SoC. 3. The system displays eco-friendly routes from Garbiñe's current location to her destination, and their characteristics based on current and predicted traffic situations, public transport and vehicle sharing options.

System output	The system outputs a number of routes from Garbiñe's current point to her destination, optimised for energy efficiency and eco-friendliness. The characteristics to display for each route include the current and predicted traffic situation (e.g. time delay and traffic tendency), estimated earliest arrival time (EAT), and its energy efficiency assessment (e.g. energy consumption and/or emissions).
Alternative flow	Steps: 1.1. There is no access to the MOVESMART platform (communication failure). 1.1.1. The system generates a warning corresponding to a communication error. 1.1.2. The system calculates the energy-efficient and eco-friendly routes from Garbiñe's current location to her destination, and their characteristics based on the replica of data stored in her device. 1.1.3. The flow continues with step 3. 2.1. The battery SoC of the available EVs is not enough to complete the trip. 2.1.1. The system displays information about nearby charging stations (e.g. location, minimum charge level and charging time required). 2.1.2. The flow continues with step 3.
Services involved	Pre-trip planning, on-trip routing
Devices	Portable navigation device (PND), smartphone
Critical success parameters	First, the routes shall be computed by taking into account time-dependent traffic information. Second, the proposed routes shall be appealing enough to Garbiñe to keep her using this feature.
Constraints	Due to the necessity of monitoring user activity, the system must ensure that the collected data are protected and anonymous.
Relevant UCs	UC1.2, UC1.12
Relevant functional requirements	FR9, FR11
Notes and issues	Loss of connectivity with the MOVESMART platform will probably result in reduced availability of options and accuracy of information.
Author	Konstantinos Genikomsakis, UD
Version	0.2
Date	20/05/2014

Use Case ID **Use Case Name**	**UC1.8** **Fastest route**
Description	• Purpose and goal: To provide the fastest route based on historical, live and predicted traffic data. • Scenario of use: Aingeru is late at work and wants to know the fastest route from his current point to his destination. He receives the optimal time-dependent route suggestion (based on his profile preferences) in terms of total travel time, taking into account current and predicted traffic conditions.
Primary actor	Private driver, commuter, resident, tourist
Secondary actors	EV sharing service provider, public transport operator, charging infrastructure operator
Priority level	Essential
Reason for assigning this priority	The provision of the fastest route is an essential feature in routing applications.
Preconditions	• Aingeru has registered to the MOVESMART platform. • A connection has been established with the MOVESMART platform to obtain historical and/or real-time traffic information.
Trigger	Aingeru logs into the MOVESMART platform to request the fastest route suggestion to his destination.
Main flow	Steps: 1. Aingeru inputs the time and point of departure, as well as the destination point, and requests the fastest route. 2. The system requests/retrieves information on availability of shared-use EVs and their battery SoC. 3. The system displays a time-dependent route optimised for short travel time from Aingeru's point of departure to his destination for the time chosen, and its characteristics based on current and predicted traffic situations, public transport and vehicle sharing options.
System output	The system outputs the fastest route to Aingeru's destination. The characteristics to display for this route include the predicted traffic situation (e.g. time delay and traffic tendency), estimated earliest arrival time (EAT), and its energy efficiency assessment (e.g. consumption and/or emissions).

Alternative flow	Steps: 1.1. There is no access to the MOVESMART platform (communication failure). 1.1.1. The system generates a warning corresponding to a communication error. 1.1.2. The system calculates the fastest route from Aingeru's point of departure to his destination for the time chosen, and its characteristics based on the replica of data stored in his device. 1.1.3. The flow continues with step 3. 2.1. The battery SoC of the available EVs is not enough to complete the trip. 2.1.1. The system: (i) recommends a more efficient route to reach the final destination (if applicable), and (ii) displays information about nearby charging stations (e.g. location, minimum charge level and charging time required). 2.1.2. The flow continues with step 3.
Services involved	Pre-trip planning, on-trip routing
Devices	Portable navigation device (PND), smartphone
Critical success parameters	First, the fastest route shall be computed by taking into account time-dependent traffic information. Second, the proposed route shall be appealing enough to Aingeru to keep him using this feature.
Constraints	Due to the necessity of monitoring user activity, the system must ensure that the collected data are protected and anonymous.
Relevant UCs	UC1.2, UC1.12
Relevant functional requirements	FR9, FR13
Notes and issues	Loss of connectivity with the MOVESMART platform will probably result in reduced availability of options and accuracy of information.
Author	Yoseba Penya Landaburu, UD
Version	0.2
Date	03/07/2014

Use Case ID **Use Case Name**	**UC1.9** **Time-balanced robust route**
Description	• Purpose and goal: To provide a time-balanced robust route (i.e. a route that is less likely to incur traffic incidents and delay) based on historical, live and predicted traffic data. • Scenario of use: Enara has an interview for a new job and thus it is very important for her to show up on time at the appointment. To this end, she wants to receive a route suggestion with reliable time of arrival from her point of departure to her destination for the time chosen, taking into account current and predicted traffic conditions.
Primary actor	Private driver, commuter, resident, tourist
Secondary actors	EV sharing service provider, public transport operator, charging infrastructure operator
Priority level	Supportive
Reason for assigning this priority	The provision of time-balanced robust routes is a desirable feature that could increase user satisfaction.
Preconditions	• Enara has registered to the MOVESMART platform. • A connection has been established with the MOVESMART platform to obtain historical and/or real-time traffic information.
Trigger	Enara logs into the MOVESMART platform to request a time-balanced robust route suggestion to her destination.
Main flow	Steps: 1. Enara inputs the time and point of departure, as well as the destination point, and requests a time-balanced robust route. 2. The system requests/retrieves information on availability of shared-use EVs and their battery SoC. 3. The system displays a time-dependent route based on the reliability of earliest arrival time (EAT) from Enara's point of departure to her destination for the time chosen, and its characteristics based on current and predicted traffic situations, public transport and vehicle sharing options.
System output	The system outputs a reliable route in terms of earliest arrival time (EAT). The characteristics to display for this route include the predicted traffic situation (e.g. time delay and traffic tendency), the estimated EAT, the reliability of EAT, and its energy efficiency assessment (e.g. consumption and/or emissions).

Alternative flow	Steps: 1.1. There is no access to the MOVESMART platform (communication failure). 1.1.1. The system generates a warning corresponding to a communication error. 1.1.2. The system calculates a time-balanced robust route from Enara's point of departure to her destination for the time chosen, and its characteristics based on the replica of data stored in her device. 1.1.3. The flow continues with step 3. 2.1. The battery SoC of the available EVs is not enough to complete the trip. 2.1.1. The system: (i) recommends a more efficient route to reach the final destination (if applicable), and (ii) displays information about nearby charging stations (e.g. location, minimum charge level and charging time required). 2.1.2. The flow continues with step 3.
Services involved	Pre-trip planning, on-trip routing
Devices	Portable navigation device (PND), smartphone
Critical success parameters	First, the time-balanced robust route shall be computed by taking into account time-dependent traffic information, while avoiding unreasonable waiting times between connections of means of transportation. Second, the proposed route shall be appealing enough to Enara to keep her using this feature.
Constraints	Due to the necessity of monitoring user activity, the system must ensure that the collected data are protected and anonymous.
Relevant UCs	UC1.2, UC1.12
Relevant functional requirements	FR9, FR15
Notes and issues	Loss of connectivity with the MOVESMART platform will probably result in reduced availability of options and accuracy of information.
Author	Yoseba Penya Landaburu, UD
Version	0.2
Date	03/07/2014

3.1.2 EV-enabling Park & Ride functionality

Figure 9 depicts the UML diagrams for the use cases that enable the Park & Ride functionality with EVs by providing information about charging/drop-off stations along a given route and the sufficiency of the EV battery charge to reach the final destination. The corresponding use case descriptions are shown in the following tables.

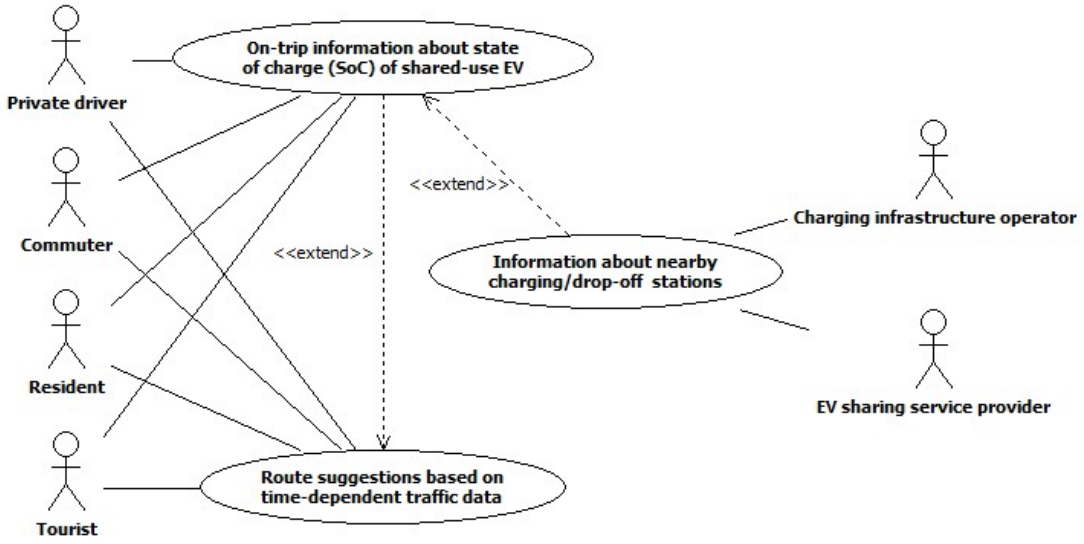

Figure 9: UML diagram for UC1.10-UC1.11

Use Case ID	**UC1.10**
Use Case Name	**Information about nearby charging/drop-off stations**
Description	• Purpose and goal: To provide information about nearby charging/drop-off stations in support of the Park & Ride functionality. • Scenario of use: Maite usually drives to the nearest Park & Ride station and continues her trips with public transportation media. While planning her trip or en route with a shared-use EV, she wants to receive information about the nearby charging/drop-off stations along her selected route.
Primary actor	Private driver, commuter, resident, tourist
Secondary actors	EV sharing service provider, charging infrastructure operator
Priority level	Essential
Reason for assigning this priority	The EV-enabling Park & Ride functionality is one of the key concepts in MOVESMART.

Preconditions	• Maite has registered to the MOVESMART platform. • A connection has been established with the MOVESMART platform to obtain historical and/or real-time traffic information. • Maite's location is known, either entered by her or through GPS. • Maite has selected the route to her destination. • The routing optimisation criterion is known as a Maite's preference.
Trigger	Maite has selected the route to follow towards her destination and requests information about nearby charging/drop-off stations along this route or this feature is triggered automatically when the battery SoC of the EV is not enough to reach her destination.
Main flow	Steps: 1. Maite requests information about nearby charging/drop-off stations along her route. 2. The system requests/retrieves information on the location of nearby charging/drop-off stations, as well as the availability of parking spots/charging posts therein. 3. The system displays route suggestions to the nearby charging/drop-off stations and relevant information for each option.
System output	The system outputs the location of available charging/drop-off stations and route suggestions to get there, as well as relevant information for each option on the availability of parking spots/charging posts.

Alternative flow	Steps: 1.1. There is no access to the MOVESMART platform (communication failure). 1.1.1. The system generates a warning corresponding to a communication error. 1.1.2. The system computes route suggestions from Maite's location to nearby charging/drop-off stations based on the replica of data stored in her device. 1.1.3. The flow continues with step 3. 2.1. There is no parking spot available at nearby drop-off stations. 2.1.1. The system computes the estimated waiting time for a parking spot to become available. 2.1.2. The flow continues with step 3. 2.2. There is no charging post available at nearby charging stations. 2.2.1. The system computes the estimated waiting time for a charging post to become available. 2.2.2. The flow continues with step 3. 2.3. The battery SoC of the EV is not enough to reach a nearby charging station (according to Maite's optimisation criterion). 2.3.1. The system recommends more efficient routes to reach a nearby charging/drop-off station (if applicable). 2.3.2. The flow continues with step 3.
Services involved	Pre-trip planning, on-trip routing
Devices	Portable navigation device (PND), smartphone
Critical success parameters	The information provided shall be accurate and appealing enough to Maite to keep her using this feature.
Constraints	Due to the necessity of monitoring user activity, the system must ensure that the collected data are protected and anonymous.
Relevant UCs	UC1.3
Relevant functional requirements	FR3, FR19
Notes and issues	This use case may occur on a stand-alone basis or as part of other use cases. Moreover, loss of connectivity with the MOVESMART platform will probably result in reduced availability of options and accuracy of information.
Author	Konstantinos Genikomsakis, UD
Version	0.2
Date	20/05/2014

Use Case ID **Use Case Name**	**UC1.11** **On-trip information about state of charge (SoC) of shared-use EV**
Description	• Purpose and goal: To provide on-trip information on the sufficiency of the battery SoC of a shared-use EV to complete a given trip. • Scenario of use: Laura is a frequent user of the Park & Ride functionality that prefers to walk to the nearby station in order to continue her trips with a shared-use EV. While Laura is en route, she wants to know if the current SoC of the EV is sufficient to reach her destination.
Primary actor	Private driver, commuter, resident, tourist
Secondary actors	EV sharing service provider, charging infrastructure operator
Priority level	Essential
Reason for assigning this priority	Checking whether the available range of an EV is sufficient to complete a given trip is a key functionality in MOVESMART.
Preconditions	• Laura has registered to the MOVESMART platform. • A connection has been established with the MOVESMART platform to obtain historical and/or real-time traffic information. • Laura's location is known, either entered by her or through GPS. • Laura has entered her destination. • The routing optimisation criterion is known as a Laura's preference.
Trigger	Laura has selected the route to follow with the shared-use EV and requests information on the sufficiency of the battery SoC to reach her destination or this feature is triggered periodically by the system.

Main flow	Steps: 1. Laura requests information on the sufficiency of the battery SoC to complete her trip. 2. The system requests/retrieves information on the battery SoC of the EV. 3. The system calculates the energy needed for the trip based on Laura's preferences. 4. The system displays a message to inform her whether the current battery SoC is sufficient or not to complete her trip.
System output	The system outputs either a confirmation indicating that the current battery SoC is sufficient to reach her destination or a warning indicating that battery charging is needed.
Alternative flow	Steps: 3.1. There is no access to the MOVESMART platform (communication failure). 3.1.1. The system generates a warning corresponding to a communication error. 3.1.2. The system retrieves information on the battery SoC of the EV and determines whether it is sufficient or not based on the replica of data stored in Laura's device. 3.1.3. The flow continues with step 4.
Services involved	On-trip routing
Devices	Portable navigation device (PND)
Critical success parameters	The information provided shall be accurate enough to keep Laura her using this feature.
Constraints	Due to the necessity of monitoring user activity, the system must ensure that the collected data are protected and anonymous.
Relevant UCs	UC1.5
Relevant functional requirements	FR7, FR23
Notes and issues	This use case may occur on a stand-alone basis or as part of other use cases. Moreover, loss of connectivity with the MOVESMART platform will probably result in reduced accuracy of information.
Author	Konstantinos Genikomsakis, UD
Version	0.2
Date	20/05/2014

Next, Figure 10 presents the UML diagrams for the use cases that allow the user to search for an EV with sufficient battery charge to complete a given trip and then proceed with the EV reservation process. The relevant use cases are detailed in the following tables.

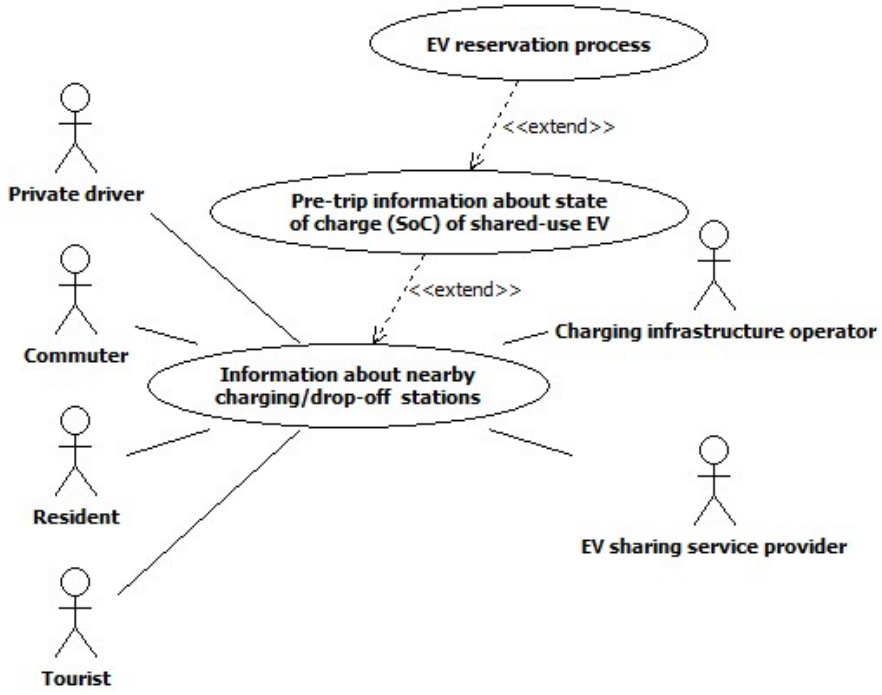

Figure 10: UML diagram for UC1.12-UC1.13

Use Case ID **Use Case Name**	**UC1.12** **Pre-trip information about state of charge (SoC) of shared-use EV**
Description	• Purpose and goal: To provide pre-trip information on the availability of shared-use EVs with sufficient battery SoC to complete a given trip. • Scenario of use: Sendoa usually goes to the nearby Park & Ride station in order to continue his trips with a shared-use EV. While Sendoa is planning one of his trips, he wants to receive information about shared-use EVs with sufficient battery SoC to drive from the Park & Ride station to his destination.
Primary actor	Private driver, commuter, resident, tourist
Secondary actors	EV sharing service provider
Priority level	Essential

Reason for assigning this priority	Checking whether there are available shared-use EVs to complete a given trip is a key functionality in MOVESMART.
Preconditions	• Sendoa has registered to the MOVESMART platform. • A connection has been established with the MOVESMART platform to obtain historical and/or real-time traffic information. • The routing optimisation criterion is known as a Sendoa's preference.
Trigger	Sendoa has selected a Park & Ride station and requests information on the availability of a shared-use EV with sufficient battery SoC to reach his destination.
Main flow	Steps: 1. Sendoa inputs the time of departure (from the selected Park & Ride station) and his destination, and requests information on shared-use EVs with sufficient battery SoC to complete his trip. 2. The system requests/retrieves information on the availability of EVs at the Park & Ride station and their battery SoC. 3. The system calculates the energy needed for the trip based on Sendoa's preferences. 4. The system displays the available options along with relevant information.
System output	The system outputs a list of EVs with sufficient battery SoC to reach his destination, along with their characteristics and the available range. Alternatively, the system outputs further information on estimated waiting time for a shared-use EV to become available, alternative routes that allow Sendoa to change EV or details on charging options (minimum charge level and charging time required) along his route, depending on the case.

Alternative flow	Steps: 1.1. There is no access to the MOVESMART platform (communication failure). 1.1.1. The system generates an error message to inform Sendoa that a connection to the MOVESMART platform is required. 1.1.2. The process is terminated. 2.1. There is no shared-use EV available at the Park & Ride station. 2.1.1. The system computes the estimated waiting time for a shared-use EV to become available. 2.1.2. The flow continues with step 3. 3.1. The battery SoC of the available EVs is not enough to complete the trip. 3.1.1. The system: (i) recommends an alternative route in which Sendoa will be able to change the EV, or (ii) displays a number of possible in-route changing points along with the estimated needed charging time. 3.1.2. The flow continues with step 4.
Services involved	Pre-trip planning
Devices	Smartphone
Critical success parameters	The information provided shall be accurate enough to keep Sendoa using this feature.
Constraints	Connectivity with the MOVESMART platform is required. Moreover, due to the necessity of monitoring user activity, the system must ensure that the collected data are protected and anonymous.
Relevant UCs	UC1.4, UC1.6, UC1.7, UC1.8, UC1.9, UC1.13
Relevant functional requirements	FR23
Notes and issues	This use case may occur on a stand-alone basis or as part of other use cases.
Author	Konstantinos Genikomsakis, UD
Version	0.2
Date	20/05/2014

Use Case ID **Use Case Name**	**UC1.13** **EV reservation process**
Description	• Purpose and goal: To enable the user to reserve a shared-use EV for a given trip. • Scenario of use: Ugaitz finds the EV-sharing service very convenient for his daily mobility needs, mainly because of the flexibility it offers. For example, on his way back home from work on the bus, he realises that he has forgotten his keys in the office. To this end, he wants to reserve an EV in order to go back and pick them up.
Primary actor	Private driver, commuter, resident, tourist
Secondary actors	EV sharing service provider
Priority level	Essential
Reason for assigning this priority	Enabling the user to create eco-friendly mobility chains that involve shared-use EVs is a key concept in MOVESMART.
Preconditions	• Ugaitz has registered to the MOVESMART platform. • Ugaitz holds a driving licence for the corresponding vehicle category. • Ugaitz has entered his destination.
Trigger	Ugaitz has selected a shared-use EV at a Park & Ride station to reserve it for the next leg of his trip.
Main flow	Steps: 1. The system displays the details of the reservation (e.g. point and time of departure, destination point, time of reservation, and EV characteristics), the corresponding cost and possible incentives. 2. Ugaitz proceeds with the next step of the reservation process. 3. The system displays the available payment options as well as the terms and conditions that may apply. 4. Ugaitz chooses a payment option and the amount from his bonus account he wishes to use, fills in the payment details, accepts the terms of service and proceeds with the next step of the reservation process. 5. The system performs the booking and billing actions required. 6. The system reports on the outcome of the reservation process.
System output	The system outputs a message to either confirm the successful completion of the EV reservation process or provide error information if a problem occurred.

Alternative flow	Steps: 1.1. There is no access to the MOVESMART platform (communication failure). 1.1.1. The system generates an error message to inform Ugaitz that a connection to the MOVESMART platform is required. 1.1.2 The process is terminated.
Services involved	Pre-trip planning
Devices	Smartphone
Critical success parameters	Continuous availability of EVs in sharing stations
Constraints	Connectivity with the MOVESMART platform is required. Moreover, due to the necessity of monitoring user activity, the system must ensure that the collected data are protected and anonymous.
Relevant UCs	UC1.12, UC1.14, UC1.15, UC2.1, UC2.2
Relevant functional requirements	FR3, FR18
Notes and issues	–
Author	Yoseba Penya Landaburu, UD
Version	0.2
Date	03/07/2014

3.1.3 Users receive reward information and incentives

The UML diagram for the use cases related to the provision of reward information and incentives to the users for adopting "good practices" for their urban displacement is depicted in Figure 11. The tables below describe in detail the relevant use cases.

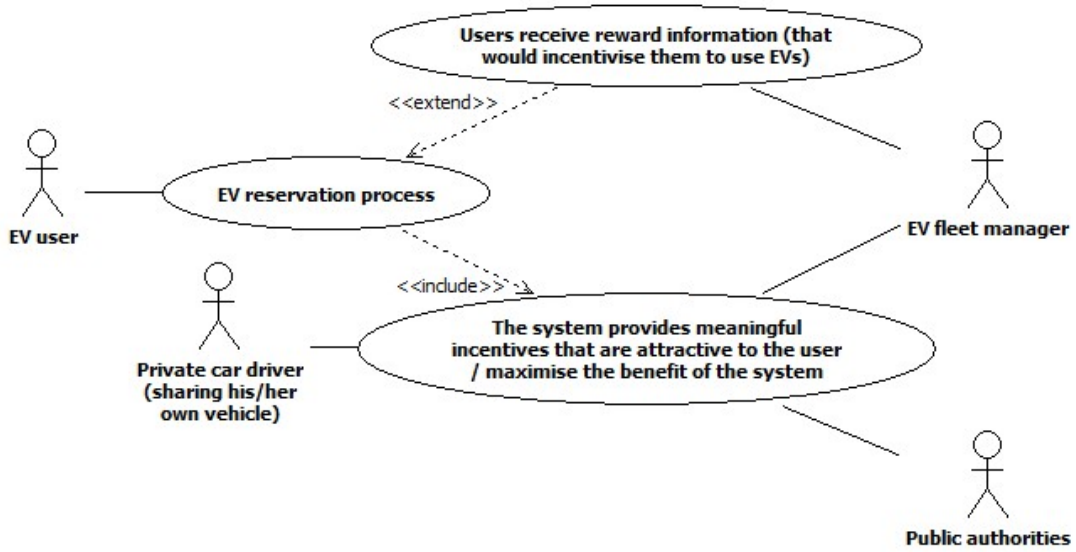

Figure 11: UML diagram for UC1.14-UC1.15

Use Case ID **Use Case Name**	**UC1.14** **Users receive reward information (that would incentivise them to use EVs)**
Description	• Purpose and goal: To incentivise the adoption of "good practices", e.g. use of EVs for urban displacements, offering some rewards to the potential users. These rewards will be managed by the system, in the form of a personal bonus account. Indicatively, the user may increase his/her bonus account by choosing the most ecological option when planning his/her route or by giving to the system feedback information about traffic incidents. • Scenario of use: Sandra wants to book an EV. After the identification in the App and presentation of her bonus account on her smartphone, Sandra has the option to proceed with the EV reservation process and increase the balance of her bonus account.
Primary actor	EV user
Secondary actors	EV fleet manager
Priority level	Secondary

Reason for assigning this priority	It is important to offer some rewards to the users for adopting "good practices" that promote sustainable mobility in the urban areas and increase the use of EVs.
Preconditions	The user must be identified by the system.
Trigger	Sandra wants to book an EV and check her bonus account.
Main flow	Steps: 1. Sandra identifies herself in the application. 2. The system checks Sandra's bonus account and presents her bonus balance. 3. Sandra chooses an EV and enters the booking time along with her route. 4. The system displays information about any bonuses/rewards that may apply. 5. Sandra proceeds with the EV reservation process. 6. The system updates Sandra's bonus account.
System output	The system should: (i) identify the user and present his/her bonus account, (ii) communicate with the EVs management system for booking an EV, (iii) calculate the bonus/reward for renting the EV, and (iv) interface the EVs management system to communicate the bonus/reward to Sandra and update the balance of her bonus account.
Alternative flow	–
Services involved	EV reservation
Devices	Smartphone
Critical success parameters	Online connection for communicating with EVs management system
Constraints	Connectivity with the MOVESMART platform is required.
Relevant UCs	UC1.1, UC1.7, UC1.10, UC1.13, UC1.15, UC2.3, UC3.3, UC3.5, UC3.6, UC3.7
Relevant functional requirements	FR2, FR3, FR6, FR8, FR18, FR21
Notes and issues	An agreement with the owner of the EVs is required to apply the rewarding policy.
Author	Juan Martin, DENOKINN
Version	0.3
Date	03/07/2014

Use Case ID **Use Case Name**	**UC1.15** **The system provides meaningful incentives that are attractive to the user / maximise the benefit of the system**
Description	• Purpose and goal: To minimise the CO_2 emissions and the energy consumption in urban displacements, the users are incentivised to adopt "good practices", e.g. use EVs, specially travelling from a low demand area to a high demand area, and/or share their own private vehicle with other users following the same route. Indicatively, the incentives to be offered to the users may include: (i) discount in the use of EVs, (ii) discount in public parking lots, which will be managed by a personal bonus account in the system, and (iii) other kind of incentives (i.e. free coffee in some restaurants, discounts in certain shops, etc.). To increase his/her bonus account, the user can: (i) use EVs for urban displacement, (ii) share his/her own private vehicle, and (iii) receive geo-located publicity advertisement along the route. The benefits for the stakeholders are: (i) for public authorities, reduction on the ecological footprint and on traffic impact inside the city, and (ii) for the EV fleet manager, dynamic relocation of the vehicles and increase of the turnover due to the incomes by advertising. • Scenario of use: Cristina is planning her route (using a rented EV or her private car). The system asks Cristina if she wants to share the vehicle with other users and/or to receive advertising along the route. Depending on her choices, Cristina can increase the balance of her bonus account.
Primary actor	EV user, private car driver (sharing his/her own vehicle)
Secondary actors	EV fleet manager, public authorities
Priority level	Essential
Reason for assigning this priority	To contribute to the urban traffic sustainability is one of the key success factors of the project. In order to achieve this goal, it is of capital importance to incentivise the users.
Preconditions	The incentives should be attractive enough to the users.
Trigger	Cristina requests to book an EV, or offers to share her own private vehicle.

Main flow	Steps: 1. Cristina requests to use an EV or offers to share her own vehicle, giving indications about the route and the time for the journey. 2. In the second case, the system offers this possibility to other users that could be potentially interested. 3. The system matches all the offers/demands for each route and communicates it along with potential bonuses/rewards that may apply to all the interested users. 4. Cristina may access her profile to enable or disable the option for receiving geo-located advertisements along the route. 5. Cristina's bonus account is updated depending on the previous decisions.
System output	The system should fulfil the following functions: (i) manage the booking of EVs, (ii) match the offers and demands for a specific route at a specific time, and (iii) manage the bonus account of each user.
Alternative flow	If the system fails to match the offer and demand for a specific route, the user will be informed and his/her bonus account will not be increased.
Services involved	EV reservation, sharing of private cars
Devices	Smartphone
Critical success parameters	The incentives policy has great acceptance from the users.
Constraints	Connectivity with the MOVESMART platform as well as conformity of all the stakeholders involved in the incentives policy are required.
Relevant UCs	UC1.1, UC1.7, UC1.10, UC1.13, UC1.14, UC2.3, UC2.4, UC2.5, UC3.3, UC3.5, UC3.6, UC3.7
Relevant functional requirements	FR3, FR8, FR11, FR18, FR20, FR22
Notes and issues	–
Author	Juan Martin, DENOKINN
Version	0.3
Date	03/07/2014

3.1.4 User choice on the next leg of the route (requires live data)

Figure 12 shows the UML diagram related to the user's choice on the next leg of the route, while the precise description of the corresponding use case is given in the table that follows.

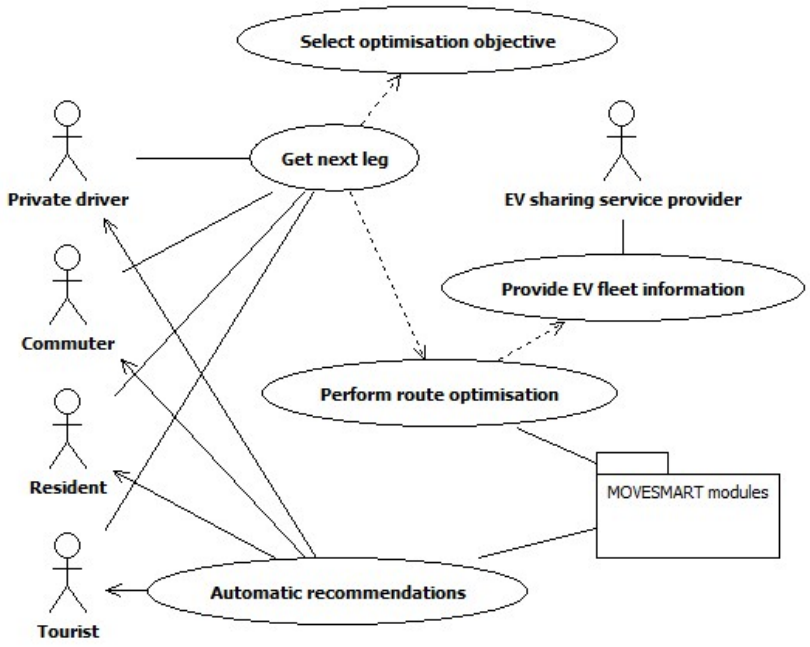

Figure 12: UML diagram for UC1.16

Use Case ID **Use Case Name**	**UC1.16** **User choice on the next leg of the route (requires live data)**
Description	• Purpose and goal: To allow the users for choosing the next leg of the route, based on the provided information about the EAT, cost, eco-friendliness, etc. • Scenario of use: Dimos requests to receive information about the next leg of his route. The system informs him that the battery of the EV he drives is not sufficient enough for reaching the next leg, so he needs to park it at the nearest station and continue from there by using another means (e.g. PT). Alternatively, the user requests to see which is the most energy-efficient route among the available options. The systems returns the most energy-efficient route, i.e. the one that results in the lowest battery consumption. Dimos is free to choose this leg of the route, or another one, according to his preferences.

Primary actor	Private driver, commuter, resident, tourist
Secondary actors	EV sharing service provider
Priority level	Essential
Reason for assigning this priority	The primary goal of the system is to provide recommendations in an automated way, however common practice and relevant surveys show that the users want to decide themselves about how to proceed, taking into account the system recommendations, but not necessarily adhering to them.
Preconditions	• The system must be able to provide recommendations. • There are more than one options regarding the next leg of the trip.
Trigger	The user wants to decide on the next leg out of several options.
Main flow	Steps: 1. The user stops to decide which leg to use. 2. The user requests the optimal route according to one (or more?) optimisation objectives. 3. The system asks the user about the optimisation objective(s). 4. The user selects one (or more) objectives. 5. The system calculates the route according to the selected objective. 6. The user selects a route and proceeds.
System output	The system should: (i) be able to capture the route optimisation objective, and (ii) calculate the optimal route according to the objectives in question.
Alternative flow	If the user does not know which optimisation objective to use, the system should be able to propose by default the most cost-effective.
Services involved	Route calculation
Devices	Portable navigation device (PND), smartphone
Critical success parameters	Online connection for interfacing the EV management system
Constraints	Network availability
Relevant UCs	UC1.1, UC1.2, UC1.3, UC1.6, UC1.7, UC1.8, UC3.1, UC3.2, UC3.9, UC3.10
Relevant functional requirements	FR1, FR2, FR6, FR9, FR10, FR11, FR13, FR14, FR15, FR16
Notes and issues	The system should take into account the current charge level of the EV.
Author	Dionysios Kehagias, CERTH
Version	0.2
Date	23/05/2014

3.2 Incentivised Vehicle Sharing Feature

3.2.1 Incentives and dynamic pricing policy

Figure 13 shows the UML diagram for the use cases related to the provision of incentives for the use of EVs, the implementation of a dynamic pricing policy, as well as the offer of potential discounts to the user. The details of the use case descriptions are presented in the tables that follow.

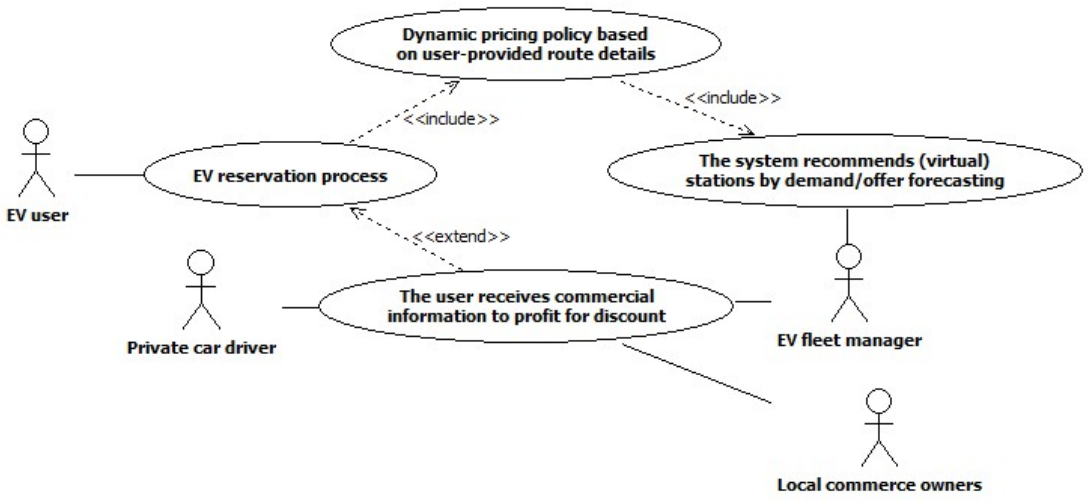

Figure 13: UML diagram for UC2.1-UC2.3

Use Case ID **Use Case Name**	**UC2.1** **The system recommends (virtual) stations by demand/offer forecasting**
Description	• Purpose and goal: To achieve a dynamic relocation of the EV fleet, the system should incentivise the displacement of EV users from locations with low demand and high density of available EVs towards locations with high demand and low density of available EVs. To achieve it, a dynamic pricing policy must be implemented, with low rental prices for users travelling from the first location to the second one and vice versa, with increased prices for users travelling from the second location to the first one. • Scenario of use: Pilar wants to book an EV. She indicates her current position (or the system gets the GPS position automatically) and the final destination. The system checks the position of the available EVs (in a radius of 0,5 km for instance), makes the prices calculation according the demand/offer balance and presents to Pilar the different pricing options for the selected route. Pilar compares the prices and takes the final decision.
Primary actor	EV users
Secondary actors	EV fleet manager
Priority level	Essential
Reason for assigning this priority	The problem of the relocation of the EVs is of vital importance to assure a good correspondence between the demand of EVs and the availability of these EVs. Transfer of EVs from low demand areas towards high demand areas should be incentivised.
Preconditions	It is required to know (or to estimate) the demand for EVs in different geographical areas in the city. This demand changes during the day.
Trigger	Pilar requests to book an EV.
Main flow	Steps: 1. Pilar requests to book an EV, indicating the final destination. 2. The system communicates with the EVs management system (or check it's own forecast) in order to have a map of the demand and the availability of EVs at that moment. 3. The system presents to the user the estimated price for the required displacement between the initial and final destination chosen by the user, along with other more economical alternatives, depending on the demand/offer balance. 4. Pilar chooses between the alternatives, and completes the booking operation.

System output	After receiving a request for booking an EV, the system should: (i) communicate with the EVs management system (or check it's own forecast) in order to have a map about the demand of EVs, (ii) make the calculation for alternatives, according to the algorithms defined for the dynamic pricing policy, and (iii) interface the EVs management system to communicate the final decision from the user and the calculated price.
Alternative flow	If there are not any economical alternatives for the user within a radius of walking distance (i.e. 1 km), just inform the user and close the booking operation.
Services involved	EV reservation
Devices	Smartphone
Critical success parameters	Online connection for communicating with the EVs management system
Constraints	An agreement with the owner of the EVs is required to apply a discount policy.
Relevant UCs	UC1.3, UC1.10, UC1.11, UC1.12, UC1.13, UC1.14, UC1.15, UC2.2, UC2.4, UC2.5, UC3.6
Relevant functional requirements	FR2, FR3, FR6, FR8, FR18, FR19, FR20, FR23, FR24
Notes and issues	–
Author	Juan Martin, DENOKINN
Version	0.3
Date	03/07/2014

Use Case ID **Use Case Name**	**UC2.2** **Dynamic pricing policy based on user-provided route details**
Description	• Purpose and goal: A dynamic pricing policy, in the form of fixed prices with dynamic bonuses or varying prices depending on the demand from the users / available EVs balance in each geographical area in the city, will be implemented to facilitate the relocation of EVs. An EV moving from a low demand area towards a high demand area will be rewarded, in contrast to another EV moving from a high demand area towards a low demand area. The objective is to try to achieve a good balance between demand and available EVs, to avoid the cost of the EV fleet manager of relocating the EVs at the end of the journey (as it happens currently). • Scenario of use: Ana wants to book an EV. She indicates her current position (or the system gets the GPS position automatically) and the final destination. The system checks the position of the available EVs (in a radius of 0,5 km for instance, this radius represents the walking distance and can be selected by the user), calculates the price and potential bonuses according to the demand/offer balance and presents to Ana the different options for the selected route, with a similar tolerance (i.e. 0,5 km for the final destination). Ana compares the available options and makes her final decision, according to the walking distance, as well as prices and bonuses offered.
Primary actor	EV user
Secondary actors	EV fleet manager
Priority level	Secondary
Reason for assigning this priority	To achieve a dynamic relocation of EVs that does not impact on the global ecological footprint, while at the same time it is important to the user's satisfaction and contribution to reducing costs for the EV fleet manager. This reduction of costs can be applied to the incentives for using EVs.
Preconditions	To define properly the dynamic pricing policy.
Trigger	Ana requests to book an EV.

Main flow	Steps: 1. Ana requests to book an EV, indicating the final destination. 2. The system communicates with the EVs management system (or check it's own forecast) to have a map of the demand and the availability of EVs at that moment. 3. The system presents to Ana the estimated price for the required trip between the initial and final destination chosen by the user, along with other more economical alternatives, depending on the demand/offer balance. 4. Ana chooses between the alternatives, and completes the booking operation.
System output	After receiving a request for booking an EV, the system should: (i) communicate with the EVs management system (or check it's own forecast) in order to have a map about the demand of EVs, (ii) make the calculation for alternatives, according to the algorithms defined for the dynamic pricing policy, and (iii) interface the EVs management system to communicate the final decision from the user and the calculated price.
Alternative flow	If there are not any economical alternatives for the user within a radius of walking distance (i.e. 1 km), just inform the user and close the booking operation.
Services involved	EV reservation
Devices	Smartphone
Critical success parameters	Online connection for communicating with the EVs management system
Constraints	An agreement with the owner of the EVs is required to apply the dynamic pricing policy.
Relevant UCs	UC1.10, UC1.11, UC1.12, UC1.13, UC2.1, UC2.4, UC2.5, UC3.6
Relevant functional requirements	FR2, FR3, FR6, FR8, FR18, FR19, FR23, FR24
Notes and issues	–
Author	Juan Martin, DENOKINN
Version	0.3
Date	03/07/2014

Use Case ID **Use Case Name**	**UC2.3** **The user receives commercial information to profit for discount**
Description	• Purpose and goal: To increase his/her incentives bonus account, the user can enable the option to receive commercial advertisements during the route. These ads will be geo-located, and will offer special conditions on purchasing goods or services for EV users (i.e. free parking space if you have your meal in a restaurant located close to you route). If the EV user selects the option that enables the receipt of ads in his/her smartphone, the balance of his/her bonus account will increase. • Scenario of use: Sonia has accessed her profile to set her preference on receiving geo-located advertisements and offers to her smartphone, and she continues with planning her route. If the option is enabled while Sonia is on route, the balance of her bonus account will increase, and she can take advantage of the facilities (parking spaces, free charge of the EV, etc.) offered by the local commerce owners.
Primary actor	EV user, private car driver
Secondary actors	EV fleet manager, local commerce owners
Priority level	Supportive
Reason for assigning this priority	This option will not reduce the ecological footprint or increase the use of EVs, but it will suppose an increment in the turnover of the EV fleet manager (due to the publicity incomes, paid by the local commerce owners), and this extra-benefit for the EV manager can be applied to support the incentives policy.
Preconditions	The collaboration and support of the local commerce owners is required.
Trigger	Sonia requests to plan a route.
Main flow	Steps: 1. Sonia requests to plan a route, either by booking an EV or using her private car. 2. The system retrieves from Sandra's profile her selection on enabling or disabling commercial ads during the trip. 3. If the option is enabled, the balance of Sonia's bonus account will increase as she receives commercial ads along her selected route.
System output	The system should manage the bonus account for each user, and schedule the sending of the commercial ads depending on the selected route.

Alternative flow	–
Services involved	EV reservation, commercial advertising
Devices	Smartphone
Critical success parameters	To have the commitment of the local commerce to implement the commercial ads system.
Constraints	–
Relevant UCs	UC1.3, UC1.14, UC1.15, UC3.3, UC3.7
Relevant functional requirements	FR1, FR2, FR8, FR18, FR19, FR20
Notes and issues	–
Author	Juan Martin, DENOKINN
Version	0.3
Date	03/07/2014

3.2.2 Vehicle relocation strategies

The UML diagram for the vehicle relocation strategies is depicted in Figure 14, while the detailed descriptions of the relevant use cases are given in the next tables.

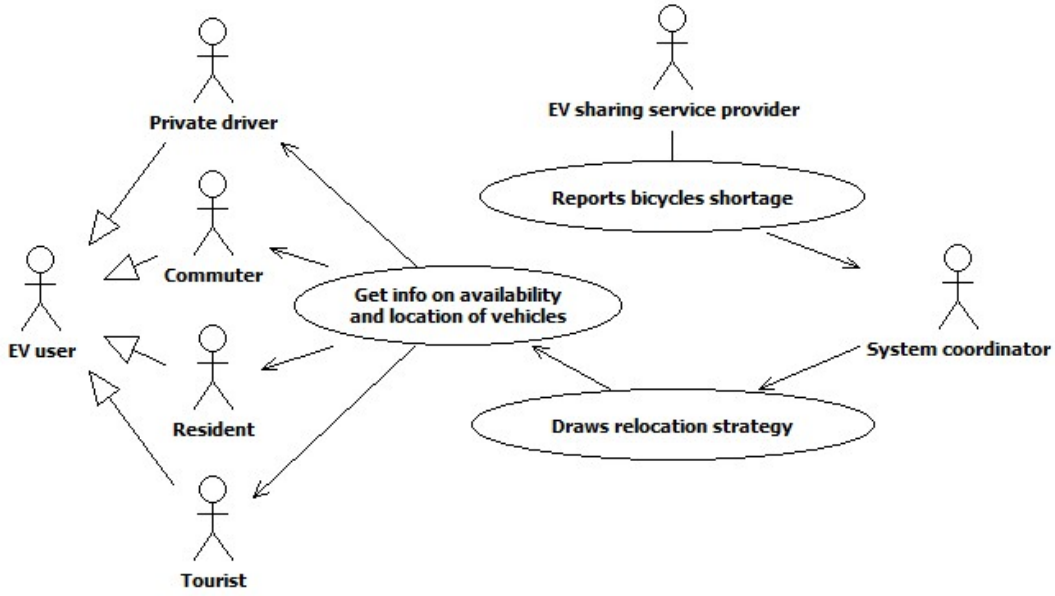

Figure 14: UML diagram for UC2.4-UC2.5

Use Case ID **Use Case Name**	**UC2.4** **Vehicle relocation strategies, Bike-sharing system**
Description	• Purpose and goal: Each station of a vehicle-sharing system must provide sufficient availability of vehicles to increase the possibility that each user can find a vehicle when needed. Due to the one-way rental policy of vehicle-sharing systems, vehicles are likely to get stuck in stations of lower rental demand while needed in stations of higher demand. To make the system more efficient and profitable, this imbalance of supply and demand should be adjusted by applying an appropriate vehicle relocation strategy. • Scenario of use: Mary wants to see a redistribution of bicycles among stations, taking place using a fleet of dedicated vehicles. The repositioning can either be static i.e. it can take place during the night (i.e. when no customer asks for bicycles) or dynamic, i.e. occur during the day in order to remove bicycles from full stations and transfer them to stations with shortage of bicycles. Two main factors are considered in the repositioning process, the number of vehicles removed/transferred to a station to meet the customers' need and the operational cost of the fleet of vehicles performing the repositioning.
Primary actor	EV user - Private driver, commuter, resident, or tourist
Secondary actors	EV sharing service provider
Priority level	Essential
Reason for assigning this priority	This case is important for enabling bicycle sharing stations to operate at full potential, minimising availability shortages.
Preconditions	• A centralised management system of bicycle collections and drop-offs. • A fleet of dedicated relocation vehicles and employed drivers to undertake scheduled relocations or on-demand relocations.
Trigger	Shortage of bicycles in stations with high demand.

Main flow	Steps: 1. At the end of each day the management system identifies the bicycle shortages in the stations and a system coordinator creates a relocation plan. 2. A required number of relocation vehicles are deployed to pick-up the surplus bicycles. 3. Bicycles are redistributed according to the relocation plan from step 1 to the stations that have shortages.
System output	All stations are adequately stocked with bicycles in order to meet daily demand.
Alternative flow	Steps: 1.1. There are bicycle shortages in popular stations that require immediate restocking. 1.1.1. The management system flags during the day stations that might require a restock before the end of the day. 1.1.2. The management system coordinator assesses urgency of shortages and issues immediate relocation plans trying to serve as many stations as possible with a minimum cost overhead. 1.1.3. Flow continues with step 2 of main flow.
Services involved	–
Devices	–
Critical success parameters	• Continuous availability of bicycles in all sharing stations regardless of station demand volume. • Connectivity with the EV fleet management system.
Constraints	Cost and time overhead for relocating bicycles.
Relevant UCs	UC1.10, UC2.5, UC2.6, UC2.7
Relevant functional requirements	FR3, FR7, FR18, FR19, FR24
Notes and issues	–
Author	Dionysios Kehagias, CERTH
Version	0.3
Date	03/07/2014

Use Case ID **Use Case Name**	**UC2.5** **Vehicle relocation strategies, Car-sharing systems**
Description	• Purpose and goal: Each station of a vehicle-sharing system must provide sufficient availability of vehicles to increase the possibility that each user can find a vehicle when needed. Due to the one-way rental policy of vehicle-sharing systems, vehicles are likely to get stuck in stations of lower rental demand while needed in stations of higher demand. To make the system more efficient and profitable, this imbalance of supply and demand should be adjusted by applying an appropriate vehicle relocation strategy. • Scenario of use: A team of employed drivers undertake the relocation of cars among stations. The main factors considered in the redistribution process, are: (i) the labor cost corresponding to employees hired to perform the repositioning, and (ii) the cost of transferring the employees from a station to another one to undertake a car relocation.
Primary actor	EV user - Private driver, commuter, resident, or tourist
Secondary actors	EV sharing service provider
Priority level	Secondary
Reason for assigning this priority	This case is important for enabling vehicle stations to operate at full potential, minimising vehicle availability shortages. However, it is assigned a lower priority compared to that of UC2.4 because MOVESMART foresees the deployment of electric scooters and bicycles at the pilots, but not electric cars.
Preconditions	• A centralised management system of vehicle collections and drop-offs. • A fleet of dedicated relocation vehicles and employed drivers to undertake vehicle relocations on-demand.
Trigger	Shortage of vehicles in stations with high demand.
Main flow	Steps: 1. At the end of each day the management system identifies the vehicle shortages in the stations and a system coordinator creates a relocation plan. 2. A required number of relocation drivers are deployed to pick-up the surplus vehicles. 3. Vehicles are redistributed according to the relocation plan from step 1 to the stations that have shortages.

System output	All stations are adequately stocked with vehicles in order to meet daily demand.
Alternative flow	Steps: 1.1. There are vehicle shortages in popular stations that require immediate restocking. 1.1.1. The management system flags during the day stations that might require a restock before the end of the day. 1.1.2. The management system coordinator assesses urgency of shortages and issues immediate relocation plans trying to serve as many stations as possible with a minimum cost overhead and ensure vehicle availability at all stations. 1.1.3. Flow continues with step 2 of main flow.
Services involved	–
Devices	–
Critical success parameters	Continuous availability of vehicles in all sharing stations regardless of station vehicle demand volume.
Constraints	Cost and time overhead for relocating vehicles.
Relevant UCs	UC1.10, UC2.4, UC2.6, UC2.7
Relevant functional requirements	FR3, FR7, FR18, FR19, FR24
Notes and issues	–
Author	Dionysios Kehagias, CERTH
Version	0.3
Date	03/07/2014

3.2.3 Vehicle pooling in multimodal routing (including EVs)

Figure 15 illustrates the use cases related to the provision of vehicle pooling services in the context of multimodal routing, the detailed descriptions of which are presented in the following tables.

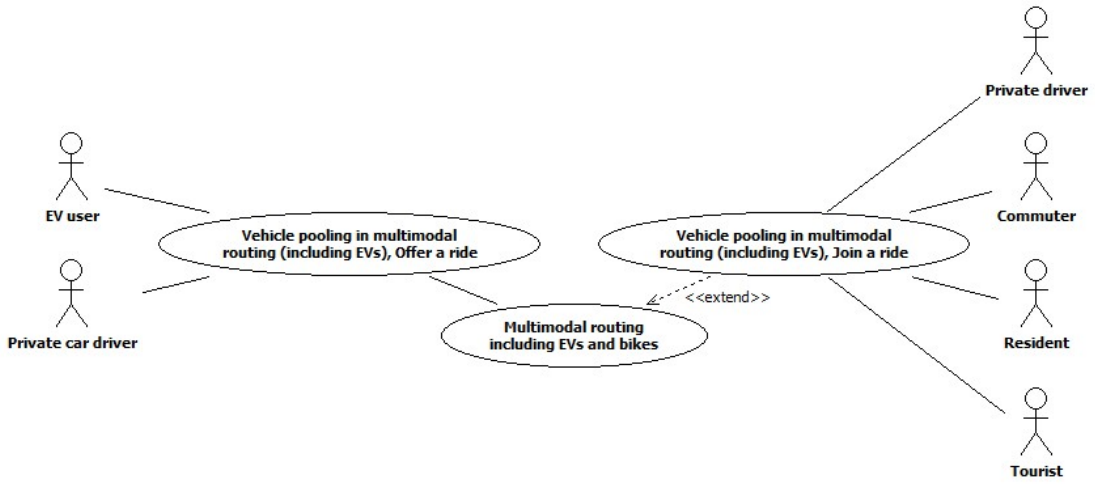

Figure 15: UML diagram for UC2.6-UC2.7

Use Case ID **Use Case Name**	**UC2.6** **Vehicle pooling in multimodal routing (including EVs), Offer a ride**
Description	• Purpose and goal: A service supplied by the MOVESMART system should be the car-pooling service (for private cars and EVs, including multimobility, combining both vehicles), sharing each vehicle between the users going through the same route. • Scenario of use: Patxi is willing to share a vehicle (his own vehicle or a rented EV) in a specific route. When he plans the route, he informs the system about this possibility, and the latter matches it with other (if any) requests for the same route at the same time. If he accepts the matching, all the involved users are notified, and the balance of Patxi's bonus account will increase.
Primary actor	EV user, private car driver
Secondary actors	–
Priority level	Secondary
Reason for assigning this priority	This service is an added value for the set of MOVESMART services and contributes positively to the reduction of traffic congestion in urban areas.

Preconditions	–
Trigger	Patxi (EV user or private car driver) requests to plan his route and declares his intention of sharing the vehicle.
Main flow	Steps: 1. The system receives a request from Patxi for planning a specific route. 2. The system asks Patxi if he prefers to travel alone or he is willing to share the vehicle. 3. If he agrees to share the vehicle, the system tries to match other pending requests: it checks if there are other requests for approximately the same route (i.e. with less than 1 km coincidence between the origin of all the pending routes and similar destination) at approximately the same time (i.e. with less that 5 minutes difference). 4. If the matching is possible, the system sends a message to all the users involved presenting this possibility and asking for an answer. 5. With the positive answers received, the system fulfils the maximum capacity of the vehicle, and notifies the new situation to all the users involved. 6. The system updates the balance of Patxi's bonus account.
System output	The system should match all the requests planning for a "similar" route.
Alternative flow	If the system fails in the matching of "similar" routes, it must inform Patxi that the request for sharing his vehicle is not possible and he may proceed with his trip alone.
Services involved	Multimodal route planning, ride-matching
Devices	Smartphone
Critical success parameters	Algorithms for matching similar routes
Constraints	Maximum legal capacity of the vehicle, and other legal conditions (i.e. security measures for children)
Relevant UCs	UC1.6, UC1.13, UC2.7, UC3.1, UC3.9
Relevant functional requirements	FR1, FR2, FR8, FR18, FR22
Notes and issues	–
Author	Juan Martin, DENOKINN
Version	0.3
Date	03/07/2014

Use Case ID **Use Case Name**	**UC2.7** **Vehicle pooling in multimodal routing (including EVs), Join a ride**
Description	• Purpose and goal: A service supplied by the MOVESMART system should be the car-pooling service (for private cars and EVs, including multimobility, combining both vehicles), sharing each vehicle between the users going through the same route. • Scenario of use: Juantxu wants to travel through a specific route at a specific time, but he prefers not to use his own vehicle. He asks the system for this specific route, declaring that he prefers to share the vehicle of other users for the same route. If the matching is possible, the system informs Juantxu about this possibility and asks for his confirmation.
Primary actor	Private driver, commuter, resident, tourist
Secondary actors	–
Priority level	Secondary
Reason for assigning this priority	This service is an added value for the set of MOVESMART services and contributes positively to the reduction of traffic congestion in urban areas.
Preconditions	–
Trigger	Juantxu requests to plan his route and declare his intention of not using his own vehicle and not renting an EV.
Main flow	Steps: 1. The system receives a request from Juantxu for planning a specific route, and a notification from him that he prefers to join a ride with another vehicle in order to share the costs. 2. The system tries to match other pending requests: it checks if there are other requests for approximately the same route (i.e. with less than 1 km coincidence between the origin of all the pending routes and similar destination) at approximately the same time (i.e. with less that 5 minutes difference). 3. If the matching is possible, the system sends a message to all the users involved presenting this possibility and the rewards/bonuses that may apply and asks for an answer. 4. With the positive answers received, the system fulfils the maximum capacity of the vehicle, notifies all the users involved of the new situation, and updates the balance of their accounts.
System output	The system should match all the requests planning for a “similar” route.

Alternative flow	If the system fails in the matching of "similar" routes, it must inform Juantxu that no vehicle pooling option is available for his trip.
Services involved	Multimodal route planning, ride-matching
Devices	Smartphone
Critical success parameters	Algorithms for matching similar routes
Constraints	Maximum legal capacity of the vehicle, and other legal conditions (i.e. security measures for children)
Relevant UCs	UC1.6, UC2.6, UC3.1, UC3.9
Relevant functional requirements	FR1, FR2, FR22
Notes and issues	–
Author	Juan Martin, DENOKINN
Version	0.3
Date	03/07/2014

3.3 Integrated Personal Mobility Service

3.3.1 Multimodal routing including EVs and bikes

Figure 16 depicts the UML diagram for the use case related to multimodal routing, while the following table presents the corresponding use case definition.

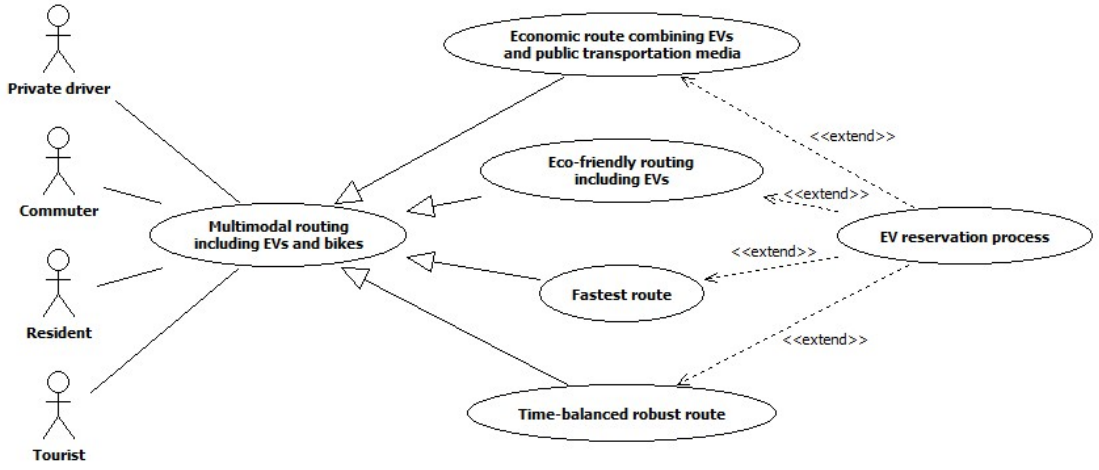

Figure 16: UML diagram for UC3.1

Use Case ID	**UC3.1**
Use Case Name	**Multimodal routing including EVs and bikes**
Description	• Purpose and goal: The purpose of this use case is to enable the potential users to use multimodal routing including EVs and e-bikes. The goal is to minimise total travel time and/or make the route more ecological using EVs and bikes if possible. Combining different means of transport can help a great deal in a number of cases, e.g.: – In urban areas with heavy traffic on roads it is sensible to use public transport and EV- or bike-sharing schemes for arriving to the city centre. It reduces the consumption of time for waiting in a traffic jam and/or trying to find a parking spot. It also reduces the distance travelled by car, and hence the carbon footprint by using EVs and/or bikes. – Commuters/tourists coming to the city by train, long distance or suburban buses seek the best way to get to their final destination in the city centre and therefore use multimodal routing (public transport, taxi, EVs and bikes). • Scenario of use: A private driver, commuter, resident or tourist requests a multimodal route suggestion with low cost or minimal travel time or the most ecological.
Primary actor	Private driver, commuter, resident, tourist
Secondary actors	EV/bike-sharing service provider, public transport operator
Priority level	Essential
Reason for assigning this priority	The multimodal functionality is one of the key concepts in MOVESMART project.

Preconditions	• The user has registered to the MOVESMART platform. • A connection has been established with the MOVESMART platform. • The user's location is known, either entered by him/her or through GPS. • The user's final destination has been entered. • The routing optimisation criterion has been entered.
Trigger	The user logs into the MOVESMART platform to request the best multimodal route to arrive from his/her current location to the final destination.
Main flow	Steps: 1. The user identifies him/herself and requests the best multimodal route. 2. The system requests/retrieves information on real time traffic conditions, public transport availability and shared-use EVs and bikes. 3. The system displays the multimodal routes and the key characteristics (travel time, number of transfers, means of transport,. . .) offering the user to choose the route that suits him/her best.
System output	The system outputs a multimodal route optimised for short travel time, eco-friendliness or cost. The characteristics to display for each available option include total cost, estimated earliest arrival time (EAT), and its energy efficiency assessment (e.g. consumption and/or emissions).
Alternative flow	Steps: 1.1 There is no access to the MOVESMART platform (communication failure). 1.1.1 The system calculates the routes from user's current location to his/her destination, and the characteristics based on the replica of data stored in the device. 1.1.2 The flow continues with step 3.
Services involved	Pre-trip planning, on-trip routing
Devices	Smartphone
Critical success parameters	Online connection for interfacing the EVs and bike sharing and also public transport management system.
Constraints	Due to the necessity of monitoring user activity, the system must ensure that the collected data are protected and anonymous. Due to the requirement for a connection with the MOVESMART platform, network coverage is needed in the area of the service.

Relevant UCs	UC1.4, UC1.5, UC1.6, UC1.10, UC1.11, UC1.12, UC1.16
Relevant functional requirements	FR1, FR2, FR3, FR4, FR5, FR6, FR9, FR10, FR11, FR13, FR14, FR16, FR19
Notes and issues	This use case may occur on a stand-alone basis or as part of other use cases.
Author	Kristina Fedel Timovski, PULA Iva Ivančić, PULA
Version	0.3
Date	03/07/2014

3.3.2 Door-to-door routing based on real time data and accurate predictions using personalised information

Figure 17 shows the UML diagram for door-to-door routing based on real time data and accurate predictions using personalised information, the detailed description of which is given in the following table.

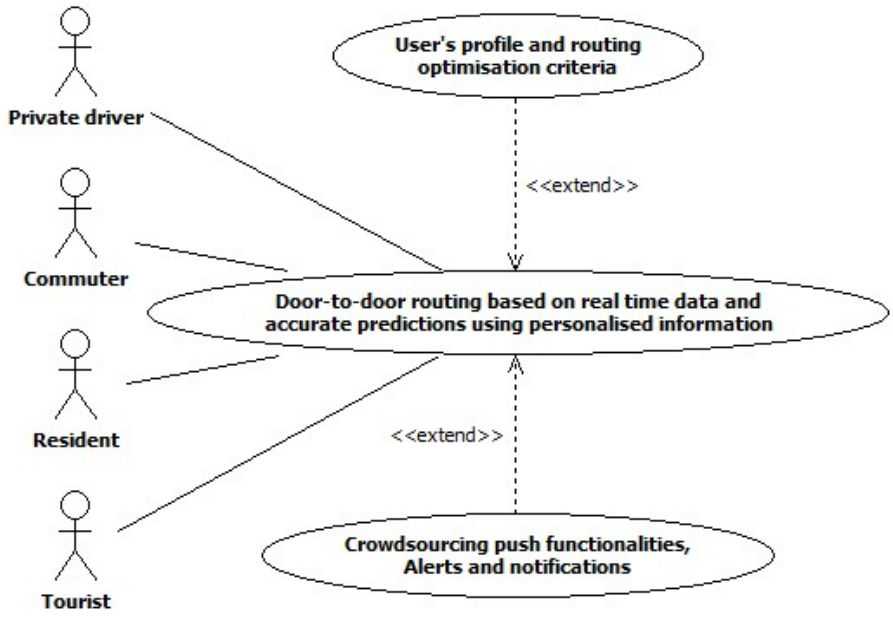

Figure 17: UML diagram for UC3.2

Use Case ID **Use Case Name**	**UC3.2** **Door-to-door routing based on real time data and accurate predictions using personalised information**
Description	• Purpose and goal: The purpose of this use case is to provide the potential users with door-to-door routing based on real time data and accurate predictions using personalised information. The goal is to minimise total travel time and/or make the route more safe and robust using real time data. • Scenario of use: A private driver, frequent commuter, resident or tourist requests a door-to-door route suggestion with minimal travel time and taking into account real-time on-road situation.
Primary actor	Private driver, commuter, resident, tourist
Secondary actors	–
Priority level	Essential
Reason for assigning this priority	The door-to-door routing functionality is one of the key concepts in the MOVESMART project.
Preconditions	• The user has registered to the MOVESMART platform. • A connection has been established with the MOVESMART platform. • The user's location is known, either entered by him/her or through GPS. • The user's final destination has been entered.
Trigger	The user logs into the MOVESMART platform to request the best route to arrive from his/her current location to the final destination (door-to-door routing).
Main flow	Steps: 1. The user identifies him/herself and requests the best route. 2. The system requests/retrieves information on real time traffic conditions. 3. The system predicts possible scenarios based on current on-road situation and taking into account historical data on incidents. 4. The displays the best scenario for the user.

System output	The system outputs the route optimised for short travel time but taking into account possible difficulties (based on historical data on incidents, traffic jams, etc). The characteristic to be displayed for the route is estimated earliest arrival time (EAT) and possible delays based on historical data and traffic foresight.
Alternative flow	Steps: 1.1 There is no access to the MOVESMART platform (communication failure). 1.1.1 The system calculates the routes from user's current location to his/her destination, and the characteristics based on the replica of data stored in the device (excluding real time data). 1.1.2 The flow continues with step 4.
Services involved	Pre-trip planning, on-trip routing
Devices	Smartphone
Critical success parameters	Online connection to the MOVESMART platform
Constraints	Due to the necessity of monitoring user activity, the system must ensure that the collected data are protected and anonymous. Due to the requirement for a connection with the MOVESMART platform, network coverage is needed in the area of the service.
Relevant UCs	UC3.3, UC3.4, UC3.5, UC3.6, UC3.7, UC3.8
Relevant functional requirements	FR4, FR5, FR6, FR7, FR9, FR15, FR17
Notes and issues	This use case may occur on a stand-alone basis or as part of other use cases.
Author	Kristina Fedel Timovski, PULA Iva Ivančić, PULA
Version	0.2
Date	15/05/2014

3.3.3 Crowdsourcing push and pull functionalities

Figure 18 illustrates the UML diagram for the group of use cases related to the crowdsourcing push and pull functionalities, while the following tables present the precise use case descriptions.

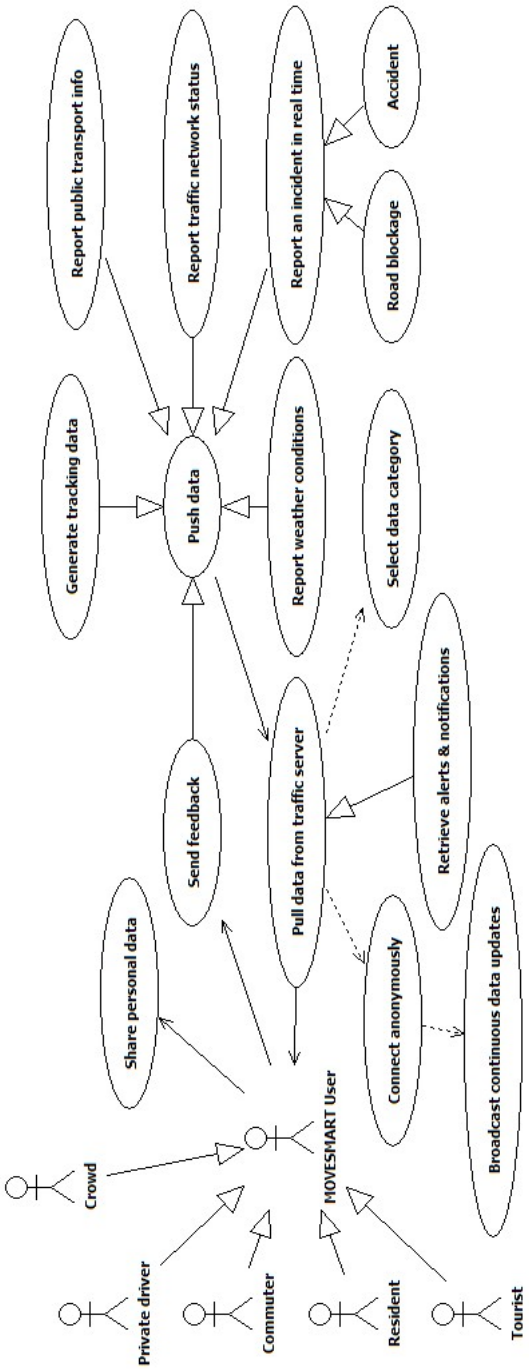

Figure 18: UML diagram for UC3.3-UC3.8

Use Case ID **Use Case Name**	**UC3.3** **Crowdsourcing push functionalities, Information updates**
Description	• Purpose and goal: To provide updates to the user navigation device regarding traffic, transport, carpooling, shared vehicles location and other crowdsourced retrieved data that will provide to the user and the system the information needed to make informed decisions regarding route planning. • Scenario of use: George, as soon as he is online, connects to the MOVESMART data servers and receives data streams on the background without any user interaction. The information data are processed in George's device and displayed on his screen in a meaningful way to him. The process can also be jumpstarted by George via an update on demand interface.
Primary actor	Private driver, commuter, resident, tourist
Secondary actors	Crowd
Priority level	Essential
Reason for assigning this priority	This is the core functionality of usage for the crowdsourced collected data.
Preconditions	Successful connection establishment with the MOVESMART servers.
Trigger	Start of MOVESMART application and connection establishment and/or user request for update-on-demand.
Main flow	Steps: 1. The user starts the personal navigation device (PND) or smartphone application. 2. The data connectivity subsystem tries to establish a connection to the MOVESMART server anonymously. 3. When connection is established the server starts to push current data to the application. 4. The server data updates will run thereafter in set time intervals that can be user configurable, and/or on user demand.
System output	The data received from the server will be processed in the application and will be translated, depending on the data type, into either visual information elements in the application (e.g. traffic network status, public transport information, location of available private vehicles, available seats, location of available bicycles and electric vehicles can be displayed on screen) or used as input to the traffic prediction and eco-routing algorithms.

Alternative flow	Steps: 2.1. There is no access to the MOVESMART server, or connection is lost. 2.1.1. Start a background service to retry connection attempts to the server. 2.1.2. While connection cannot be established user is notified and any dependent functionality is disabled. Traffic prediction and routing algorithms will try to use historical data whenever possible. 2.1.3. When connection is established the application continues with step 3 of the main flow.
Services involved	–
Devices	Portable navigation device (PND), smartphone
Critical success parameters	Data connection availability and data stream reliability
Constraints	Network availability
Relevant UCs	UC1.14, UC3.4
Relevant functional requirements	FR4, FR8, FR21, FR25
Notes and issues	–
Author	Nick Papakonstantinou, CERTH
Version	0.2
Date	23/05/2014

Use Case ID **Use Case Name**	**UC3.4** **Crowdsourcing push functionalities, Alerts and notifications**
Description	• Purpose and goal: To provide alerts and notifications to the user navigation device from the system or other users. • Scenario of use: George, as soon as he is online connects to the MOVESMART data servers and establishes a connection with the messaging subsystem of the server. If George chooses to connect anonymously, system wide alerts or notifications will be received, else if George chooses to login with a private account or a supported popular social network account (e.g. his facebook account) private notifications can be received from his private contacts in the social network (e.g. user status updates, comments) context or a MOVESMART related context (e.g. estimated time arrivals to meetings, current location).
Primary actor	Private driver, commuter, resident, tourist

Secondary actors	Crowd, users in the contacts or friend list of the current user
Priority level	Essential
Reason for assigning this priority	This is the core functionality of usage for the crowdsourced collected data.
Preconditions	Successful connection establishment with the MOVESMART servers.
Trigger	Start of MOVESMART application and connection establishment. Login to MOVESMART network or use a supported social network platform to login.
Main flow	Steps: 1. The user starts the personal navigation device (PND) or smartphone application. 2. The data connectivity subsystem tries to establish a connection to the MOVESMART server anonymously. 3. When connection is established the server starts to push whenever required system wide alerts and notifications. 4. The application provides acknowledgement for each message it receives. 5. The user can choose to use a private account to login to the system in order to receive personal alerts and notifications from his/her personal list of contacts. 6. The server pushes private alerts and notifications and receives acknowledgement similar to step 4. 7. The application receives notifications from logged in social network servers. 8. The application processes the received alerts and notifications and determines the level of impact in current traffic conditions and integrates the data in current or new routing requests.
System output	Alerts and notifications will be visually displayed on screen in a notification area and also as graphical elements on the map. The user can select each element and retrieve more information regarding the alert or notification. Also a list of all received messages will be available via a menu option. Alerts will have an expiration time that when reached they will be deleted from the application automatically.

Alternative flow	Steps: 2.1. There is no access to the MOVESMART server, or connection is lost. 2.1.1. Use the background service from UC3.3 to retry connection attempts to the server. 2.1.2. While connection cannot be established user is notified and any dependent functionality is disabled. Already received alerts and notifications (if any) will still be displayed until they expire (if they have an expiration date/time). 2.1.3. When connection is established application continues with step 3 of the main flow. 2.1.4. If user was logged in with a private account prior to disconnection then the application will try to automatically login again with the same account.
Services involved	–
Devices	Portable navigation device (PND), smartphone
Critical success parameters	Data connection availability
Constraints	Network availability
Relevant UCs	UC1.14, UC3.3
Relevant functional requirements	FR8, FR21
Notes and issues	–
Author	Nick Papakonstantinou, CERTH
Version	0.2
Date	23/05/2014

Use Case ID **Use Case Name**	**UC3.5** **Crowdsourcing pull functionalities, Reports**
Description	• Purpose and goal: To send user reports regarding real-time incidents, current network (traffic/transport) conditions and city related information (e.g. accidents, police road blocks, road works, city transport vehicle status, availability of bicycle or EV, damaged street lights). The goal is to retrieve data from the users and inform swiftly the appropriate parties, improving efficiency in all aspects of urban living. • Scenario of use: Mary, as soon as she is online connects to the MOVESMART data servers and establishes a connection. Mary, via the use of an application menu interface will be able to select the desired report category and select either a predefined report option or fill in a custom report.

Primary actor	Private driver, commuter, resident, tourist
Secondary actors	–
Priority level	Essential
Reason for assigning this priority	This is the core functionality of usage for the crowdsourced collected data.
Preconditions	Successful connection establishment with the MOVESMART servers.
Trigger	Start of MOVESMART application and connection establishment with server. Selection of the report menu.
Main flow	Steps: 1. The user starts the personal navigation device (PND) or smartphone application. 2. The data connectivity subsystem tries to establish a connection to the MOVESMART server anonymously. 3. The user selects the report menu. 4. The user selects a reporting category (e.g. traffic status, traffic incident, transport vehicle status, carpooling, etc.) and subcategory if it exists. 5. The user selects the appropriate report item from a set of predefined reports (these are the most common options). If the predefined reports do not cover the user, then a custom report form can be used where the user can type in free text. 6. The report is then created and the application adds geolocation information and a timestamp. 7. A data channel is opened to the server in order to transmit the report. 8. The server will acknowledge the receipt of the report. And a success message will be displayed to the user. 9. The report will be logged into the system for evaluation and upon success it will be distributed to the users as per UC3.3.
System output	A success message

Alternative flow	Steps: 2.1. There is no access to the MOVESMART server, or connection is lost. 2.1.1. Use the background service from UC3.3 to retry connection attempts to the server. 2.1.2. While connection cannot be established user is notified and any reporting functionality is disabled temporarily. 2.1.3. When connection is established application continues with step 3 of the main flow. 8.1. The server does not acknowledge the report receipt. 8.1.1. The user tries to send a new report as per step 3 of main flow. 8.1.2. The server does not respond with an acknowledgement of receipt. 8.1.3. The application retries to transmit the report. If retransmission is successful then the application proceeds with step 8 of main flow. 8.1.4. The application stores the report and notifies the user that transmission was not successful. 8.1.5. When connection is restored the application notifies the user that there are pending reports that require review from the user. The user can select to delete or resubmit the report.
Services involved	–
Devices	Portable navigation device (PND), smartphone
Critical success parameters	Data connection availability
Constraints	Network availability
Relevant UCs	UC3.6, UC3.7, UC3.8
Relevant functional requirements	FR4, FR7, FR8, FR21, FR25
Notes and issues	–
Author	Nick Papakonstantinou, CERTH
Version	0.2
Date	23/05/2014

Use Case ID **Use Case Name**	**UC3.6** **Crowdsourcing pull functionalities, Tracking data**
Description	• Purpose and goal: To send user location and other related data elements like speed and heading direction data in frequent time intervals. The data can be processed by the system along with data received from other users and determine the current traffic conditions or calculate actual ETA time of vehicles to destinations (e.g. bus to next bus stop). • Scenario of use: Dimos, as soon as he is online connects to the MOVESMART data servers and establishes a connection. Dimos enables the tracking option and the application anonymously transmits required data to the server.
Primary actor	Private driver, commuter, resident, tourist
Secondary actors	–
Priority level	Essential
Reason for assigning this priority	This is the core functionality of usage for the crowdsourced collected data.
Preconditions	Successful connection establishment with the MOVESMART servers.
Trigger	Start of MOVESMART application and connection establishment with server. Enabling of the tracking option.
Main flow	Steps: 1. The user starts the personal navigation device (PND) or smartphone application. 2. The data connectivity subsystem tries to establish a connection to the MOVESMART server anonymously. 3. The user enables the tracking mode. 4. Data are collected at frequent time intervals and are sent to the server.
System output	A graphical element that informs the user that tracking is on.
Alternative flow	Steps: 2.1. There is no access to the MOVESMART server, or connection is lost. 2.1.1. Use the background service from UC3.3 to retry connection attempts to the server. 2.1.2. While connection cannot be established user is notified and any tracking functionality is disabled temporarily. 2.1.3. When connection is established the user is notified and the application continues with step 4 of the main flow. If the user has disabled the tracking mode before reconnection then the application takes no action upon reconnection.

Services involved	–
Devices	Portable navigation device (PND), smartphone
Critical success parameters	Data connection availability
Constraints	Network availability
Relevant UCs	UC3.5, UC3.7, UC3.8
Relevant functional requirements	FR4, FR5, FR17
Notes and issues	–
Author	Nick Papakonstantinou, CERTH
Version	0.2
Date	23/05/2014

Use Case ID	**UC3.7**
Use Case Name	**Crowdsourcing pull functionalities, User feedback**
Description	• Purpose and goal: To retrieve user feedback regarding the application and suggestions regarding the usage that could be used to improve the level of service and introduce new features based on user needs. • Scenario of use: Dimos, as soon as he is online connects to the MOVESMART data servers and establishes a connection. Dimos selects the feedback menu. He selects the feedback type and types in the feedback form. He then submits the data to the server.
Primary actor	Application user
Secondary actors	–
Priority level	Essential
Reason for assigning this priority	This is additional value functionality of usage for the crowdsourced collected data.
Preconditions	Successful connection establishment with the MOVESMART servers.
Trigger	Start of MOVESMART application and connection establishment with server. Selection of the feedback report menu.

Main flow	Steps: 1. The user starts the personal navigation device (PND) or smartphone application. 2. The data connectivity subsystem tries to establish a connection to the MOVESMART server anonymously. 3. The user selects the feedback menu. 4. The user fills in the feedback form and selects an applicable category. 5. The feedback report is created when the user selects the submit button and the application adds geo-location information and a timestamp. 6. A data channel is opened to the server in order to transmit the data. 7. The server will acknowledge the receipt of the feedback and a success message will be displayed to the user. 8. The feedback will be logged into the system for evaluation.
System output	A success message
Alternative flow	Steps: 2.1. There is no access to the MOVESMART server, or connection is lost. 2.1.1. Use the background service from UC3.3 to retry connection attempts to the server. 2.1.2. While connection cannot be established user is notified and any reporting functionality is disabled temporarily. 2.1.3. When connection is established application continues with step 3 of the main flow. 7.1. The server does not acknowledge the feedback report receipt. 7.1.1. The user tries to send a new report as per step 3 of main flow. 7.1.2. The server does not respond with an acknowledgement of receipt. 7.1.3. The application retries to transmit the report. If retransmission is successful then the application proceeds with step 7 of main flow. 7.1.4. The application stores the report and notifies the user that transmission was not successful. 7.1.5. The application will automatically send the feedback report as soon as connection is restored.
Services involved	–
Devices	Portable navigation device (PND), smartphone
Critical success parameters	Data connection availability
Constraints	Network availability
Relevant UCs	UC3.5, UC3.6, UC3.8

Relevant functional requirements	FR4, FR5, FR17, FR21
Notes and issues	–
Author	Nick Papakonstantinou, CERTH
Version	0.2
Date	23/05/2014

Use Case ID **Use Case Name**	**UC3.8** **Crowdsourcing pull functionalities, Sharing and personal data storage**
Description	• Purpose and goal: To share personal user data with other users of the service or social network contacts of the user and store data to cloud server. Providing an enhanced user experience where information like location and ETA of contacts and friends is available. • Scenario of use: Mary, as soon as she is online, her device connects to the MOVESMART data servers and establishes a connection. Mary logs in to the service or to a popular social network using her private credentials. Using a data sharing menu Mary either posts to the server the information and if applicable the intended recipients list or selects data to upload to a cloud storage facility.
Primary actor	Application user
Secondary actors	Users in the contacts or friend list of the current user
Priority level	Supportive
Reason for assigning this priority	This is a desirable functionality of usage for the crowdsourced collected data.
Preconditions	Successful connection establishment with the MOVESMART servers.
Trigger	Start of MOVESMART application and connection establishment with server. Selection of the sharing and storage menu.

Main flow	Steps: 1. The user starts the personal navigation device (PND) or smartphone application. 2. The data connectivity subsystem tries to establish a connection to the MOVESMART server anonymously. 3. The user selects the sharing and storage menu. 4. If the user is not logged in with a private account or social network account a log in prompt is presented. 5. The user selects what to share (e.g. location, ETA, text, image, point of interest (POI), route, etc.) or what to store to the cloud. 6. User selects the intended recipient crowd (e.g. public share, sub-list of contacts or friends) or storage location. 7. User submits the data and a success message is presented to the user.
System output	A success message
Alternative flow	Steps: 2.1. There is no access to the MOVESMART server, or connection is lost. 2.1.1. Use the background service from UC3.3 to retry connection attempts to the server. 2.1.2. While connection cannot be established user is notified and any sharing or storage functionality is disabled temporarily. 2.1.3. When connection is established usage continues with step 3 of the main flow. 3.1. The server does not acknowledge the sharing/storage submission receipt. 3.1.1. The user tries to submit data as per step 3 of main flow. 3.1.2. The server does not respond with an acknowledgement of receipt. 3.1.3. The application retries to transmit the data. If retransmission is successful then the application proceeds with step 7 of main flow. 3.1.4. The application notifies the user that transmission was not successful and cancels the transaction.
Services involved	–
Devices	Portable navigation device (PND), smartphone
Critical success parameters	Data connection availability
Constraints	Network availability
Relevant UCs	UC3.4, UC3.5, UC3.6, UC3.7, UC3.9
Relevant functional requirements	FR25
Notes and issues	–

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3.3.4 Social routing (user-to-user)

The UML diagram for the group of use cases related to social routing is depicted in Figure 19, while the definitions of the corresponding use cases are detailed in the tables that follow.

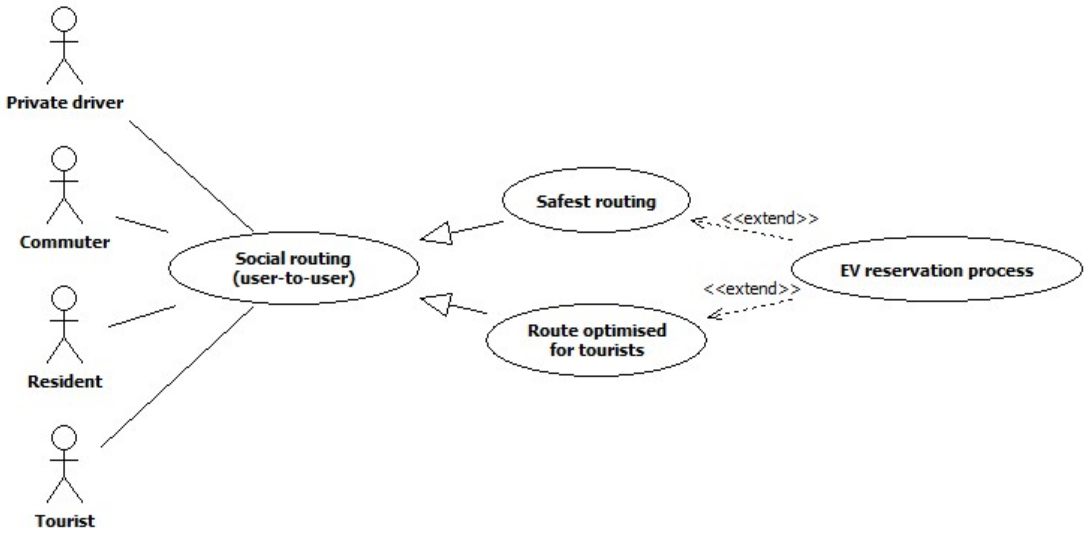

Figure 19: UML diagram for UC3.9-UC3.11

Use Case ID **Use Case Name**	**UC3.9** **Social routing (user-to-user)**
Description	• Purpose and goal: The purpose of this use case is to enable the system to allow participation from multiple users in optimising routes for other road users. The goal is to minimise total travel time and/or make the route safer. Nowadays social media, information sharing and cyber mass participation is an on-going phenomenon that can be very useful in different ways, including transportation and route planning. Using users' traffic information data for optimising another users' route could be made possible by enhancing the data gathering with different forms of rewarding the data sharing. • Scenario of use: A private driver, commuter, resident or tourist sends live data from his/her route and from EV- and bike- sharing systems to the MOVESMART platform which processes them and forwards optimised data to other users on the same or a similar road.
Primary actor	Private driver, commuter, resident, tourist
Secondary actors	–
Priority level	Supportive
Reason for assigning this priority	This is a desirable feature, but not essential for the MOVESMART project.
Preconditions	• The user has registered to the MOVESMART platform. • A connection has been established with the MOVESMART platform. • The user's location and movements are known (but anonymous) via GPS tracking of the mobile device. • He/she is willing to send traffic data and information about available EVs and bikes for free or for a small reward.
Trigger	The user logs into the MOVESMART platform and starts sending data.

Main flow	Steps: 1. The user identifies him/herself and can be tracked via GPS. 2. The user starts sending road and traffic information (incidents, traffic jams, road works, sudden weather changes) or information about EVs or bikes availability. 3. The system retrieves information on real time traffic conditions, public transport availability and shared-use EVs and bikes. 4. The system forwards optimised data to other users that request information. 5. The system rewards users sending the data with free rentals, free mobile internet, etc.
System output	The system outputs real-time accurate data and optimised routes for users who have requested it, based on other users' sent data.
Alternative flow	Steps: 1.1 There is no access to the MOVESMART platform (communication failure). 1.1.1 No data collection is possible hence no real time and accurate reports can be made. 1.1.2 The system reports that no information is available.
Services involved	Data gathering, on-trip routing
Devices	Smartphone
Critical success parameters	Online connection for data gathering and dissemination
Constraints	Due to the necessity of monitoring user activity, the system must ensure that the collected data are protected and anonymous. Due to the requirement for a server connection, network coverage is needed in the area of the service.
Relevant UCs	UC3.3, UC3.4, UC3.5, UC3.6, UC3.7, UC3.8
Relevant functional requirements	FR4, FR6, FR8, FR9, FR21
Notes and issues	This use case may occur on a stand-alone basis or as part of other use cases.
Author	Kristina Fedel Timovski, PULA Iva Ivančić, PULA
Version	0.3
Date	03/07/2014

Use Case ID **Use Case Name**	**UC3.10** **Safest routing**
Description	• Purpose and goal: The purpose of this use case is to enable the suggestion of safe routes, i.e. routes for EVs (bicycles and scooters) less dangerous for the safety of the users. The goal is to make the route safer but at the same time minimise total travel time (not jeopardising the safety). • Scenario of use: A private driver, commuter or resident requests the safest route suggestion with minimal travel time and taking into account safety first.
Primary actor	Private driver, commuter, resident
Secondary actors	EV/bike-sharing service provider, public transport operator
Priority level	Supportive
Reason for assigning this priority	This is a desirable feature, but not essential for the MOVESMART project.
Preconditions	• The user has registered to the MOVESMART platform. • A connection has been established with the MOVESMART platform. • The user's location is known, either entered by him/her or through GPS. • The user's final destination has been entered.
Trigger	The user logs into the MOVESMART platform to request the safest route to arrive from his/her current location to the final destination.
Main flow	Steps: 1. The user identifies him/herself and requests the safest route from his current location to the final destination. 2. The system requests/retrieves information on real time traffic conditions and predicts possible traffic conditions. 3. The system displays the safest route. 4. While the user is on the route, the system alerts the user if any incident or other problems occur.
System output	The system outputs the route optimised for safety, as well as relevant real-time information about traffic incidents.

Alternative flow	Steps: 1.1 There is no access to the MOVESMART platform (communication failure). 1.1.1 No data collection is possible hence no real time and accurate reports can be made. 1.1.2 The system reports that no information is available.
Services involved	Real time data gathering, on-trip routing
Devices	Smartphone
Critical success parameters	Online connection for data gathering and dissemination
Constraints	Due to the requirement for monitoring user activity, the system must ensure that the collected data are protected and anonymous. Due to the requirement for a server connection, network coverage is needed in the area of the service.
Relevant UCs	UC3.3, UC3.4, UC3.5, UC3.6, UC3.7, UC3.8
Relevant functional requirements	FR4, FR5, FR6, FR7, FR9, FR15, FR17
Notes and issues	This use case may occur on a stand-alone basis or as part of other use cases.
Author	Kristina Fedel Timovski, PULA Iva Ivančić, PULA
Version	0.3
Date	03/07/2014

Use Case ID **Use Case Name**	**UC3.11** **Route optimised for tourists**
Description	• Purpose and goal: The purpose of this use case is to enable the suggestion of routes optimised for tourists. The goal is to make possible for the tourists to safely go around the city with the possibility to visit different points of interest (POIs). • Scenario of use: The tourists want to receive multimodal route suggestions for a one- or several-day itinerary from their hotel (or other accommodation possibilities) to visit various sights fitting their preferences and the current time circumstances (e.g. weather, day of the week, time of the day).
Primary actor	Tourist
Secondary actors	EV/bike-sharing service provider, public transport operator
Priority level	Supportive

Reason for assigning this priority	This is a desirable feature, but not essential for the MOVESMART project.
Preconditions	• The tourist has registered to the MOVESMART platform. • A connection has been established with the MOVESMART platform. • The user's location is known, either entered by him/her or through GPS. • The user's preferences, needs and POIs have been entered.
Trigger	The tourist logs into the MOVESMART platform to request the best multimodal route for his/her corresponding tourist itinerary.
Main flow	Steps: 1. The user identifies him/herself and requests the best multimodal route for his/her corresponding tourist itinerary. 2. The system requests/retrieves information on real time traffic conditions as well as availability of public transport, shared-use EVs and bikes. 3. The system displays the possible routes (few itinerary suggestions) including multimodal routes in between the itinerary stops and the key characteristics of the itinerary, e.g. number of stops and budget needed offering the user to choose the route that suits him/her best.
System output	The system outputs a tourist itinerary with corresponding multimodal routes according to user preferences, together with the itinerary's key characteristics.
Alternative flow	Steps: 1.1 There is no access to the MOVESMART platform (communication failure). 1.1.1 No real time data service is possible, but the tourist can use the earlier downloaded trip suggestions. 1.1.2 The flow continues with step 3.
Services involved	Pre-trip planning, on-trip routing
Devices	Smartphone
Critical success parameters	The itinerary returned shall be feasible (e.g., it shall respect POI's opening hours and sufficient time between stops for multimodal transport), and fit the user's preferences.
Constraints	Due to the requirement for a server connection, network coverage is needed in the area of the service.
Relevant UCs	UC3.1, UC3.10
Relevant functional requirements	FR2, FR4, FR5, FR6, FR7, FR9, FR17, FR18, FR20

Notes and issues	This use case may occur on a stand-alone basis or as part of other use cases.
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4 Priority Application Scenarios

This section presents the selected use cases in the form of priority application scenarios that shall be deployed during the pilots of the MOVESMART project. The priority application scenarios are divided into groups according to the innovative MOVESMART applications and services, namely "Renewable Mobility on Demand Feature", "Incentivised Vehicle Sharing Feature" and "Integrated Personal Mobility Service". Each scenario is assigned a unique identifier in the form of $x.y$, where x is an integer number from 1 to 3, corresponding to each one of the main MOVESMART features/services, while y is an integer number that specifies each subsequent priority application scenario. Moreover, each scenario is described according to the template shown in the following table.

Scenario ID **Scenario Name**	**<unique identifier in the form $x.y$>** **<brief title that expresses the functionality/goal of this scenario>**
Description	<a brief statement summarising the context of the use cases considered for the creation of this scenario>
Relevant UCs	<IDs of the relevant MOVESMART use cases for the creation of this scenario>

4.1 Renewable Mobility on Demand Feature

Scenario ID **Scenario Name**	**1.1** **Eco-friendly mobility chains consisting of EVs with public transportation media**
Description	This scenario involves the use cases that allow combining EVs with public transportation media in order to create eco-friendly mobility chains. The user receives a number of route suggestions (e.g. fastest, economic, eco-friendly and/or robust) according to his/her routing preferences, while detailed information on a specific route are provided upon request. All the route calculations take into account time-dependent traffic data and the suggested routes are based on live and predicted traffic conditions. At the end of the trip, the user is requested to report his/her level of satisfaction with respect to the recommended options and information provided.
Relevant UCs	UC1.1, UC1.2, UC1.3, UC1.4, UC1.5, UC1.6, UC1.7, UC1.8, UC1.9

Scenario ID	**1.2**
Scenario Name	**EV-enabling functionalities and reward information**
Description	This scenario includes the use cases that enable, support and incentivise the use of EVs in the context of the Renewable Mobility on Demand feature. Depending on the use case, the user may request information about nearby charging/drop-off stations, SoC of available EVs, sufficiency of battery charge to complete a given trip, and then proceed with the EV reservation process, while receiving any potential incentives that may apply.
Relevant UCs	UC1.10, UC1.11, UC1.12, UC1.13, UC1.14, UC1.15

Scenario ID	**1.3**
Scenario Name	**"On the spot" choice of the next leg of a trip**
Description	This scenario encompasses the use cases that allow the user to decide "on the spot" which transportation medium he/she wishes to choose for the next leg of his/her trip. It also covers the situations where the user receives alerts and notifications about real time disruptions (due to emergency traffic incidents or weather changes) or insufficiency of battery charge to complete a given trip with an EV, and thus he/she is shown a number of options to choose from in order to proceed with his/her trip.
Relevant UCs	UC1.1, UC1.2, UC1.3, UC1.6, UC1.7, UC1.8, UC1.11, UC1.16

4.2 Incentivised Vehicle Sharing Feature

Scenario ID	**2.1**
Scenario Name	**Incentivised vehicle sharing**
Description	To incentivise the adoption of "good practices" for urban displacements, some rewards will be offered to the potential users. These rewards will be managed by the system, in the form of a personal bonus account. Indicatively, the users can increase their bonus account in several ways, such as: (i) by choosing the most ecological option when planning their route, (ii) by using EVs for urban displacements, (iii) by supplying the system with feedback information about traffic conditions and incidents, (iv) by travelling from a low demand area for EVs to a high demand area, and (v) by sharing their own private vehicle or a rented EV with other users following the same route. Examples of incentives to be offered to the users (that will be managed by their personal bonus account) may include: (i) discount in the use of EVs, (ii) discount in public parking lots, and (iii) discount in charging stations for the EV.
Relevant UCs	UC1.7, UC1.14, UC1.15, UC2.1, UC2.2, UC2.6, UC2.7, UC3.5, UC3.6, UC3.7

Scenario ID	**2.2**
Scenario Name	**Dynamic relocation strategies**
Description	The problem of the vehicle relocation among the EV parking stations is of key importance to assure a good correspondence between the demand for and the availability of the EVs. Each station of a vehicle sharing system must provide sufficient availability of vehicles to increase the possibility that each user can find a vehicle when needed. But, usually, along the day and due to the one-way rental policy, vehicles tend to be concentrated on low-demand stations, while they are required mainly in high-demand stations. To solve this problem, two strategies can be followed: (i) The "static strategy": A team of employed drivers undertake the relocation of vehicles among stations (usually at night). To make the system more efficient and profitable, this relocation must take into account the offer / demand forecast for each station. (ii) The "dynamic strategy": In order to achieve a dynamic relocation of the EV fleet, the system should incentivise the displacement of EV users from locations with low demand and high density of available EVs towards locations with high demand and low density of available EVs. To achieve it, a dynamic pricing policy must be implemented, in the form of fixed prices with dynamic bonuses or varying prices depending on the demand from the users / available EVs balance in each geographical area in the city. The system will provide the user with these options (i.e. the nearest picking stations and estimated prices for the possible routes) upon his/her request for reserving an EV. The "dynamic strategy" is based on a dynamic pricing policy that must be implemented by the EV fleet manager. If the incentives of this dynamic pricing policy are appropriate, the EV fleet manager can reduce drastically the costs of the employed drivers needed for the "static strategy".
Relevant UCs	UC1.13, UC1.14, UC1.15, UC2.1, UC2.2, UC2.4

4.3 Integrated Personal Mobility Service

Scenario ID	**3.1**
Scenario Name	**Crowdsourcing push functionalities and optimised multi-modal routing based on crowdsourced data**
Description	This scenario deals with the alerts, notifications and updates provided to the user device from crowdsourced retrieved data processed by the system. The data pushed to the device will contain traffic, transport, shared vehicle locations and availability (e.g. EVs, bicycles), information. The system will stream background data to the device including system wide alerts, notifications, private messages and any related information that can be displayed in the user application interface (e.g. traffic information, vehicle locations, transport network status updates). The data will be used to provide up-to-date point-to-point route directions minimising travel time and optimising efficiency, utilising different means of travel depending on user preferences (i.e. public transport, private transport, EVs, bicycles).
Relevant UCs	UC3.1, UC3.2, UC3.3, UC3.4

Scenario ID	**3.2**
Scenario Name	**Crowdsourcing pull functionalities**
Description	This scenario involves the retrieval of information from the users connected to the system in the form of regular anonymous data streams that contain locations, direction headings and speeds. This information can be used to determine current transport or traffic conditions. Additional types of information include user initiated reports or feedback that will contain information regarding various traffic or transport incidents, shared vehicle availability updates and any other type of user generated report, which will be used to provide up-to-date information to other users of the system and improve the quality of service offered.
Relevant UCs	UC3.5, UC3.6, UC3.7

4.4 Excluded use cases

The priority application scenarios defined in the previous subsections were structured on the basis of the important aspects of the MOVESMART project that shall be demonstrated and evaluated at the pilots, such as the use of crowdsourcing techniques and cloud computing technologies, optimisation of energy use and environmental impact, as well as business models about incentivising users on

the use of EVs. Despite their importance and relevance to the goals of the project, a number of use cases was excluded from the formation of the priority application scenarios because of practical issues. Specifically:

- "UC2.3 The user receives commercial information to profit for discount" because of its low priority and the fact that its implementation requires agreements with third parties outside the project consortium, the establishment of which cannot be guaranteed at the present stage of the project.
- "UC2.5 Vehicle relocation strategies, Car-sharing systems" because MOVESMART foresees the deployment of electric scooters and bicycles at the pilots, but not electric cars.
- "UC3.8 Crowdsourcing pull functionalities, Sharing and personal data storage", "UC3.9 Social routing (user-to-user)", "UC3.10 Safest routing" and "UC3.11 Route optimised for tourists" because of their low priority as well as the potential legal issues that may arise under certain conditions, e.g. reading user-to-user messages while driving.

It is noted though that use cases of the list above may still be employed to further enrich the test scenarios of MOVESMART should the conditions during the pilots planning allow for it.

5 Summary & Conclusions

The present deliverable was prepared in the frame of WP2 User Requirements and System Architecture with the goal to precisely describe the use cases that adhere to the user requirements and can be realised by the foreseen MOVESMART applications and services, as well as to define a sufficient number of priority application scenarios to be deployed at the pilots, through which the results of the project can be evaluated and demonstrated.

The use cases were defined following the engineering methodology presented in section 2, and detailed using both a tabular template developed for the specific needs of MOVESMART and UML use case diagrams. For the sake of clarity and coherence, the defined use cases were classified into three groups according to the innovative MOVESMART applications and services, namely "Renewable Mobility on Demand Feature", "Incentivised Vehicle Sharing Feature" and "Integrated Personal Mobility Service". The use cases that refer to the "Renewable Mobility on Demand Feature" provide the user with all the necessary information required to create eco-friendly mobility chains consisting of EVs and public transportation media, allowing him/her at the same time to decide on the spot which transportation medium he/she wishes to choose for the next leg of his/her trip. The use cases under the "Incentivised Vehicle Sharing Feature" deal with travellers' rewards and proper strategies to incentivise the use of EVs and vehicle sharing/pooling systems, while the use cases related to the "Integrated Personal Mobility Service" provide door-to-door navigation opportunities, based on real time data and accurate predictions.

Last, a prioritisation scheme was devised to extract, among the define use cases, those scenarios that represent the innovative applications and services of MOVESMART to deploy during the pilots of the project. Taking into account the specific priority levels assigned to each use case along with other practical considerations for their demonstration and evaluation at the pilots, the whole process led to the selection of 28 out of 34 use cases for the formation of 7 priority application scenarios.

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