ALMANAC

RELIABLE SMART SECURE
INTERNET OF THINGS FOR SMART CITIES

(FP7 609081)

D8.4 Application Definition - Waste Management

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Index:

1. Executive summary

The work-package 8 focuses on evaluation and demonstration activities of the ALMANAC Smart City platform. For this purpose, three types of prototype applications have to be specified, developed, deployed and evaluated within the respective tasks:

- T8.2: Water Management Application
- T8.3: Waste Management Application
- T8.4: Citizen-centric Application

This deliverable provides an informal description, collection of related resources (research projects, concepts, available software) and a formal specification of the "Waste Management Application" underlying the implementation of the task T8.3.

Initially an informal analysis and scenario-based application description is presented along with references to related resources. This is followed by a formal specification according to IEEE 42010, intended to guide the prototype development done in three iteration steps scheduled for the months M12, M24 and M36. The document concludes with an overview of open issues that could not be clarified because of the theoretical nature and early delivery phase of this document, but are to be resolved during the implementation stage.

2. Introduction

2.1 Purpose, context and scope of this deliverable

This deliverable provides an informal description and a formal definition of the "Waste Management Application" developed within task 8.3. The application is intended to showcase the capabilities and help to evaluate the ALMANAC Smart City Platform. Its development will be done iteratively and materialized in a series of prototype deliverables (M12, M24, M36). At each stage newly discovered or updated user requirements, research findings and technologies will be considered.

Due to its early timing and theoretical character, this deliverable will necessarily remain generic and high-level and will be concretized by further evolution of the prototype.

For the writing of this document following relevant deliverables were consulted:

- D2.1 Scenarios for Smart City applications (M2)
- ID2.3 Prototype Application Specification (M9)
- ID8.1 Evaluation Framework (M9)

An alignment with the deliverable "D8.2 Application Definition – Water Management" was sought concerning a shared conceptualization and definition of ALMANAC prototype applications.

3. Application Description

3.1 Introduction

An extensive description of the waste management domain in City of Turin was given by deliverable D2.1, section "3.2 Waste management". We try to summarize and generalize the findings in order to make them compliant with conditions found in other European communes. An informal description of the current status, identified problems and requirements is provided in order to motivate the solutions proposed in subsequent sections.

In the city of Turin there is a single company handling the entire waste management, AMIAT.In general, there might be situations, where multiple utility companies are engaged in collection of (different types of) waste. Such e.g. in city of Bonn close to ALMANAC partner FIT's premises recyclable and non-recyclable waste are collected by different companies running independent businesses (REMONDIS AG & Co. KG vs. bonnorange AöR). This introduces a requirement on the system to maintain separate scopes (discrete data domains for individual companies) while offering shared services and a unified user interfaces for citizen participation.

The main collection methods indicated by D2.1:

Door-to-door (household waste)	Covers 45% of the total population of Turin (2011). The door-to door waste bins are small, located on/close to the property and can be matched to a specific household. Normally the waste is of higher than average quality due personal attention and fees applied.
Underground ecological islands (UEI)	UEIs are underground metal containers with a large storage capacity (5 m^3) used e.g. in large apartment buildings or very small backyards. Recently there are 9 UEIs in 5 areas. UEIs exhibit *occasionally* waste quality issues: waste being abandoned beside the UEIs and being of poor quality (sorting).
Street-based collection ("stradale")	Small waste bins located on the side of the streets. A collection type that produces the poorest quality of waste, being *often* abandonment beside the bins and unsorted. The recycling rate is low, maximum of 32-33%.

Many variations and hybrid forms of waste containers exist supplemented by elaborated (semi-automatic) collection equipment in order to best fit given environmental conditions (demand, traffic, architecture etc.) [1].

The *underground ecological islands* (UEI) are the focus of the application due to their manageable count, intense utilization by a number of citizens and apparent waste quality issues. These issues result from various factors e.g. insufficient collection, indifference, low degree of knowledge and ownership and should be mainly addressed, according to D2.1, by these goals:

1. Optimization of waste collection
2. Increased quality of waste (proportion of recycled waste)
3. Education and engagement of citizens in waste recycling

The ALMANAC Description of Work (DOW) envisages an automatic measuring of the fill level in the garbage bin and data aggregation techniques. This is done to support the waste management activities and to enable business- and decision intelligence solutions for the municipality and provide insights in actual demand (waste production).

[1] http://www.nordengineering.com/en/products/easy-waste-collection-system.html

3.2 Scenario 1: Collection optimization by unified waste issue management

This scenario assumes that the overall process efficiency of the waste collection process and citizen satisfaction would increase by joining the disparate information sources within a unified "waste issue management system". For this purpose we generalize the notion of a waste (collection) issue from, among others:

- Explicit citizen's complaint or collection request supplied via a variety of media (mobile app, email, phone, SMS). A request may need an administrative approval (sanity check) and comply to business policies (e.g, requesting the presence of a contract) in order to become an "issue";
- Issues observed and reported by utility employees in course of their normal collection activity;
- Automatically retrieved fill level of a waste container (UEI) indicating a close-to overload status;
- Scheduled extra collection of a container (in case the default collection failed because of traffic conditions etc.);
- Scheduled default collection of a container based on historical usage patterns gained from statistical analysis of fill level data.

All these "waste issue" types share the way they are handled (by collecting the waste), but they may differ significantly in terms of precedence, location, amount, material and personal costs etc.

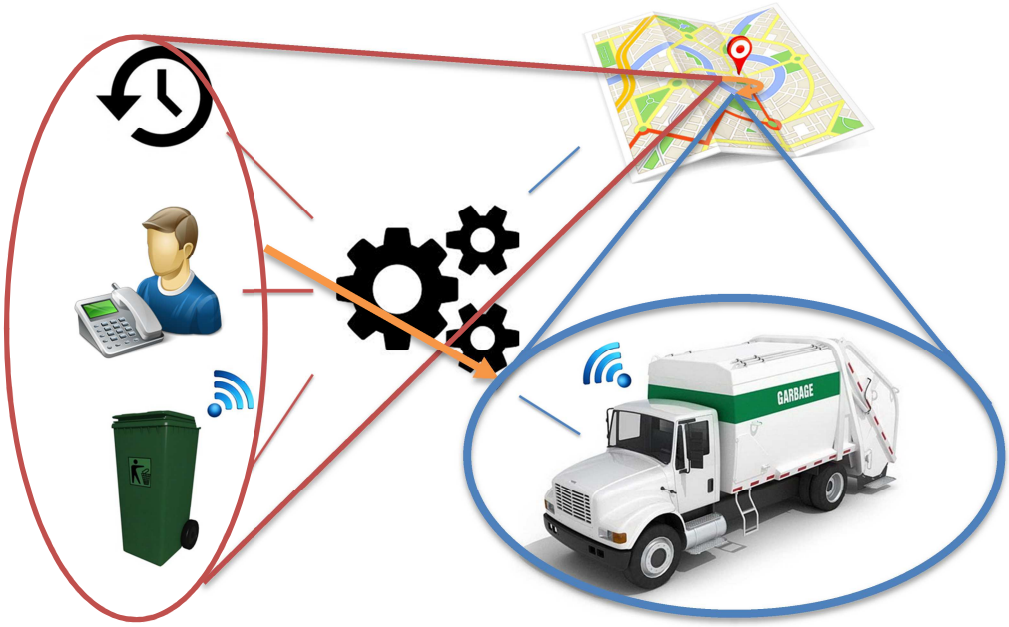
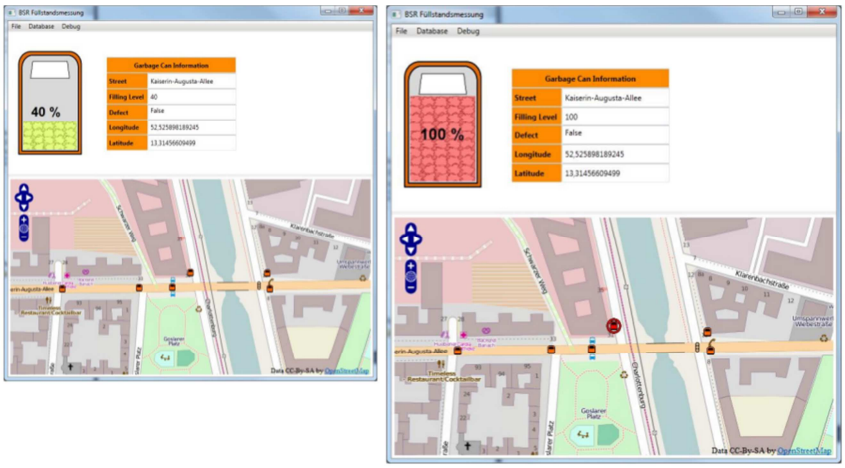


Figure 1. Waste issue management outline

Figure 1 outlines the main constituents of the "waste issue management system". A variety of waste issue instances (left) are being fed into a collection optimization and routing algorithm (center). This is equipped with geographical (routing, bin location) and contextual knowledge (current position and fill level of a collection vehicle, traffic situation, etc.) and further constraints. The interplay of these components results in generation and execution of an accurate, efficient and reactive route plan.

3.2.1 Related resources

Issue tracking systems (ITS)	This type of software is commonly used to track and manage the overall lifecycle of user requests/tickets (incident, enhancement, change etc.) from their inception until their resolution. The analysis of these systems will provide valuable hints/extension point for creating the citizen-centric

	part of the waste issue management system.
Vehicle routing problem (VPR)	VPR seeks to optimize routing of vehicles e.g. to minimize the total route cost, number of retours etc. Open source solutions exist (OptaPlanner).
Waste collection routing	Commercial solution tailored for routing, scheduling and optimization of waste collection should be consulted when designing the application (e.g. SmartService).
Waste management software	Software supporting esp. the operational needs of waste management businesses, than the collection routing (e.g. WASTELOGICS).
OUTSMART Project	The goals of OUTSMART's use case "Berlin intelligent waste collection" are closely related to ALAMANC's vision. It attempts to optimize the waste management by deploying a network of "intelligent waste baskets" and corresponding sensors in collection vehicles. A user interface leveraging OpenStreet maps indicates the fill level of waste bins:  Figure 2. OUTSMART Berlin cluster user interface (excerpt) The bins are identified by RFID tags persisting bin's rewritable metadata: GPS-coordinates, type, colour, last maintenance and date of installation. Collection teams may automatically extract this ID in order to indicate the collection done or indicate any encountered issues.

3.3 Scenario 2: Waste quality optimisation

Both remaining goals – to increase the quality of waste and optionally gain knowledge and to educate and guide citizens in waste recycling – target especially larger collection units (UEI). Fundamentally this scenario focuses on monitoring only those who do not manage the waste properly. Unfortunately it is impossible to know ahead which waste had been correctly separated and which not, therefore all waste must be monitored. The goals are based on some fundamental concepts:

Waste quality report	Message indicating the quality of waste underlying an issue. Normally intended to report significant portion of inappropriate or unexpected materials in recycled waste.
Waste traceability	Regular waste bags (e.g. handed out to customers by the utility company) are equipped with unique, persistent identifiers (QR or Bar Code) giving a portion of included

	recyclable waste an opaque identity. The IDs are either directly printed on the bags or attached via a robust sticker on the surface. If the IDs are involved in sensible operations (e.g. billing-per-amount) every customer should be provided with a list of private ID-ranges, comparable to TAN[2] lists, in order to prevent their fraudulent use. The IDs encode in an encrypted and opaque way the waste provenance of arbitrary precision (household, apartment etc.) along the whole process of collection and manual separation. Only an implementation guaranteeing thorough privacy and security considerations will achieve citizen's acceptance. Possible waste quality issues identified along this chain (or their absence) may be internally traced back to the customer and trigger an appropriate action: the activation of an informative "customer feedback loop", a fining or reward procedure.
Customer feed-back loop	The customer feedback loop comprises a bundle of informative and educational media used to explain occurred issues and help in their prevention.

Figure 3. Outline of the waste recycling process

According to the simplified waste recycling chain depicted in Figure 3 the customers use provided waste bags to collect and package their sorted waste. In order to stimulate and enforce the usage of such traceable packaging the ID codes on the bags may optionally be used to first unlock the container/compacter.

[2] http://en.wikipedia.org/wiki/Transaction_authentication_number

Once that is collected, the waste arrives in the sorting-hall for recyclable waste to be separated along the conveyor line (manually or semi-automatically). The respective portions are delimited and marked by the ID tag. In case of identified problems, the operators send "waste quality reports" via a robust input device (e.g. a "toughpad").

Depending on business cases and the contract clauses in place, the frequency or severity of the reported issues a number of escalating actions may be triggered via a "customer feedback loop". On the contrary a positive feedback loop and reward program may be provided to cooperative customers.

3.3.1 Related resources

TerraCycle Zero Waste Boxes 	US upcycling and recycling company TerraCycle offers waste collection boxes for more or less homogenous "waste streams" (coffee capsules, alkaline batteries etc.). The UPS shipping and additional processing are included in the price. "Zero Waste Boxes" are priced according to separation level, some are sponsored by product manufacturers.
Waste bin identification	(RFID-based) Waste bin identification has in the past mostly been used to support particular business cases (individual billing, proof generation etc.) via a sensor-processing and transmission cycle, see e.g. MOBA.
FP5 European Waste Management Cluster (EUWMC) - 1999 to 2005	The six FP5 EU research projects tackled topics like waste production simulation, methodologies and business models (Pay-as-you-throw, variable rate pricing for reduction of residual waste disposal in order to increase recycling rate).

4. Application specification

4.1 Introduction

Following the IEEE 42010 methodology for architecture description, we specify the target application according to the functional, informational and deployment view. According to the methodology, a "view" represents one or more structural aspects of the architecture that illustrates how the architecture addresses one or more concerns of its stakeholders.

4.2 Functional view

This section gives an overview over the different components, their functionalities, interfaces (APIs) and interactions.

In the Figure 4 the high-level functional definition is presented in terms of use case packages. Due the complexity of the functional model the UCs are grouped in 8 packages which identify functional subsystems in the application:

1. Waste Issue Management
2. Waste disposal
3. Report management
4. Route Planning
5. Monitoring and Analytics

These five use cases cover the basic functionalities of the waste application. There are additionally three use cases (these are not presented in Figure 4 but are discussed in the subsequent sections) that are functionality needed for the correct functioning of the system, but they are not the goal of the application:

1. User Administration
2. Identification
3. Equipment Administration

Altogether the application should implement the two above mentioned scenarios, which after extensive study are split in several functional units (UCs) implemented in dedicated subsystems.

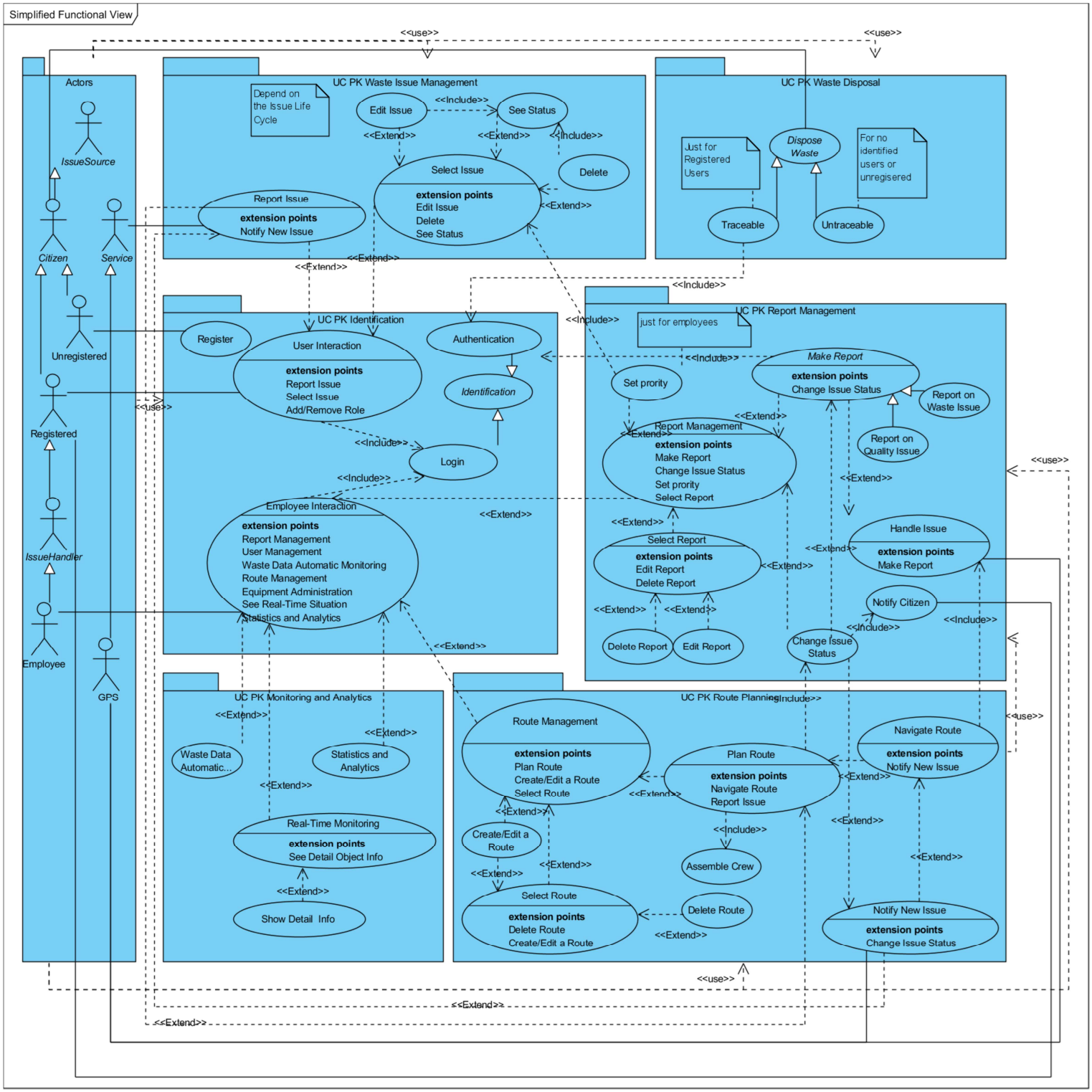


Figure 4. Main functionalities of the application

We assume the following types of actors that interact with the system:

ID	Actor Name	Description
A01	IssueSource	Abstraction of any entity that could "report" an issue, either a human being or a digital service.

A02	IssueSource::Service	Representation of a software entity capable to report issues or act as a source of arbitrary data (e.g. a sensor)
A03	IssueSource::*Citizen*	Any person interacting with the system.
A04	Citizen::Unregistered	Representation of citizen which interacts with the system but its identity is unknown (general public).
A05	Citizen::Registered	A citizen which identity is known thanks to a prior registration and authentication steps.
A06	Registered::IssueHandler	A citizen which is allowed to handle (solve) issues.
A07	IssueHandler::Employee	A citizen which works for a service provider and is allowed to handle issues.
A08	Service::GPS	Services providing GPS positioning data.
A09	Service ::FillLevelObserver	Services evaluating fill level data of waste bins turning them into "issues" according to predefined rules and thresholds.

In each of the following chapters the UCs will be explained in they correspondent package. It is worth to mention that the UC are described at "high level" due to the reasons mentioned in the introduction.

4.2.1 Package: Identification

This package is a transverse package of the system and is used over all the packages presented in this document. An overview of the Identification related use cases is presented in Figure 5. This package offers the functionality needed for bringing an identified access token (UC-ID03 Login) to the application allowing role based interaction with the system (just a Registered Citizen or an Employee). It also allows new users to enrol in the system (UC-ID06 Register).

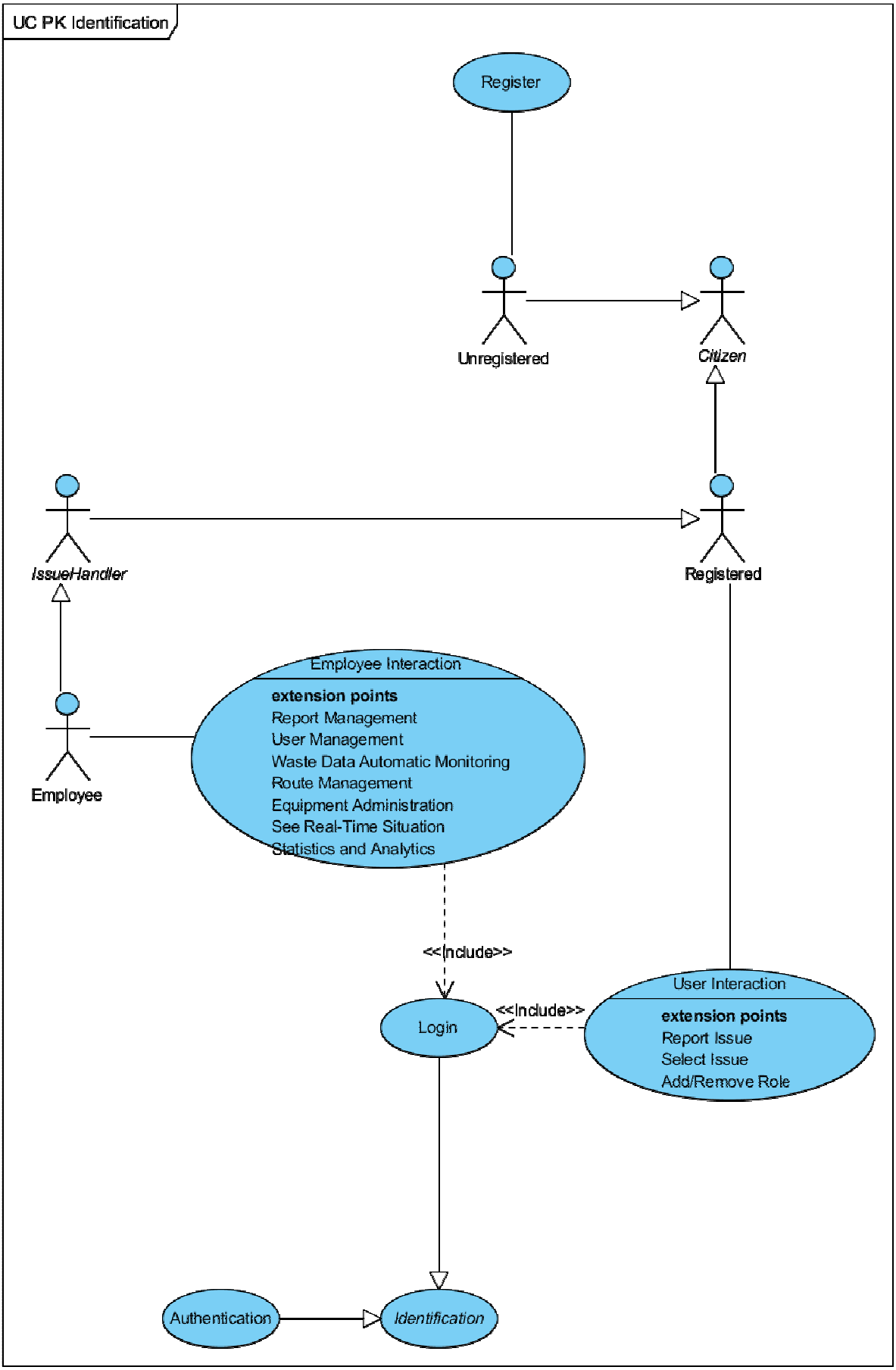


Figure 5. Package Identification

UC-ID01 Identification

Abstract use case, which has the goal to identify (and optionally authenticate) discrete entities of the system.

UC-ID02 Authentication

This use case refers to the authentication of the user or a traceable waste item within the IoT infrastructure through an identification object (QR code etc.). As result of a successful authentication, the user is e.g. able to open the cover of the collection bin (UEI) and the container is being recognized. This use case is precondition of a controlled waste disposal (UC-WD02) and quality report creation (UC-RM06).

UC-ID03 Login

This UC involves a user entering credentials via GUI in order to become a registered actor (A05) with access to a selective, role-based access to system's functionality. The user enters a user name and password, the system shows if the login was successful or failed.

UC-ID04 User Interaction

Root of use cases specifying interactions any registered actor (A05) may perform on the system. When login finished successfully, the system shows the possibility of starting derived use cases, e.g. issue reporting (UC-IR01).

UC-ID05 Employee Interaction

Root of use cases specifying interactions an employee user (A05) may additionally perform on the system. When login finished successfully, the system shows the possibility of starting derived use cases, e.g. issue and report management, route planning etc.

UC-ID06 Register

This use case is triggered by an unregistered citizen actor (A02) in order to create a system account and thus obtain access to restricted system functionality. The system presents a form with required data, some configuration options etc. Upon a successful registration the user is given the status of registered citizen actor (A05).

4.2.2 Package: Waste disposal

The problem of waste management starts when the citizen disposes waste. This package tackles this basic functionality. The content of the package is summarized in Figure 6.

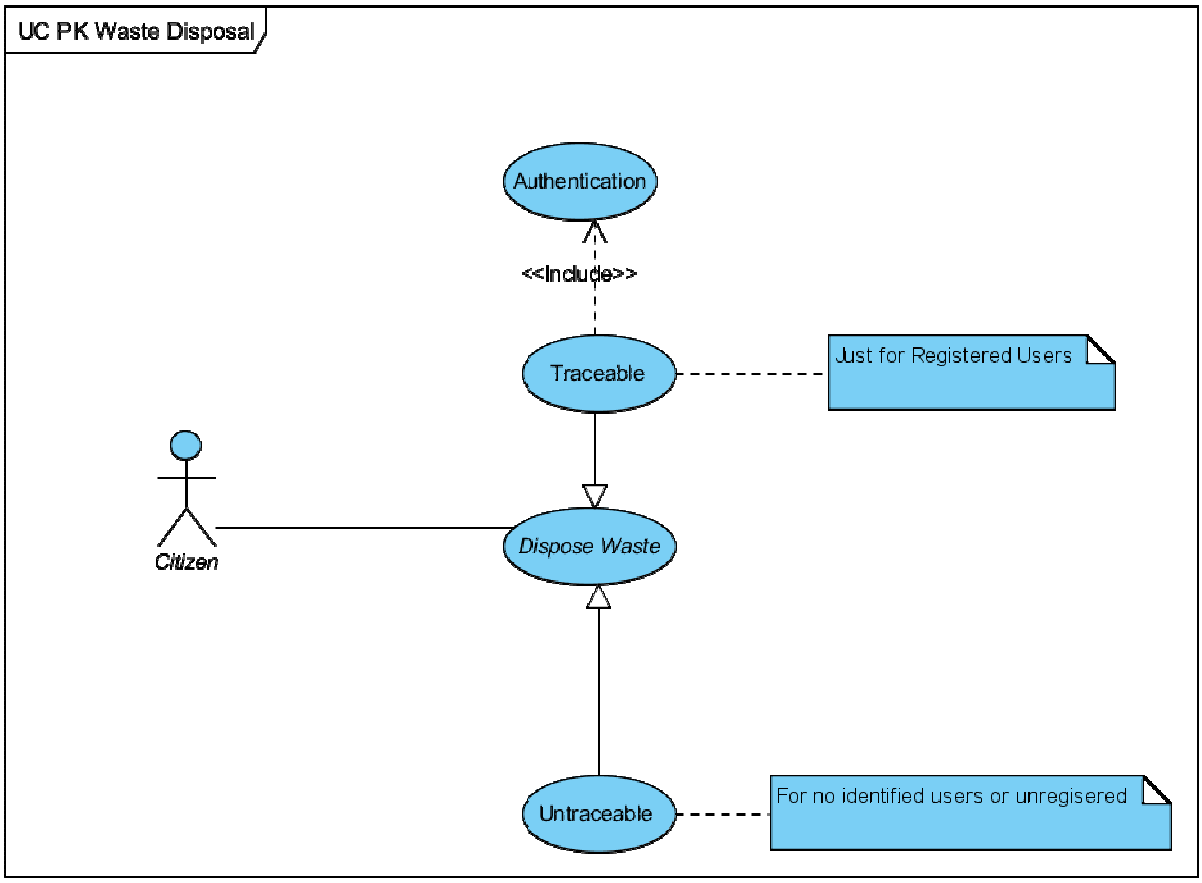


Figure 6. Waste disposal package

UC-WD01 Waste disposal

This is an abstract UC and is concretized as UC-WD02 and UC-WD03.

UC-WD02 Traceable disposal

This UC describes scenarios where a preceding user authentication (UC-SI02) is required, e.g. via a QR code on a traceable bag in order to open the collection bin (UEI).

UC-WD03 Untraceable disposal

This UC describes scenarios where no preceding user authentication is required and the waste container is available to any citizen actor (A03).

4.2.3 Package: Waste Issue Management

This package tackles the functionality needed by the user to interact with the waste collection service provider, to create and manage waste issues. The summary of the package can be seen in Figure 7.

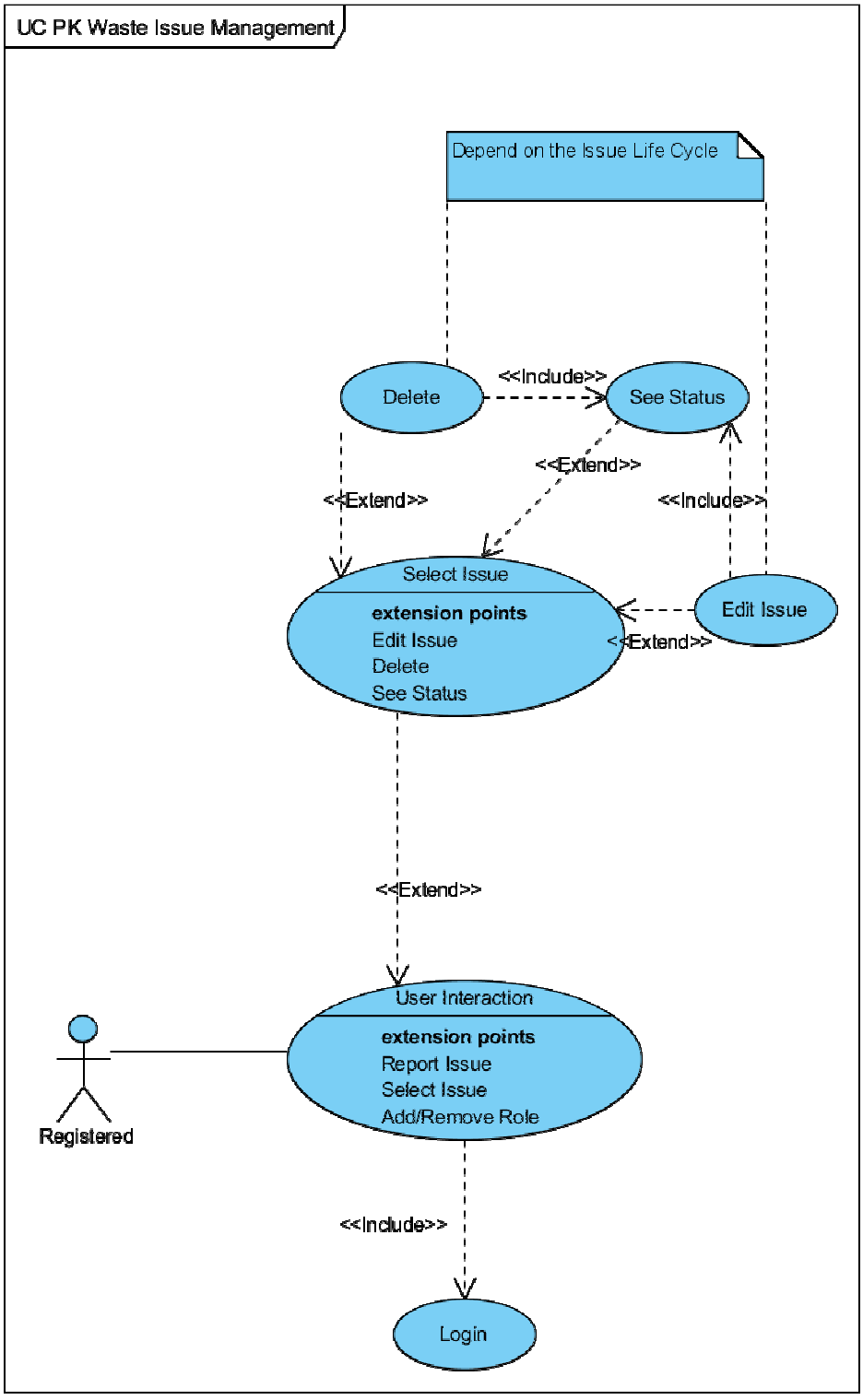


Figure 7. Waste issue management package

UC-WI01 Report Issue

A waste issue indicating the need for collection may be initiated by a registered citizen (A05) or service actor (A02) – the latter being e.g. a service evaluating the fill level of a bin.

Depending on the user the UC behaves differently:

For the **A02**:

An ALMANAC service (e.g. sensor) identifies a waste issue in the city

For the **A05**:

After the login the registered citizen (A05) selects that he/she wants to report an issue. Upon creation this issue may be forwarded to an appropriate collection handling in a compatible route via the use case UC-RP03 **"**Notify new issue".

UC-WI02 Select Issue

The registered citizen actor (A05) is provided with a list of issues created by her. She may see the issue status (UC-IR07) and manage the issue unless these modifications conflict with the status of the issue. Such, the application may prevent deletion of an issue that has already been scheduled for collection. Please consider the state diagram describing valid issue life-cycle changes in Figure 14.

UC-WI03 Edit Issue

The registered citizen actor (A05) may edit her issues unless this modification conflicts with current issue state. For this purpose an issue is selected first (UC-IR02), edited and saved. The system returns an acknowledgement on completion.

UC-WI04 Delete Issue

The registered citizen actor (A05) may delete her issues unless this modification conflicts with current issue state.

UC-WI07 See Status

The status of a selected issue is displayed.

4.2.4 Package: Report Management

The process of handling issues is made explicit by creating "reports". The issue-report interaction may naturally be implemented by a massage-oriented middleware. Reports received from the processing unit (collection lorry) will trigger status changes of the issue (e.g. transiting to "done" state). This package comprises functionality used by an employee to create and manage the reports as depicted in Figure 8.

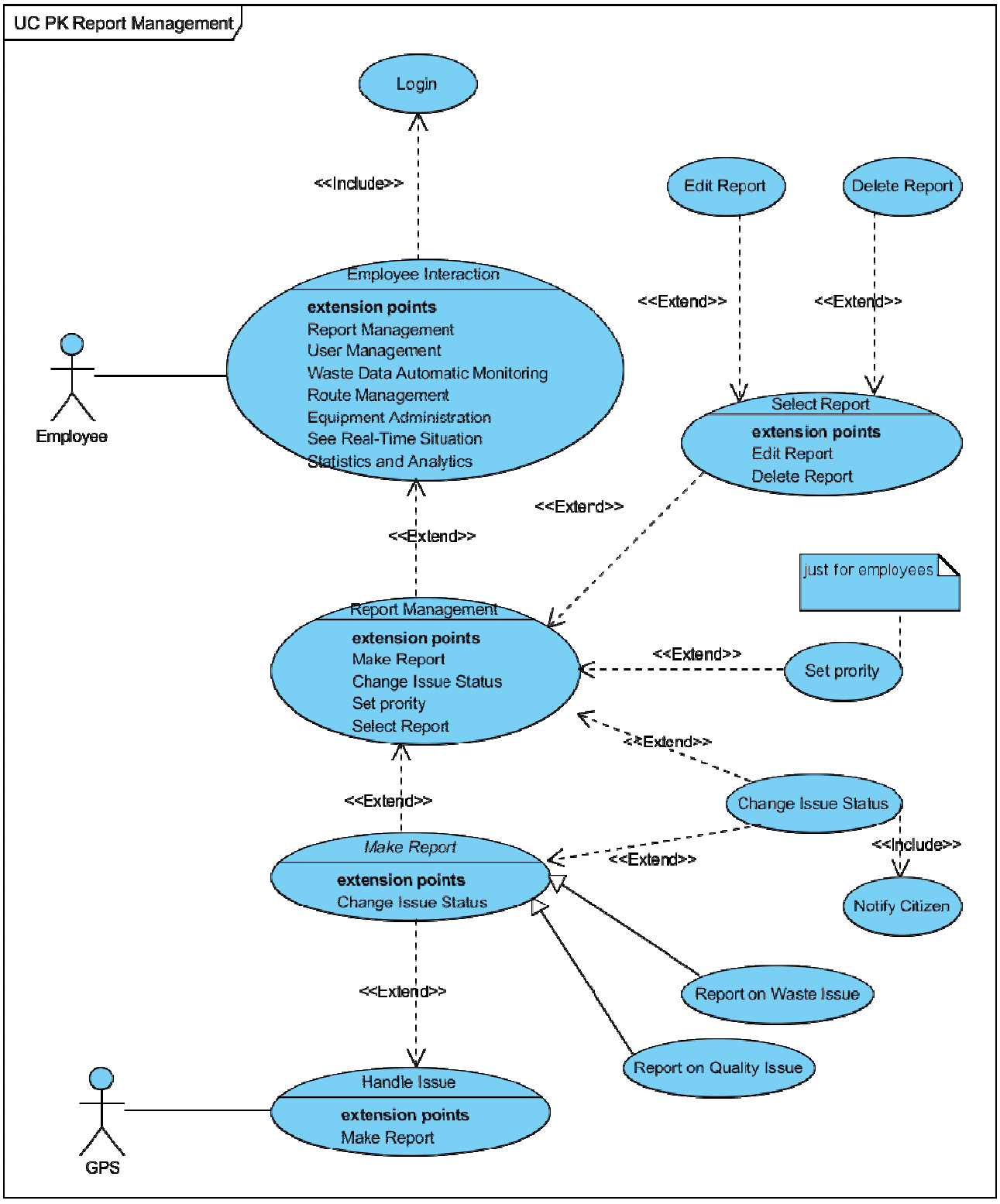


Figure 8. Issue handling

UC-RM01 Report management

This use case subsumes issue handling and report management functionality operated by an employee actor (A07).

UC-RM02 Select Report

Within this use case the employee actor (A07) may search for and select a report for subsequent management (UC-RM03 or UC-RM11).

UC-RM03 Delete Report

The employee actor (A07) selects a report for deletion. The system asks for confirmation, after a confirmation the report is deleted.

UC-RM04 Make Report

This UC is triggered by employee actor (A07) while doing the Report Management (UC-RM01). This is an abstract UC and could be made doing one of the children of the UC. The system asks which kind of report is wanted and starts either UC-RM05 or UC-RM06.

UC-RM05 Report on Waste Issue

Within this use case an employee actor (A07) with the role "WasteCollector" indicates the processing of a waste issue as a result of UC-RM09 (handle issue).

UC-RM06 Report on Waste Quality

Within this use case an employee actor (A07) with the role "WasteController" creates a report on waste quality. This might occur in process of the collection or during the manual waste separation.

UC-RM07 Change Issue Status

This UC is performed by an employee actor (A07) to manually set the issue status. The system shows searchable list of issues with status information and possible state transition. The user selects one and confirms the status change.

The change of status may take place automatically as part of handle issue use case (UC-RM09). An appropriately equipped collection car senses the identity of the container (bag or bin), resolves the corresponding issue and optionally displays a message to confirm its handling. An explicit confirmation is not needed, per default.

In case this issue was based on a user request, UC-RM12 (Notify citizen) will be triggered to announce the successful handling.

UC-RM09 Handle Issue

An employee actor (A07) of role "WasteCollector" or an automated service triggered by the GPS service (A08) executed on the collection car reports the successful handling of a waste issue (i.e. its collection).

UC-RM11 Edit Report

This use case allows the employee actor (A07) to select and edit a particular report.

UC-RM12 Notify Citizen

This use case captures the notification of the issue initiator, doing so by notifying the old status and the new status. The way to communicate to the user should be configurable.

4.2.5 Package: Monitoring and Analytics

This package captures the creation of monitoring services, visualisation of historical and real-time data. For a summary, see Figure 9.

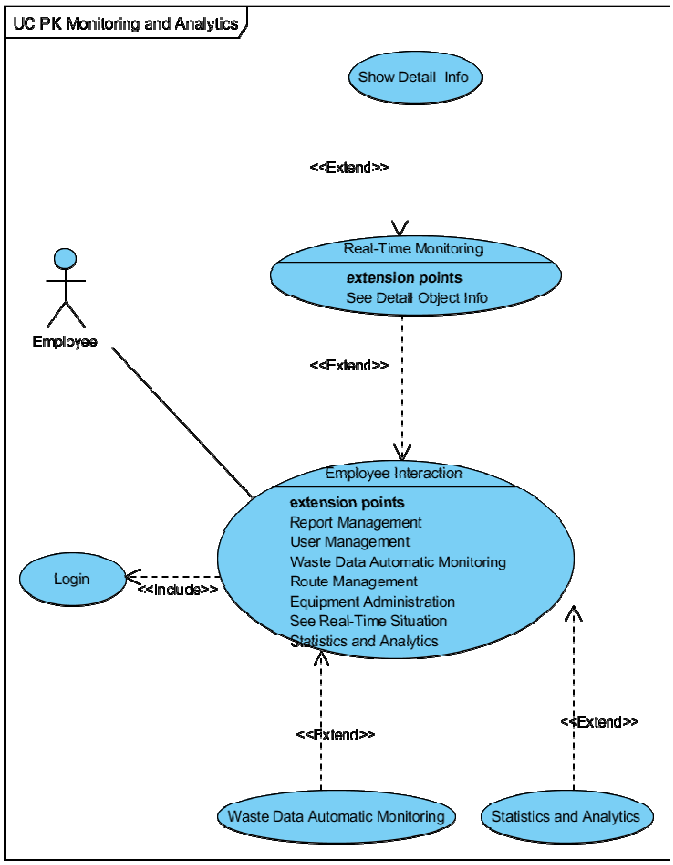


Figure 9. Package monitoring

UC-MA01 Real-Time Monitoring

Initiated by an employee actor (A07) the system displays a configurable amount of information within an overview map. This may include visualisation of the collection vehicles (status and location), status of the waste containers or pending issues.

UC-MA02 Show Detail Info

The user of UC-RT01 may drill down to a separate view in order to see further details on an entity (e.g. issue history and container statistics).

UC-MA03 Waste Data Automatic Monitoring

Within this use case an employee actor (A07) creates monitoring services (instances of FillLevelObserver actor, A09), that based on automatic fill-level sensing generate waste issues when a configurable threshold has been reached.

UC-MA04 Statistics and analytics

This use case performed by an employee actor (A07) results in retrieval and aggregation of statistical data (e.g. container usage trends, repeated quality issues etc.) and its appropriate visualisation. This data may feed generation of collection schedules for respective containers, which in turn generate waste issues of default priority.

4.2.6 Package: Route Planning

This package comprises the generation, management and real-time updates of collection routes as seen in Figure 10.

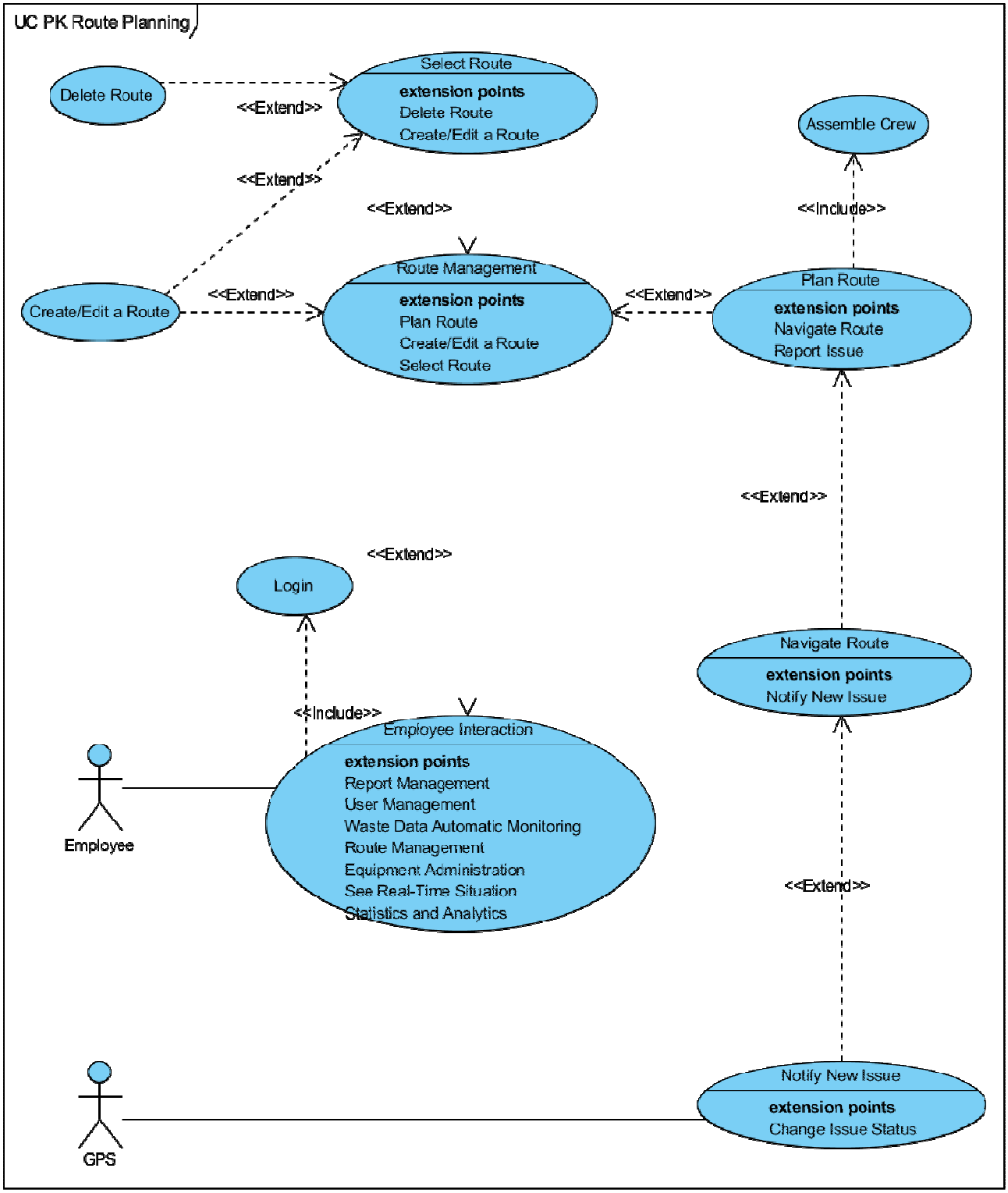


Figure 10. Route Planning Package

UC-RP01 Plan route

This use case is performed by an employee actor (A07) in order to plan a collection route. The route is generated either based on a manual selection of prioritized waste issues or based on one of "standard routes".

The first case starts with a listing of pending issues. These are visually grouped by common features (waste type, priority) via a clustering algorithm. The user may select and deselect the issues to be handled (either individually or in batch mode through area selection) and trigger a route generation. It is also possible to select dumps which have no issues yet. Selecting dumps without issues will start "Report Issue" automatically, generating an issue to each selected dump.

In the latter case the system presents a series of pre-defined routes (defined in UC-RP04) and series of issues. The user (A07) selects a route, adds a series of issues which should be handled in the route and modifies the route if needed.

Once the route creation is finished, the user may start UC-RP08 to assemble the processing crew. Upon completion the status of the involved issues is automatically set to "scheduled" (compare to Figure 14).

UC-RP02 Navigate route

This use case comprises the navigation of the crew while following a predefined route. During the navigation the crew may be notified of newly occurred issues located on or near to the route provided by the "notify issue" use case (UC-RP03). The crew may accept or deny its processing.

UC-RP03 Notify issue

This use case comprises the interactive update of an active route. Using the GPS positioning data of the vehicles and their capacity status, newly created issues are offered for handling to appropriate crews. Upon its acceptance the route is recalculated taking the new issue into account.

UC-RP04 Route Management

This use case comprises operations on predefined, "standard" routes.

UC-RP05 Create/Edit Route

Within this use case a route template is interactively created by an employee actor (A07). The system shows a map view. If the UC started from the use case "select route" (UC-RP07) the map would be prepopulated by the selected route. Then the user designs/edits the route, and if the route is new, gives it a name. At the end the route is stored.

UC-RP06 Delete Route

The employee actor selects a route (UC-RP07) and choses to delete it. Upon confirmation the system deletes the route.

UC-RP07 Select Route

The employee actor is presented (A07) with a list of available, predefined routes. Then the user selects one of them and starts either of the use cases UC-RP01, UC-RP06 or UC-RP07.

UC-RP08 Assemble Crew

This use case is performed by an employee actor (A07) within the "plan route" use case (UC-RP01). The system shows a list of available vehicles and employees, the user assembles a crew and confirms the selection.

4.2.7 Package: User Administration

This package tackles the functionality needed mostly by the Employee to manage users. This package is not the main goal of the application but is needed for its proper operation. A summary of this package is presented in Figure 11.

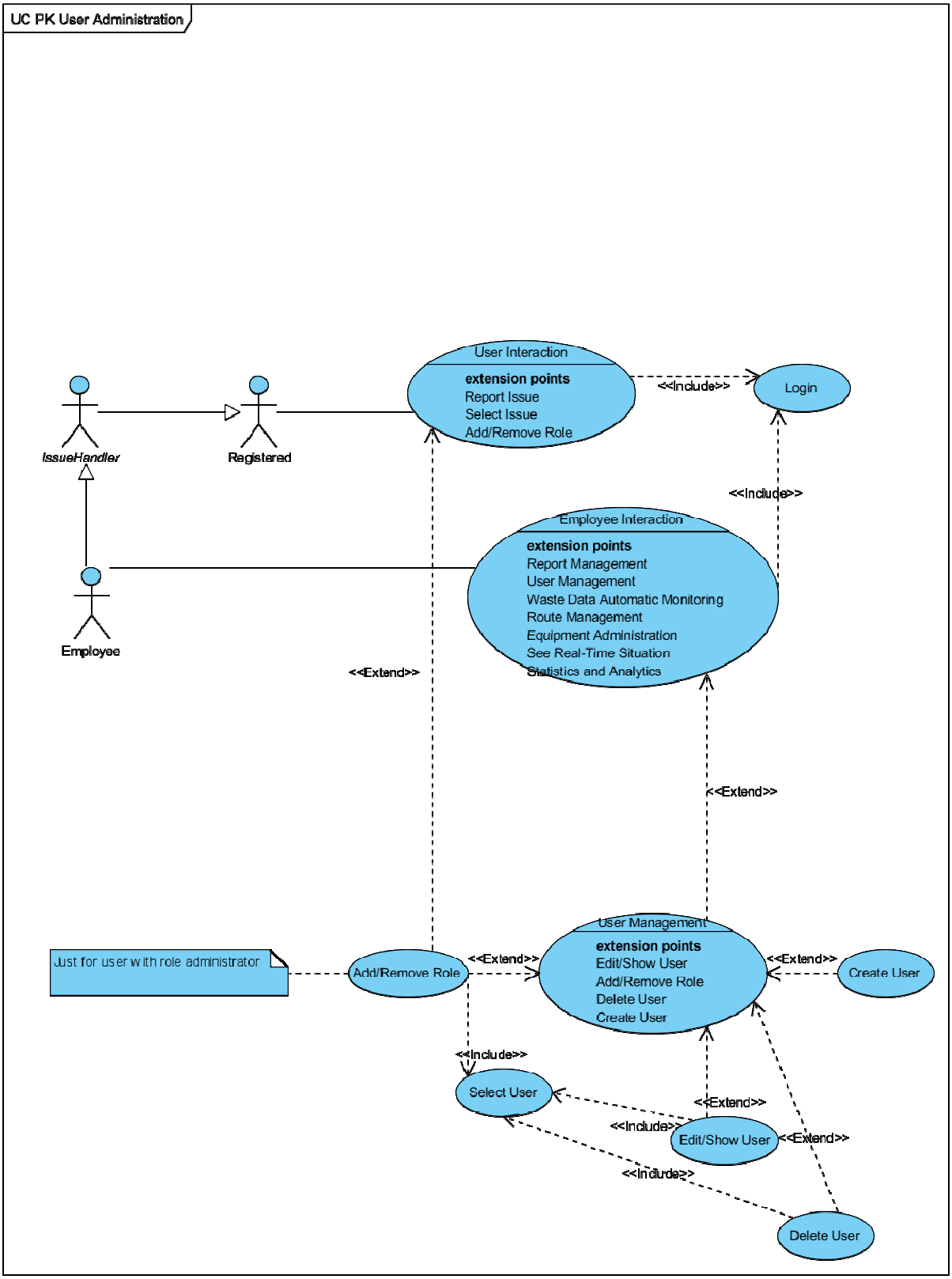


Figure 11. User Administration Package

UC-UA01 User Management

This UC can be triggered by an Employee (A07) with the administrator role while doing the Login (UC-IS05). The system shows all the options available to the user. Each option can start a UC which could be either UC-UA05 or UC-UA03.

UC-UA02 Change Role

This UC can be trigger by a Registered User (A05) with the administrator role, while doing the User Management (UC-UA01) or while doing the User Login (UC-ID03). The UC starts by showing UC-UA05. The view shows the current role of the selected user, and then shows the possible roles that the actor (A05) is allowed to change into and the selected user is allowed to have. The system acknowledges the change.

UC-UA03 Create User

This UC can be trigger by Employee (A07) with the role administrator, while doing the User Management (UC-UA01). The system shows the fields needed for creating a user. The user fills out the form and submits it. The system asks for a confirmation for the creation of the user, and tests if the user already exists. Then the creation is confirmed.

UC-UA04 Delete User

This UC can be trigger by Employee (A07) with the role administrator, while doing the User Management (UC-UA01). The UC start by starting the UC-UA05 Select User. The system asks for a confirmation of the actor (A07) to delete the selected user (form UC-UA05). After the confirmation the system confirms that the user was deleted.

UC-UA05 Select User

This UC can be trigger by an Employee (A07) with the role administrator. This UC is used in Delete User (UC-UA04), Edit User (UC-UA06) or Change Role (UC-UA02). The system shows some method/s to search/select users. After a user selection the UC ends retuning the user selected by the actor.

UC-UA06 Edit/Show User

This UC can be trigger by an Employee (A07) with the role administrator, while doing the User Management (UC-UA01). The UC start by starting the UC-UA05 Select User. Shown the available information of the selected user, the user (A07) can change its parameters. If the change is confirmed the system changes the user and confirms the changes; if there was no change then the UC ends.

4.2.8 Package: Equipment Administration

This package tackles the functionality needed by the Employee to manage the work equipment. This package is not the main goal of the application but is needed for its proper functioning. See Figure 12 for a summary of the package.

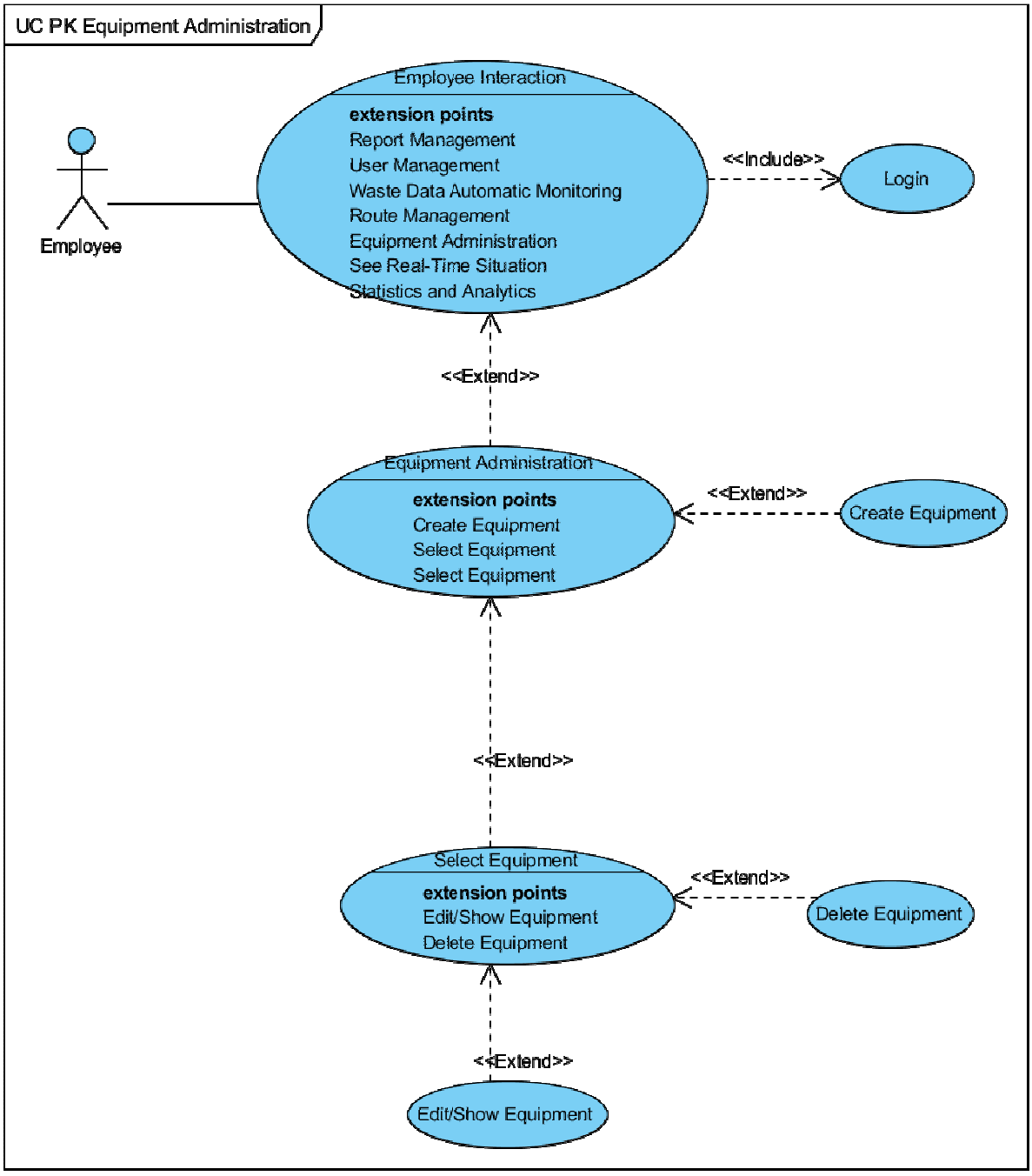


Figure 12. Equipment administration

UC-EA01 Equipment Administration

This UC can be trigger by an Employee (A07) with the role administrator while doing the Login (UC-IS05). The system shows the options available to the user. Each option can start a UC which could be either UC-EA02 or UC-EA03.

UC-EA02 Create Equipment

This UC can be trigger by an Employee (A07) with the role administrator, while doing the Equipment Management (UC-EA01). The system shows the fields needed for creating a piece of equipment. The user fills them in, and then submits the form. The system asks for a confirmation before the creation. At the end the system confirms the new equipment.

UC-EA03 Select Equipment

This UC can be trigger by an Employee (A07) with the role administrator, while doing the Equipment Administration (UC-EA01). The system shows some method/s to search/select equipment. If the UC was started in the UC-RP08 then the system displays only vehicles. After the selection of equipment the user can start either UC-EA04 or UC-EA05 or return to any UC which started this UC.

UC-EA04 Edit/Show Equipment

This UC can be trigger by an Employee (A07) with the role administrator, while doing the Select Equipment (UC-EA03). Shown the available information of the selected equipment in UC-WM03, the user (**A07**) can change some properties. After submission the system confirms the changes; if there was no change then the UC ends.

UC-EA05 Delete Equipment

This UC can be trigger by an Employee (A07) with the role administrator, while doing the Select Equipment (UC-EA03). The system asks for confirmation of the actor (A07) to delete the selected user (form UC-EA03). After the confirmation, the system confirms that the user was successfully deleted.

4.3 Informational view

The information view describes the data models and the data flow as well as the distribution. The viewpoint also defines which data will be stored and where.

The class diagrams have been split into a generic package containing classes that are referenced in a variety of applications and classes specific to the waste management domain. The summary of the information view is presented in Figure 13.

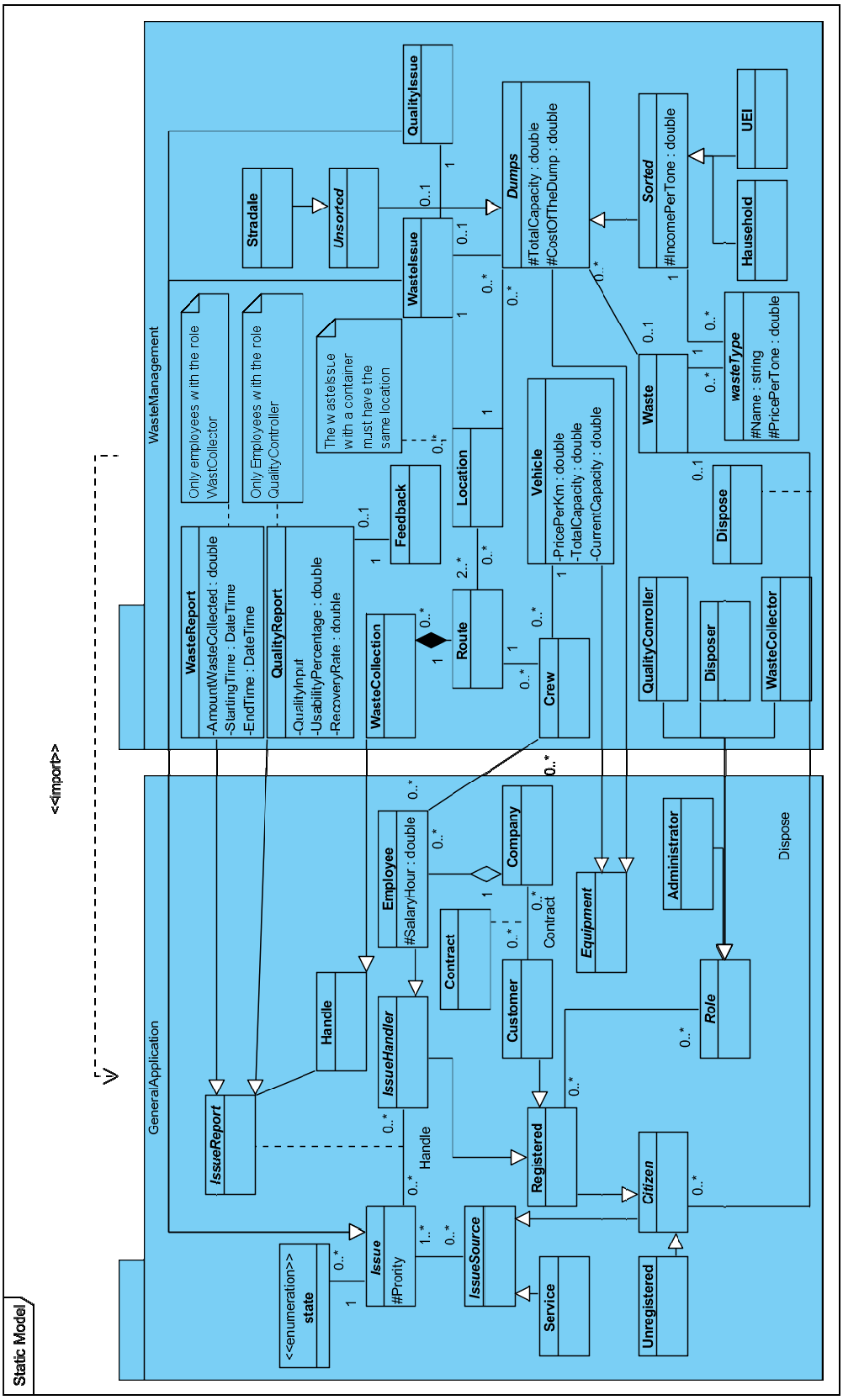


Figure 13. Information view of the waste management application

Class Name	Description
Administrator	An implementation of Role. It could be an item of an enumeration. This is the Role which any Registered Citizen can take so it's allowed to administrate other users.
Citizen	Abstract. Any citizen which is allowed to interact with the system.
Company	Company/s which provide the waste collection service.
Contract	Legal binding between the utility company and a Customer.
Customer	Legal contractor of the utility company.
Disposal	In the UC-WD02 the identity of the Disposer and the Waste is known. Then the system can capture this process in this class.
Disposer	An implementation of Role. It could be an item of an enumeration. This is the Role which any Registered Citizen can take so it's allowed to dispose waste.
Dumps	Abstract. Any recipient/container of waste.
Employee	An implementation of IssueHandler. The representation of a worker of a city service provider.
Feedback	A notification which of the waste disposer (a Citizen) normally due to the low quality of the waste she disposed.
Handle	Abstract. Action taken to solve an Issue.
Households	An implementation of Sorted Container. This is the bin which normal households have.
Issue	Abstract. The representation of a problem which an IssueSource reported to the system.
IssueHandler	Abstract. The representation of any entity that can handle Issues.
IssueReport	Parent class of reports classes.
IssueSource	Abstract. Any entity which can generate Issues.
Location	Point of interest for the system.
QualityReport	Report generated to indicate (deficient) quality of recyclable waste.
Registered	Users (Citizens) which have been registered in the system.
Role	Abstract. Represent the set of operations that a registered citizens are allowed to do.
Route	A series of locations (path) which a Lorry should follow. This could be a general one or specific. A general route is pre-generated route saved in the system. The specific one is one generated 'on the run' using some customizing options.
Service	Abstract. A type of IssueSource representing a process, sensor, sensor network with no human controller in loop.
Sorted	Abstract. Generalization of all containers intended for collection of a particular waste type (recycled waste).
state	Enumeration of valid Issue states, see Figure 14
Stradale	A general public waste Container (no concept of waste ownership).
UEI	An implementation of Sorted Container. Underground Ecological Island which are big Sorted Container that many Citizens are allowed to dispose waste into.

Unregistered	Conceptual class which represent all the users which dispose waste but are not registered in the system. This class may not be implemented.
Unsorted	Abstract. A waste Container. Sub level in the waste container hierarchy. Represents all Containers without waste separation.
Waste	Unit of waste that can be processed (and traced) by the system.
WasteCollector	An implementation of Role. It could be an item of an enumeration. This is the Role which represents the Employee which recollects waste.
WasteIssue	An implementation of Issue represents a notification made by an IssueSource.
WasteReport	Report generated to confirm handling (or postponing) of an WasteIssue
wasteType	Enumeration. List of all types which all Container::Sorted could have.
QualityConroller	An implementation of Role. It could be an item of an enumeration. This class represents the Role for the Employee which takes care of controlling the quality of the waste.
Vehicle	An implementation of Equipment. The representation of a vehicle in the system.
WasteCollection	An implementation of Handle, represents a waste collection session.
Equipment	Abstract. Representation of any tool or object used for an activity of an employee.

4.4 Waste issue lifecycle

The life cycle of a waste issue and the available changes (transitions) of its state are defined by the state diagram in Figure 14.

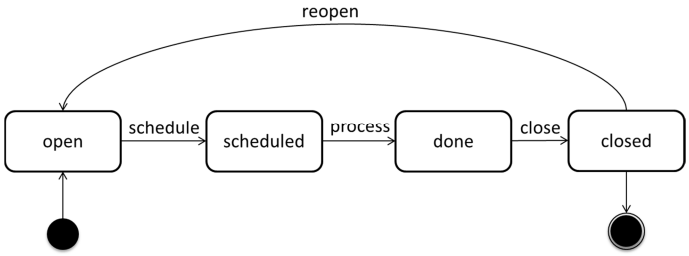


Figure 14. State diagram of a waste issue

4.5 Deployment view

This view describes how and where the system will be deployed and what dependencies exist, considering hardware requirements and physical constraints.

4.5.1 Scenario 1

The following table summarizes the deployment of hardware (sensors) and software (services) required to implement the collection optimization scenario.

Hardware	
GPS positioning sensor	GPS receivers are installed on collection cars in order to retrieve their real-time position and co-locate them to pending issues.
(Ultrasonic) fill level sensor	Fill level sensor(s) measuring the capacity

	of waste containers.
Wireless network infrastructure	Sender, network repeater and gateways required to build up a wireless sensor and actuation network.
Software	
Fleet management software	Necessary to keep track of current location and availability of vehicles. It may also include other resources, e.g. crew.
Issue management software	Stores all issues in the system with accompanying details like state, assignee, due date, etc. It also provides the UI towards citizens for keeping track of their opened issues.
Route planning software	It is the attachment point between the fleet management and issue management. It allows the assignment of issues to routes, or the definition of additional routes with specified vehicles and crew.
ALMANAC platform	The ALMANAC platform handles the integration of sensors, issuing and filtering of events, and forwarding of messages.

4.5.2 Scenario 2

The following table summarizes the deployment of hardware (sensors) and software (services) required to implement the waste quality optimisation scenario.

Hardware	
Authentication device	Installed on the UEI, this device enables the authentication of the user before allowing the disposal of waste. The device may be an RFID reader, optical sensor or PIN pad.
Identification device	Installed on or in the UEI, role of this device is to recognize the QR codes that are attached to the waste bins. The authentication and identification device may be combined.
Hand-held identification device	Used at the sorting-hall, this device is used to capture the source of individual bags and eventually provide feedback on the waste.
Software	
Waste tracking application	This application is responsible for authenticating and identifying users and their waste bags at disposal. It controls the authentication and identification device, and may reside in the cloud for multiple UEIs, or in an embedded chip

	installed at the UEI.
Waste quality monitor	This application stores the individual waste profiles of citizens, including their average waste production, their average quality and eventual extraordinary items as fines or rewards. The system has two user interfaces. For the citizens, this interface presents them their personal profile and provides them advice on actions they may take to improve they behaviour. For the sorting-hall workers the interface is displayed on their hand-held device, and allows them to add observations they make during the investigation of the waste quality.
ALMANAC platform	The ALMANAC platform handles the integration of sensors. Additionally it manages the communication with the hand-held devices and allows the citizen to attach her phone regarding extraordinary notifications.

5. Conclusions

In this deliverable we have presented the specification of the waste management application, to be implemented in three iterations in the ALMANAC project. The results presented in this document are target of refinement based on the lessons learnt over the individual iterations. Additional details are necessary about the possibilities of installing or introducing hardware into the operational environment, which could influence the exact realization of the presented use cases.

We introduced two main scenarios to be addressed by the waste management application, and defined in detail the use cases to be handled in them:

- Realization of an issue management system, including automatically generated issues by the ALMANAC platform. The issue management system will enable the creation of an overall optimized application of resources.
- Waste quality tracking system as explorative approach for realizing novel business models motivating recycling.

To support the realization of these scenarios we also introduced a number of use cases. These deal with administrative and management issues, easily deployable with off-the-shelf identity and ERP systems.