BIG IoT – Bridging the Interoperability Gap of the Internet of Things

Deliverable 2.2.b: Use Case Definition and Open Call Scoping

Version 1.0

Delivery Date: 31.03.2017

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Document Information

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<tr>
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### Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Meaning</th>
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<tbody>
<tr>
<td>AC</td>
<td>Alternating Current (Here: Slow Charging Stations)</td>
</tr>
<tr>
<td>API</td>
<td>Application Programming Interface</td>
</tr>
<tr>
<td>APM</td>
<td>Advanced Parking Management</td>
</tr>
<tr>
<td>BCN</td>
<td>Barcelona (pilot)</td>
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<tr>
<td>BIG IoT</td>
<td>Project title: Bridging the Interoperability Gap of the Internet of Things</td>
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<tr>
<td>CSI</td>
<td>Project Partner Piedmont, Italy</td>
</tr>
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<td>CSP</td>
<td>Project Partner Piedmont, Italy</td>
</tr>
<tr>
<td>DC</td>
<td>Direct Current (Here: Fast Charging Stations)</td>
</tr>
<tr>
<td>DOA</td>
<td>Description of Action</td>
</tr>
<tr>
<td>GSM</td>
<td>Global System for Mobile Communications</td>
</tr>
<tr>
<td>GUI</td>
<td>Graphical User Interface</td>
</tr>
<tr>
<td>ICE</td>
<td>Inter City Express (German High Speed Train)</td>
</tr>
<tr>
<td>IoT</td>
<td>Internet of Things</td>
</tr>
<tr>
<td>NG</td>
<td>Northern Germany (pilot)</td>
</tr>
<tr>
<td>PIE</td>
<td>Piedmont (pilot)</td>
</tr>
<tr>
<td>SDK</td>
<td>Software Development Kit</td>
</tr>
<tr>
<td>TIC</td>
<td>Traffic Information Center</td>
</tr>
<tr>
<td>TUC</td>
<td>Project Partner Northern Germany</td>
</tr>
<tr>
<td>UI</td>
<td>User Interface</td>
</tr>
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<td>UPC</td>
<td>Project Partner Barcelona, Spain</td>
</tr>
<tr>
<td>VMZ</td>
<td>Project Partner Berlin, Northern Germany</td>
</tr>
<tr>
<td>Wi-Fi</td>
<td>Wireless Local Area Network</td>
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<td>WLAN</td>
<td>Wireless Local Area Network</td>
</tr>
<tr>
<td>WMS</td>
<td>Web Map Service</td>
</tr>
<tr>
<td>WP</td>
<td>Work Package</td>
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Preface to the Second Iteration of D 2.2

This document is the second of three deliverables worked out by Task 2.2 (“Use Case Definition and Open Call Scoping”) of the BIG IoT project.

The presented second version, noted as Deliverable 2.2.b, extends the previous D 2.2.a with the scoping of the Open Calls and related expectations of the pilots for the Open Calls. For this reason, the new Part I: Open Call Scoping is added to the document.

Furthermore, between the first and the second release of the document the industry partner Vodafone exited the BIG IoT consortium. Vodafone’s withdrawal from the project and the subsequent impact on available platforms and data required the adaptation of the use cases and outlooks defined in D2.2.a. With the first amendment of the BIG IoT project, approved in February 2017, the project is provided with additional data sources within the previously defined use case clusters.

The current version of the deliverable D2.2.b therefore consists of two parts. Part I incorporates the Open Call Scoping done by the pilots. Part II is the update of previous D2.2.a and includes the adjustments resulting from the amendment for the pilot sites.

Modifications of use case description are included in chapters 4, 5, and 6 of part II. Chapter 7 of the 1st release D2.2.a (Services Outlook) has been removed from the document since meanwhile a more detailed specification of services was included in D5.1.a. Other not pilot-specific sections of the document, especially chapters on Methodology (chapter 2), BIG IoT Ecosystem Use Cases (chapter 3) and Interoperability in Use Cases (chapter 7 in the new document) as well as the annex, remain unchanged.
Part I: Open Call Scoping

1 General Open Call Requirements

The main objective of the Open Calls is testing the Big IoT components and methodology by integrating new platforms and data sources to achieve interoperability. The proposals will help to validate Big IoT results and components in scenarios deployed, mainly in the domains of smart mobility and smart environment, which the BIG IoT pilots are focused on.

There will be two Open Calls instead of one as originally planned. Open Call I aims at enriching the data sets offered via the BIG IoT Marketplace. Open Call II targets on new and innovative services and applications that make use of BIG IoT Marketplace offerings.

The scope of the Open Calls is to encourage data providers and technology providers to provide access to data and platforms via the BIG IoT Marketplace.

Focus is put on

- **Data providers** to
  - grant access to their data via the BIG IoT Marketplace and API.

- **Technology providers** to
  - offer future proof and scalable technologies and solutions,
  - provide access to open data via the BIG IoT Marketplace and API and
  - integrate data or functions offered on/with successful existing platforms or standards (e.g. Hypercat).

Expectations for participating entities

Entities taking part in the Open Call I are expected to

- integrate BIG IoT API to existing services or platforms,
- update the BIG IoT API integration based on later 3rd release,
- provide access to data for partners to be used as foundation for the second open call,
• keep systems and data streams alive at least until the end of the project lifetime (end of 2018),
• provide scalable and future proof technologies / solutions, e.g. to integrate open data into open source software while keeping gateway systems to open data streams alive at least until the end of the project lifetime (end of 2018).

2 Pilots expectations on Open Call

With Open Call I the pilots aim at extending the data base that is being set up within the overall BIG IoT pilots’ activities and provided via the BIG IoT Marketplace (mainly mobility data). With proceeding Open Call II, the pilots envisage to widen the range of new and innovative services and applications in the field of smart mobility and smart environment.

To assure a consistent development of sustainable solutions throughout the pilot implementations and upcoming activities in Open Call I and II focus is put on mobility and environment issues that are of relevance for the pilot cities and aligned with the mobility agendas of the pilot cities.

Moreover, it is intended to further develop the use cases already specified by an enlarged data base and / or by providing further services. For a detailed description of the use cases to be implemented in the pilots see Part II of this deliverable.

Thus, making use of the available BIG IoT offerings specification the partners involved in the pilot’s implementation pre-defined a list of requirements based on their knowledge of overall mobility trends, available data, services and applications.

The below mentioned list of expectations gives proposals and do not preclude submission of alternative suggestions. New ideas from interested entities to join the Open Call are welcome!
2.1 Northern Germany (Berlin / Wolfsburg) Pilot

Pilot Description

In Northern Germany we are testing the BIG IoT technology in the cities of Berlin and Wolfsburg and the transregional corridor connecting the two cities.

The Northern Germany pilot puts focus on key topics of future-oriented mobility targeting on an optimized usage of Public Transport, E-mobility, Smart Parking solutions and multimodal routing information for the cities and the corridor.

In Wolfsburg we are incorporating a city-wide WLAN network, live tracking of public buses, as well as public e-charging stations. Further, we are doing real time crowd management by using existing security cameras and crowd-sourced detection of human crowds through mobile apps.

In Berlin we integrate city-wide real time information on traffic volumes and traffic speed, real time parking data, data on available charging stations and bike sharing data. Also, Siemens’ novel, streetlight-mounted and radar-based smart parking detectors are integrated. In addition, incident news for public and private transport and traffic news provided via on-street information panels are integrated.
Using these integrated platforms, we are building applications such as Commuter App providing routing information for long distance commuters for the corridor, Smart Parking app for Berlin and Wolfsburg as well as applications for public transport operators to optimize their offers in Wolfsburg.

A detailed list of sensor, data, services and applications that will be implemented in the Northern Germany pilot is included in chap. 2.5.

2.1.1 Northern Germany Pilot Requirements for Open Calls

Within the Open Calls for the Northern Germany Pilot we intend to widen our range of mobility data and services to extend the BIG IoT offerings provided via the BIG IoT Marketplace.

In the first Open Call we target on:

- Data of public and private mobility providers to include further mobility options in multimodal information services for Berlin, Wolfsburg and the corridor,
- parking data concerning parking facilities in public and semi-public space and
- data on electric vehicle charging infrastructure.

Platforms and data are not required to refer exclusively to the territory of Berlin and Wolfsburg but can pertain to larger area scales (municipality, region, national).

Thus, integration of mobility data of additional mobility options is appreciated:

- Data on additional mobility options such as
  - bike sharing (flexible and / or station-based)
  - car sharing (flexible and / or station-based),
  - e-scooters, conventionally driven and electric,
  - taxi
  - ride sharing
  - other.
- Additional real-time Parking Data from different sources and different spaces (public, semi-public, private) within the pilot regions or in other areas
- Predictions on parking spot availability.
- Real time and scheduled data on Public Transport offers (regional and long-distance)
• Incident Messages for Public Transport (trips and infrastructure at stations and stops)
• Incident Message for Private Transport
• Additional **Charging Point Availability Data** in public, semi-public and private areas
• Integration of mobility related **data provided by open data platform** such as
  o Open Data Platform of Deutsche Bahn or
  o mCloud of BMVI or
  o Open Data Platform Berlin

In the second Open Call we target on further innovative IT-services and applications processing the BIG IoT data offerings for

• Smart Parking,
• Integration of Smart Parking and Smart Charging to provide reservation functionalities for parking spots at charging stations,
• Multimodal Mobility Information including reservation and booking services for Mobility Options and
• Multimodal Routing and Navigation Services including Incident Messages for Trip Monitoring Purposes.
2.2 Piedmont Pilot

Pilot Description

In Piedmont we are testing the BIG IoT technology in conjunction with the deployment of new sensors for vehicular traffic, microarea air quality measurements and on-street parking availability. The cities of Biella and Vercelli have agreed to host Pilot installations in their streets to test BIG IoT concepts in Traffic Monitoring, Smart Parking, Air Quality, Healthy Bike Navigation and Smart Bike Sharing.

The deployment of approximately 50 gateways that relay sensors’ data to the Internet in a urban environment is a challenge by itself, that will be tackled by optimizing and maximizing the use of existing wired infrastructure (MAN, public buildings) and Wi-Fi access points, whereas 3G routers and wireless broadband will fill the gaps.

Bike sharing information will be presented as well to end users together with air quality information in order to promote smarter and more environmental friendly mobility.

Data planned for Pilot applications will be available through CSI Piemonte Smart Data Platform. A detailed list of sensor, data, services and applications that will be implemented in the Piedmont pilot is included in chap. 0.
2.2.1 Piedmont Pilot Requirements for Open Calls

Within the Open Calls for the Piedmont Pilot we intend to widen our range of mobility data to extend the BIG IoT offerings provided via the BIG IoT Marketplace. Platforms and data are not required to refer exclusively to Biella and Vercelli territories but can pertain to one or more Piedmont areas (municipality, province, the whole region).

In the first Open Call we target on platforms carrying data on the following subjects:

- Public and private mobility providers such as (extra-)urban transport lines and trains.
- Shared mobility services (car sharing, bike sharing, parking)
- Environmental monitoring

Thus, we are looking to extend Pilot services and applications with:

- Data of public and private mobility providers in Piedmont such as scheduled timetables and real-time transit.
- Passengers count on public transport from public and private mobility providers.
- Additional data sources on road traffic: real-time, aggregated, statistical and historical.
- Parking data occupancy of on-street stalls as well as access-controlled parking facilities.
- Data on car-sharing from public and private providers, from petrol-based cars to electric vehicles and motorbikes.
- On-street electric vehicle charging infrastructure.
- Additional data on bike sharing to cover the whole Piedmont Region.
- Additional outdoor environmental data (such as air pollutants and composition, ionizing radiation, solar irradiance).
- Indoor environmental data.

In the second Open Call we will target on further IT-services and applications processing the BIG IoT data offerings for Smart Parking, Traffic Monitoring and optimization, use of air-quality data towards citizens (healthy bike navigation, green route planning).
2.3 Barcelona Pilot

Pilot Description

In Barcelona, we are using infrastructure based traffic detectors to measure speed, car count and related parameters. These detectors are provided by WorldSensing, who also provides parking spot sensors. Seat provides air quality sensing devices on connected cars.

Our IoT platforms provide access to connected buses, connected cars, over 500 street parking sensors, several road-side magnetometers control-stations, and 37 Bluetooth/Wi-Fi antennas in the city.

Access to Open Data and Barcelona City platforms (such as SENTILO) will also be enabled through the BIG IoT API, giving access to noise detectors, bike sharing data and e-charging stations.

We are using those things to implement mobility services and applications, such as a traffic information center tool, a smart parking app and green route planning.

A detailed list of sensor, data, services and applications that will be implemented in the Barcelona pilot is included in chap. 0.
2.3.1 Barcelona Pilot Requirements for Open Calls

Within the Open Calls for the Barcelona Pilot we intend to widen our range of mobility data and services to extend the BIG IoT offerings provided via the BIG IoT Marketplace for the Barcelona region (including cities in Metropolitan Area or closed to Barcelona).

In the first Open Call we target, in general, additional data related with mobility:

- Data of public and private mobility providers to include further mobility options. These data should support already defined BIG IoT use cases but also new ones enabling Mobility as a Service, or with strong impact on citizens.
- Additional off-street and on-street parking data in the Barcelona Region.
- Additional data on charging infrastructure.
- People counting sensors or People flow data to extend public transport optimization use case.
- Environmental sensors or environmental elaborated data to improve Environmental Monitoring Service.
- Additional traffic data sources.

Thus, integration of mobility data of additional mobility options is appreciated such as:

- Real time data on additional mobility options such as bike sharing, car sharing, ride sharing, shared e-scooters, conventionally driven and electric, taxi.
- Additional off-street / on-street parking. It may include public, private, shared parking lots real-time availability data.
- Updated predictions on parking spot availability.
- Parking delivery zone monitoring.
- People flow data on public transport and public vehicles tracking, to extend public transport optimization use case to additional vehicles, sensors or kind of transport (i.e. tram...) in the Barcelona region.
- People counting sensors or Pedestrian flow in public areas to gather information equivalent to the North Germany pilot in the Barcelona region, supporting public transport optimization use case or new services and applications.
- Additional environmental data (air quality, noise, etc.) to extend area of coverage in Barcelona region, including new innovative measurement sensors or data generated from advanced prediction models.
• Additional Charging Point Availability Data in public, semi-public and private areas, also Charging Point Reservation Services.
• Additional traffic data sources providing real-time data or updated elaborated data to improve Traffic Monitoring Service and extend the area of coverage. These data could also be provided by connected cars (vehicle to infrastructure /V2V data).

In the second Open Call we target on:

• Further innovative IT-services and applications processing the Barcelona BIG IoT data offerings for Smart Parking, Traffic Monitoring, Incentive Based Green Routing, Smart Bike Sharing, Public Transport Optimization, Smart Charging and Multimodal Routing and Navigation.
• New applications implementing device-to-device use case on top of BIG IoT enabled platforms.
• New App based on Incentive-based Green Route Planning for final customers, which enables to make a demo with connected cars using the navigator system through Mirror Link or Android Auto.

2.4 Pilot Comprehensive Expectations on Open Calls

Apart from pilot-specific contributions BIG IoT targets on data offerings, services and applications that go beyond the limits of the pilot areas.

Thus, contributions that extend the BIG IoT data offerings geographically and functionally to realize innovative applications covering the widest possible geographical range are welcome.

For Open Call I contributions enriching the data set offerings are welcome.

For Open Call II focus will be put on services and applications using the BIG IoT offerings.
2.5 List of sensors, integrated data and services

NG Pilot - List of sensors, integrated data and services

The following data integration and services implementation is being realized and planned:

<table>
<thead>
<tr>
<th>Available 06/2017</th>
<th>City</th>
<th>Sensors / Data</th>
<th>Services</th>
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</thead>
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<tr>
<td></td>
<td>Berlin, Wolfsburg</td>
<td>Siemens Parking Spot Sensors</td>
<td>Parking Availability</td>
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<tr>
<td></td>
<td></td>
<td>WAG Parking Spot Sensors</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Berlin, Wolfsburg</td>
<td>Siemens Parking Spot Sensors</td>
<td>Parking Spot Reservation</td>
</tr>
<tr>
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<td>Wolfsburg</td>
<td>Connected Buses: People Counting Sensors on Bus</td>
<td>People Density Load (Bus / Bus stop area)</td>
</tr>
<tr>
<td></td>
<td>Wolfsburg</td>
<td>Connected Buses: Location Sensors on Bus</td>
<td>Live Bus Location</td>
</tr>
<tr>
<td></td>
<td>Berlin</td>
<td>Bike Sharing Data (Nextbike)</td>
<td>Bike Sharing Availability</td>
</tr>
<tr>
<td></td>
<td>Berlin, Wolfsburg</td>
<td>Charging Stations</td>
<td>Charging Station Availability</td>
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<th>City</th>
<th>Sensors / Data</th>
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<td>Berlin</td>
<td>Traffic Detector (TEU)</td>
<td>Traffic Data Provider Service</td>
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<td>Berlin</td>
<td>Incidents Messages for Private and Public Transport</td>
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<td></td>
<td>Berlin</td>
<td>Info-Panel News</td>
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<th>City</th>
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<tbody>
<tr>
<td></td>
<td>Berlin</td>
<td>Parking Sensors</td>
<td>Parking Spot Reservation</td>
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Piedmont Pilot - List of sensors, integrated data, planned services and applications

The following data integration and service implementation is being realized and planned:

### Available 06 / 2017

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<th>City</th>
<th>Sensors / Data</th>
<th>Services</th>
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<tr>
<td>Biella</td>
<td>Readings of CO, NO2, PMx, T, H from Low-Cost Air Quality Stations by project partner ECONAIS (AQS)</td>
<td>Environment Monitoring</td>
</tr>
<tr>
<td>Biella</td>
<td>Automotive traffic flow through video analysis onboard Smart Cameras</td>
<td>Traffic Monitoring</td>
</tr>
<tr>
<td>Vercelli</td>
<td>On-street parking sensors (30 stalls) by a vendor to be defined</td>
<td>Parking Availability</td>
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### Available 01 / 2018

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<th>Services</th>
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<tr>
<td>Biella</td>
<td>Readings of CO, NO2, PMx, T, H, CO2, O3 (additional points) from AQS</td>
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<tr>
<td>Vercelli</td>
<td>Readings of CO, NO2, PMx, T, H, CO2, O3 from AQS</td>
<td>Environment Monitoring</td>
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<tr>
<td>Vercelli</td>
<td>Automotive traffic flow (through Smart Cameras)</td>
<td>Traffic Monitoring</td>
</tr>
<tr>
<td>Biella</td>
<td>Bike sharing stall status</td>
<td>Bike Availability</td>
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<tr>
<td>Vercelli</td>
<td>Bike sharing stall status</td>
<td>Bike Availability</td>
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### Available 08 / 2018

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<td>Readings of CO, NO2, PMx, T, H, CO2, O3 (additional points) from AQS</td>
<td>Environment Monitoring</td>
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<tr>
<td>Vercelli</td>
<td>Readings of CO, NO2, PMx, T, H, CO2, O3 (additional points) from AQS</td>
<td>Environment Monitoring</td>
</tr>
</tbody>
</table>
Barcelona Pilot - List of sensors, integrated data, planned services

The following data integration and services implementation is being realized and planned.

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<thead>
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<th>Available 06 / 2017</th>
<th>City</th>
<th>Sensors / Data</th>
<th>Services</th>
</tr>
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<tbody>
<tr>
<td>Barcelona</td>
<td></td>
<td>Worldsensing Parking Spot Sensors installed at Les Corts district</td>
<td>Parking Availability</td>
</tr>
<tr>
<td>Barcelona</td>
<td></td>
<td>Charging Stations (Barcelona City platform)</td>
<td>Charging Station Availability</td>
</tr>
<tr>
<td>Barcelona</td>
<td></td>
<td>Bike Sharing Data (Barcelona Bicing Open Data)</td>
<td>Bike Sharing Availability</td>
</tr>
<tr>
<td>Barcelona</td>
<td></td>
<td>Air-quality devices installed in SEAT cars</td>
<td>Environment Monitoring</td>
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<tr>
<td>Barcelona</td>
<td></td>
<td>Noise detectors (Barcelona City SENTILO platform)</td>
<td>Environment Monitoring</td>
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<tr>
<td>Barcelona</td>
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<td>Worldsensing Bluetooth/WIFI traffic detectors (Barcelona roundabouts)</td>
<td>Traffic Monitoring</td>
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<td>Barcelona</td>
<td></td>
<td>Loop detectors and connected cars synthetic data (Barcelona Eixample district, used for testing)</td>
<td>Traffic Monitoring</td>
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<table>
<thead>
<tr>
<th>Available 01 / 2018</th>
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<th>Sensors / Data</th>
<th>Services</th>
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<tbody>
<tr>
<td>Barcelona</td>
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<td>Connected Buses: People Counting Sensors on Bus (Touristic buses)</td>
<td>People Density Load (Bus / Bus stop area)</td>
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<tr>
<td>Barcelona</td>
<td></td>
<td>Connected Buses: Location Sensors on Bus (Touristic buses)</td>
<td>Live Bus Location</td>
</tr>
<tr>
<td>Barcelona</td>
<td></td>
<td>Worldsensing Magnetometers and additional Bluetooth/WIFI traffic detectors</td>
<td>Traffic Monitoring</td>
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Part II: Update of Use Case Definition related to 1st Amendment

1 Introduction

The objective of BIG IoT project is to establish an Internet of Things (IoT) ecosystem to bridge the interoperability gap between IoT platforms. To enable this, an IoT ecosystem will be provided that offers a BIG IoT API as a generic interface to smart object platforms and a marketplace to trade access to IoT data and services across IoT platform and domain boundaries. To demonstrate the solutions offered by the BIG IoT ecosystem use cases based on different smart object platforms, services and applications will be defined, implemented and validated in three regional pilots.

The purpose of this deliverable is to document the work carried out in the first iteration phase of WP 2, Task 2.2 Use case definition and Open call. It defines the guiding use cases for the BIG IoT ecosystem and for services and applications that will be implemented in the pilots making use of the BIG IoT API and marketplace.

1.1 Scope of this Document

This deliverable D2.2.b offers an inventory of the use cases for multi-deployable services and applications that are going to demonstrate and validate the BIG IoT concept of interoperability. The use cases defined in this deliverable set the baseline for the upcoming realization and implementation of services and applications in the pilots (WP 5) to be provided through the BIG IoT API (WP 3) and Marketplace (WP 4).

Reflecting the project’s overall state of work D2.2.b provides a list of use cases that will be finally revised in the third iteration phase of the project. Thus, the document will be updated in a further iteration step to complement the service and application portfolio of BIG IoT project.

The deliverable describes the use cases addressing IT-stakeholder’s needs to make active use of the future BIG IoT ecosystem (BIG IoT API and Marketplace). In addition, this document defines use cases derived from regional pilots making use of technical infrastructure locally available and addressing specific mobility challenges in the pilots.
1.2 Executive Summary

D2.2.b provides an update on the use cases that are relevant to demonstrate interoperability of platforms, and reports on the definition of use cases. This groundwork has been taken place in two key areas, the BIG IoT ecosystem and the BIG IoT pilots in Northern Germany, Piedmont and Barcelona.

For the BIG IoT ecosystem, those use cases have been chosen as most relevant that are supported by a clear business case and monetary benefits for the key stakeholders and lower the barrier for developers and providers to join the ecosystem. The BIG IoT ecosystem use cases included in this document are an initial set of use cases reflecting the state-of-work in the ongoing definition of the final architecture of the BIG IoT ecosystem. They will be further elaborated in the next iteration of the deliverable.

The definition of BIG IoT pilot use cases was based on an analysis of smart objects and platform infrastructures available in the pilots. Important use case topics have been discussed with local administration and other institutions involved in mobility planning to ensure that the pilot use cases meet relevant future mobility challenges.

As a result of the pilot discussion the deliverable D2.2.b captures use cases of the following use case clusters emphasizing mobility challenges: Smart Parking, Smart Traffic Management, Public Transport Optimization, Healthy Bike Navigation, Smart Bike Sharing, Incentive-Based Green Route Planning, Multimodal Route Optimization, and Smart Charging as well as Device-to-Device use cases.

Special emphasis was put on setting-up use case scenarios that illustrate the envisaged interaction of the fictive users with the future services and applications. Furthermore, the use cases are defined on a technical level indicating smart objects, platforms and their actors involved, use case stories describing the flow of events and corresponding services. A first high-level description of the corresponding services initializes the specification work to be done in WP 5 that will additionally define in detail in which iteration phase the listed use cases will be realized.
2 Methodology

In this chapter the methodology for the definition of guiding use cases is described. Due to different focusses the methodology includes specific descriptions for the definition of use cases for

- The BIG IoT ecosystem and marketplace that provide a generic interface and the tools to exchange data, services and applications across platforms and
- Three regional pilots (Northern Germany, Piedmont, Barcelona) focusing on technical solutions for smart mobility and smart road infrastructure.

2.1 Methodology for BIG IoT Ecosystem Use Case Definition

The use cases for the BIG IoT ecosystem described in chapter 3 of this document have been identified as high-priority for the development of release 1 of the BIG IoT architecture.

After a first collection of relevant use case scenarios for an IoT ecosystem, the team partners involved in the Ecosystem related tasks selected criteria for prioritizing the scenarios for release 1 of BIG IoT.

The following criteria have been chosen as most relevant, as they directly influence the success of establishing a new IoT ecosystem:

- Use cases that are supported by a clear business case and monetary benefits for the key stakeholders, and
- Use case scenarios that lower the barrier for developers and providers to join the ecosystem.

Based on those criteria the initial set of ecosystem use case scenarios for release 1 of BIG IoT was prioritized.

In a second step, all individual use cases of the prioritized scenarios were identified, aligned and grouped into four ecosystem use case clusters.
2.2 Methodology for Pilot Use Cases Definition

The pilot sites will demonstrate the usage of the BIG IoT Ecosystem in real-life conditions. Therefore, the pilot use cases must reflect the requirements and assets within the pilot sites on the one hand and the project’s overall goal of showcasing interoperability on the other side. A dual methodological approach was used to match those requirements: A first bottom-up perspective in defining the pilot use cases focused on what is available and needed in the pilots. The second top-down perspective focused on interoperability that is to be demonstrated within the pilots and across pilots in the project.

Starting from the eight Use Case Clusters mentioned in the Description of Action (DOA)\(^1\), e.g. “Smart Parking”, “Smart Traffic Management” etc., the pilot sites conducted the following steps to define the use cases:

1. **Confirmation of use case clusters** as stated in the DOA with respect to organizational, regulatory and technical feasibility within the pilots.
2. **Definition of atomic use cases** within the use case clusters as small building blocks for the future implementation and demonstration.
3. **Ranking of the atomic use cases** reflecting the relevance of the use cases for the pilots and taking into account feasibility aspects such as availability of data, required involvement of external providers or third parties (open call).
4. **Combining of the atomic use cases** from the clusters to cross-clusters and cross-pilots use case scenarios, focusing on future services and applications used by an end user.
5. **Definition of interoperability patterns** to demonstrate project’s goals within the pilots and to check if interoperability patterns aspects are addressed by the use cases.

With finalizing the 5th step, the perspectives of the pilots and the project have been matched.

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\(^1\) See p. 10 of the DOA.
2.3 Structure of the Part II of the document

The structure of the Part II of the document follows the methodological approach described above.

The following Chapter 3 depicts the use cases for the BIG IoT Ecosystem.

Chapter 4 gives an introduction of the three pilot sites Northern Germany, Piedmont and Barcelona. This section includes a general description of the pilots, relevant use case clusters as well as smart objects and platforms available for the demonstration.

Chapter 5 summarizes the pilot use cases in the use case clusters and shows the prioritization of the atomic use cases. This captures all the use cases relevant in the three pilots and shows use cases that are relevant for more than one pilot (so called cross-pilot use cases).

In chapter 6, use case scenarios are defined, representing the user view on future applications or services in a storytelling narrative.

With chapter 7, the interoperability aspects are defined and matched with the use case clusters showing which interoperability aspects are potentially addressed by which use case clusters.

Chapter 8 contains a conclusion as well as an outlook.

In the previous D 2.2.a, chapter 7 contained a service outlook that was skipped in this version since services were meanwhile specified in WP 5, Task 5.1: Pilot Specification.
3 BIG IoT Ecosystem Use Cases

The following chapter provides an overview of use cases related to the BIG IoT ecosystem. Therefore, the general objective is presented, affected stakeholders are described and finally the ecosystem use cases are presented.

3.1 Objective

The BIG IoT project aims at enabling the emergence of cross-platform, cross-standard and cross-domain IoT services and applications towards building IoT ecosystems. As an example, a cross-platform IoT application could be developed to access parking data provided by different data sources and IoT platforms, for example from a smart cities’ street parking system, from commercial parking lot providers etc. The application could discover additional data sources at run-time, as new IoT platforms providing parking data for the relevant city become available. Finally, the application could also discover and use different data sources at run-time when the user visits other cities, as different IoT platforms provide the data in other cities. Similarly, a cross-platform IoT application for a smarter workplace could be enabled to access the wearable sensors of users to utilize the gathered data for different purposes, e.g. to monitor the environment at their workplace. The described multi-purpose of things and data gathered by separate IoT platforms can create great benefits.

In order to ignite such an IoT ecosystem that is cross-platform and open to new providers of resources – so called offerings - as well as consumers of those, interoperability across platforms needs to be enabled. Once cross-platform interoperability is achieved, this will allow new applications by combining platforms (e.g. a smart city platform with a parking lot platform) and/or data (e.g. parking information from various platforms and regions), and applications to work on top of different platforms (e.g. the same application works on top of a smart city platform in Berlin, in Barcelona and in London).

The goal of the project is to design an architecture that aims at overcoming these hurdles through (1) an open marketplace as the center of the ecosystem functionalities (e.g. authentication, registration of resources to be offered by a provider (i.e. offerings), discovery of offerings desired by a consumer, and charging), (2) a common API for offering providers and consumers to interact with the marketplace and each other, as well as (3) common infor-
information models and semantic frameworks for describing and querying offerings via the marketplace.

Fig. 1 outlines the key components of how the BIG IoT project envisions an IoT ecosystem. The different IoT platforms give access to various kinds of things. Today they use their own interfaces, but are now extended with a common interface, the BIG IoT API, which offers the required set of functionalities for interoperability. Through the common API, it becomes easier to develop software artifacts as clients of different platforms. Among such software artifacts, within the project it is distinguished between services and applications. While both are consumers of information or functionalities (offerings), services can also act as providers of offerings. The offerings of providers are advertised on the marketplace, for consumers to discover them and to gain access to desired providers.
To enable interoperability for IoT platforms on server as well as on device level, the BIG IoT API offers a well-defined set of functionalities. The key functionalities that need to be part of the common API are (a) Identity management to enable the registration of offerings, (b) Discovery of offerings according to user defined search criteria, (c) Access to meta-data and data, (d) Tasking to forward commands to things, (e) Event processing and publish/subscribe of data streams, (f) Vocabulary management for semantic descriptions of concepts, as well as (g) Security management including authentication, authorization, and key management.

In order to focus the architecture work towards the project’s vision in the first year, towards BIG IoT release 1, we first selected and prioritized use case scenarios that are critical to establishing a successful ecosystem. In particular, we prioritized scenarios that are (1) supported by a clear business case and monetary benefits for the key stakeholders, and (2) lower the barrier for developers and providers to join the ecosystem. In a second step, we identified all the relevant use cases for those scenarios and grouped them into four use case clusters.

In the remainder of this section, we present the actors of the ecosystem use cases, the prioritized ecosystem use case scenarios and the use case clusters. The details of the use case scenarios are provided in part 1 of the annex.
3.2 Ecosystem Actors

The main actors of the BIG IoT ecosystem are shown in the Fig. 2.

![Fig. 2 Actors of the BIG IoT Ecosystem](image)

Next, the short description of the BIG IoT Ecosystem Actors is given:

- **BIG IoT Platform** is a smart object platform that implements the BIG IoT API and is enabled to provide its resources, i.e. offerings, in the BIG IoT Marketplace, thus acting as a BIG IoT Offering Provider.
- **BIG IoT Service** is a service that implements the BIG IoT API to provide and access offerings in the BIG IoT Marketplace, thus acting both as BIG IoT Offering Provider and BIG IoT Offering Consumer.
- **BIG IoT Application** implements BIG IoT API in order to access offerings registered in the BIG IoT Marketplace, thus acting as a BIG IoT Offering Consumer.
- **BIG IoT Core Developer** is a developer that develops the core components of the BIG IoT ecosystem e.g. BIG IoT API, SDK, marketplace and its subcomponents etc.
• **BIG IoT Developer** uses the BIG IoT technologies to develop BIG IoT enabled Platforms, Services and Applications.

• **BIG IoT Service/Application/Platform Provider** is an entity that operates (e.g. runs and administers) a BIG IoT Service/Application/Platform.

• **BIG IoT Marketplace Provider** is an entity that operates BIG IoT marketplace for providing, discovering and trading offerings.

### 3.3 Ecosystem Use Cases

The following use case scenarios have been prioritized and defined for the first release of the BIG IoT architecture. Further scenarios will be defined at a later stage to drive the architecture work for release 2 and 3 of BIG IoT.

**Use Case scenarios related to development**

The following scenarios have been identified as critical to support developers in the process of making their IoT platforms, services or applications to join the BIG IoT ecosystem. Thus, these use case scenarios target developers that a.) extend their IoT platform to support the BIG IoT API and offer resources on the marketplace, and b.), develop a service or application which uses the BIG IoT API to gain access to the marketplace to discover offering providers and connect to the respective platform or service to access the resources.

- **BEU-DEV-1**: BIG IoT Developer studies the BIG IoT documentation, example code and downloads the open source SDK: see Annex Part 1 for a detailed description
- **BEU-DEV-2**: BIG IoT Service/Platform Developer develops a Service or extends an IoT Platform to register an offering on a Marketplace: see Annex Part 1 for a detailed description
- **BEU-DEV-3**: BIG IoT Application/Service Developer develops an Application/Service which leverages a resource offering provided on a Marketplace: see Annex Part 1 for a detailed description
Use Case scenarios related to trading of resource offerings on the marketplace

The two scenarios listed here describe how (a) BIG IoT Offering Providers (Services and Platforms) can offer their offerings on the marketplace as well as how (b) BIG IoT Offering Consumers (Services and Applications) can search for offerings and access them.

- **BEU-RDA-1**: BIG IoT Service/Platform registers a resource offering on a Marketplace (→ Provider Scenario): see Annex Part 1 for a detailed description
- **BEU-RDA-2**: BIG IoT Service/Application uses/accesses a resource offering provided via a Marketplace (→ Consumer Scenario): see Annex Part 1 for a detailed description

Use Case scenarios related to charging and billing

One of the core functionalities of BIG IoT Marketplace is to enable BIG IoT Offering Providers to monetize the use of their offerings. Therefore, few scenarios describing the collection of accounting and usage data, as well as further functions necessary for charging and billing are identified.

- **BEU-CB-1**: BIG IoT Platform/Service/Application perform accounting of accessed offerings: see Annex Part 1 for a detailed description
- **BEU-CB-2**: BIG IoT Marketplace offers information/functions access to charging information to providers and consumers: see Annex Part 1 for a detailed description
- **BEU-CB-3**: BIG IoT Marketplace offers providers and consumers access to billing related functions/information: see Annex Part 1 for a detailed description

Use case scenario related to core development

The development of the core technologies of the BIG IoT ecosystem will be done as an open community process as early as possible. Thus we have identified the main use cases necessary for this process.

- **BEU-COREDEV-1**: BIG IoT Core Developer develops and documents the BIG IoT Core (API, Marketplace, ...): see Annex Part 1 for a detailed description
Based on the prioritized use case scenarios, the following four ecosystem use case clusters were defined. These clusters are used as a basis to focus the definition of the BIG IoT architecture requirements and to scope the architecture work for release 1 of BIG IoT. Note however that the final decision of what will be implemented as part of release 1 of BIG IoT will be taken by Task 2.4 as part of the high-level architecture definition by M12 of the project.

Cluster 1: Use cases related to development of BIG IoT Platforms, Services and Applications (for Offering Providers and Consumers on the marketplace)

The Fig. 3 depicts the use cases related to the development of new assets of BIG IoT Platform, Service and Application Developers based on the available BIG IoT technologies and offered resources.

These use cases enable the developers to define required semantic descriptions and queries for registering offerings on the marketplace, and to discover them respectively. Moreover the development of BIG IoT enabled assets will be simplified by providing automatically generated snippets of code for BIG IoT calls.

A BIG IoT Marketplace Provider provides composition recipes that can be used for composition of different offerings, thus providing a value add to the marketplace.
Cluster 2: Use cases related to registration, discovery and access of offerings on a marketplace

The use cases related to registration, discovery and access of resources offered on the BIG IoT marketplace are shown in the Fig. 4. In order for BIG IoT Services, Applications and Platforms to be able to register, discover and access resources they need to be authenticated and their authorization for these actions need to be verified.
When registering new resource offerings on the marketplace, semantic descriptions need to be provided based on a common information model. This information model is also used for semantic querying and composition of offerings.

Cluster 3: Use cases related to charging and billing

All use cases relevant for charging and billing are summarized in the Fig. 5. After receiving valid charging tokens Services and Applications (as Offering Consumers) are able to access resources provided by Services and Platforms (as Offering Providers). Both sides, consumers and providers, collect usage data and accounting data respectively, and report them to the marketplace. These mechanisms are the basis for the BIG IoT Offering Providers to monetize their resources. Via a Web portal on the marketplace, they are enabled to define the pricing models, invoice template and schedule etc. BIG IoT Consumers (Services and Applications) are also able to define their type of contract (prepaid or subscription) and view invoice information.
A BIG IoT Marketplace Provider is in charge of providing means for its customers (offering providers and consumers) to register, authenticate and authorize on the marketplace. Finally, the Marketplace Provider also receives payments (e.g. a share of the transactions) from its customers for providing the infrastructure and/or service.

Fig. 5 Charging and billing use cases
Cluster 4: Use cases related to core development of the BIG IoT ecosystem (i.e. BIG IoT API and marketplace)

The use cases related to the development of the BIG IoT technologies are summarized in the Fig. 6. Since the development of BIG IoT technologies will be done in an open community process, the Core Developers need to be registered on the BIG IoT Core Development Environment. Once registered, they can e.g. create issues, commit source code, deploy and test their software component, create merge request, provide documentation etc. Depending on their role, Core Developers responsible to guard the overall development and quality of the open source project will also be able to accept or reject merge requests proposed by regular Core Developers.
A BIG IoT Developer may, upon using the software components and specifications from the BIG IoT repository, report bugs, submit requests for the new features and provide feedback.
4 Pilot Descriptions

In the following chapter a short introduction to the three pilot sites Northern Germany, Piedmont (Italy) and Barcelona (Spain) is given. For each pilot site, local conditions are described, followed by addressed use case clusters and an overview of technical systems relevant for the BIG IoT project.

4.1 Northern Germany Pilot

This pilot involves and connects two northern German cities. The first city is Wolfsburg, located in the center of Northern Germany with 125,000 inhabitants. Wolfsburg is home of the Volkswagen headquarter, which is the biggest employer and economic force in the region. The second city is Berlin, capital of Germany with more than 3.5 Million inhabitants. The two cities are linked through the highway A2 in a 240 kilometer distance. ICE-trains link Berlin´s and Wolfsburg´s main stations in less than 70 minutes.

The aim of the Northern Germany pilot within the BIG IoT project is to provide adaptable mobility services for traffic participants as well as public administrations that can be implemented in any one city, depending on existing smart city infrastructure and platforms. Therefore, innovative mobility patterns in the corridor between the two cities shall be fostered. Additionally, reducing parking search traffic and promoting e-mobility is on the mobility agenda of both cities. In supporting electric cars, Car Sharing, Bike Sharing, train connections and other public transport facilities, the pilot also enables environmentally conscious decisions in road and rail traffic.

The use case clusters that are addressed in the pilot are “Multimodal Route Optimization” directed at commuters who travel between Berlin and Wolfsburg multiple times a week and consider train as well as road connections. “Smart Parking” and “Smart Bike Sharing” use cases will be implemented in Berlin, and “Smart Charging” use cases will be implemented in both cities, making use of innovative parking sensors and live data of charging stations.
“Public Transport Optimization” use cases shall support e.g. public transport providers in improving their services in Wolfsburg.

The usable smart objects in the pilot owned by the project participants as well as third party smart objects are combined via four different platforms which will be BIG IoT enabled. Via 12 services\(^2\), 32 pilot use cases are addressed within the five use case clusters mentioned above.

The following Fig. 7 depicts the technical overview of the Northern Germany Pilot.

\(^2\) In D 2.2.a, 20 services were mentioned here. In the meantime, with Task 5.1 (Pilot Specification), these services were combined to now 12 and several of them further specified for the first iteration phase.
4.2 Piedmont Pilot

This pilot involves two cities in Piedmont region of Northern Italy. Both cities have a population of about 45,000 inhabitants but have a different economic background and geographic location.

Biella, with a long history of economic wealth due to the textile industry - unfortunately now declining - lies in the foothills of the Alps. Over the years Biella has created an integrated area with suburban villages which share public transport lines and roads. As most Italian municipalities, Biella has an historical center of town with traffic restrictions that extend throughout the day and weekends.

Vercelli is situated in the plain of the river Po and it is an important center for the cultivation of rice. Being surrounded by rice paddies which are flooded from spring through summer, Vercelli suffers with cold and foggy winters followed with oppressive heat during summer months. These conditions highly influence the air quality in town that is currently measured with two official stations belonging to the regional environmental agency ARPA and do not cover satisfactorily the whole territory. On the other hand, while the expansion of Vercelli area has not reached neighboring villages, the flat land is favorable for alternative transport means like bicycle. Last but not least the center of town is subject to traffic and parking restrictions 24 hours a day.

Biella and Vercelli are about 50 km apart and there is no interconnecting highway as well as no strong economic relationship between the two towns.
The aim of Pilots in Piedmont region is to improve the awareness of citizens and public administrations on environmental and mobility management through the expansion and modernization of existing monitoring infrastructures.

The use case clusters addressed in these pilots are "Smart Parking" aimed at improving search time for a free stall and therefore reducing pollution. The latter condition will be monitored through low-cost air quality stations especially for promoting "Healthy Bike Navigation" and "Smart Bike Sharing" as well as providing local Public Administrations a view on real-time environmental situation overlaid to traffic flow in "Smart Traffic Management".

Citizens will also be involved in an "Incentive-based Green Route Planning" whose aim is to observe the impact on pollutants distribution by systematically re-routing vehicular traffic on different routes.

The following diagram shows the actors and devices addressed, as well as the smart objects and platforms involved.
Fig. 8 Piedmont Pilot – Technical Overview
4.3 Barcelona Pilot

The pilot takes place in Barcelona, a smart city reference worldwide. Barcelona has more than 1.600.000 inhabitants (over 3 million in the Barcelona metropolitan area) and hosts relevant International IT events such as Smart City World Congress, Mobile World Congress or IOT Solutions World Congress.

The Pilot activities will mainly involve L’Eixample (main Business District with 16% of total city population) and Les Corts district (an area where different innovative ICT solutions are available). Both of them are high density urban areas challenging environmental problems caused by traffic.

The use case clusters that will be addressed in the pilot are “Smart Parking”, to help citizens finding parking spaces in a more efficient way to reduce the volume of agitated traffic, “Smart Traffic Management”, supporting traffic managers to efficiently use the information elaborated from smart objects, “Incentive Based Green Route Planning”, to engage citizens in contributing to keep city environment.

Additionally, data offerings will be integrated to support use cases implemented by other pilots such as “Smart Bike Sharing”, “Smart Charging” and “Public Transport Optimization”, to provide real time information on bus load and position. An additional Use Case cluster “Device-to-Device Communication” was also identified and will be further developed in the future.

Three BIG IoT enabled platforms will be used in the pilot integrated through a BIG IoT gateway: OpenIoT (provided by NUIG), Bezirk device-level platform (provided by Bosch) and WorldSensing platforms (FastPark and Bitcarrier).
Open Data and 3rd party platforms such as the Barcelona SENTILO platform will also be integrated through a BIG IoT gateway. Access to additional Barcelona City Council real-time data through SENTILO platform will also be enabled on demand.

Smart Objects available for the pilot will be: 2 SEAT connected cars sending position & air quality data (CO, NO₂); Traffic detectors for speed or car count (3 magnetometers and 37 Bluetooth Wi-Fi antennas provided by WorldSensing); 500 Parking spot sensors from WorldSensing currently installed at Les Corts district; 10 WIFI probe sensor installed on touristic buses and Barcelona City sensors (58 noise detectors, 171 charging stations, 465 bike sharing stations)

Emulation of connected cars and loop detectors provided by UPC simulation models will provide synthetic data to be used during early development stages and to support testing BIG IoT services with large penetration of IoT.

The following diagram shows the actors and devices addressed, as well as the smart objects and platforms involved.
Fig. 9  Barcelona Pilot – Technical Overview
5 Pilot Use Case Clusters and Use Case Descriptions

5.1 Overview Use Case Cluster

The following chapter summarizes the use cases considered within the pilots. Therefore, nine use case clusters are outlined. For each use case cluster, the overall objective is mentioned, associated use cases are summarized within a table and a technical overview shows the smart objects, platforms, and devices envisaged to be used in the clusters.

Starting point for the definition of pilot use cases is the use case overview already inserted in the Description of Action (DOA) which indicated the use cases relevant for the pilot in Northern Germany (NG), Piedmont (PIE) and Barcelona (BCN). This initial definition included use cases from seven topics “Smart Parking”, “Smart Traffic Management”, “Public Transport Optimization”, “Healthy Bike Navigation”, “Smart Bike Sharing”, “Incentive-based Green Route Planning” and “Multi-modal Route Optimizer”.

In a very first step, this table has been discussed with stakeholders, platform providers, and city administrations in the pilots to ensure that the smart objects and platforms needed are available and to confirm that the use cases address mobility topics relevant for the cities. As an outcome, the use case clusters already mentioned in the DOA have been confirmed.

Furthermore, the new use case cluster “Smart Charging” has been added for the Northern Germany pilot. This reflects the increasing relevance of e-mobility in the cities of Berlin and Wolfsburg and makes use of the increasing number of e-Charging stations as smart objects to be included in BIG IoT.

Apart from that, an initial definition of the use case cluster “Device to Device-Communication” has been added. This use cases cluster support direct interaction between BIG IoT enabled devices (e.g. BEZIRK enabled mobile phone or Raspberry Pi). It has been identified as a clear candidate for open calls and hackathons and will be updated on next releases.

The following table lists the use case clusters and indicates by color highlighting in which pilot sites the use case clusters are relevant for future implementation.

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3 See DOA, p. 10.
Use cases were prioritized by the pilot sites. High priority use cases are highlighted in the use case table. They are envisaged to be implemented by the pilots during the project. Other use cases may be implemented in later stages, via the open calls or due to technical or regulatory boundaries not during the project.

The following description of the use case clusters includes

- Description of the overall objectives of the use case clusters
- The cluster’s use cases which are relevant in the different pilots
- A graphical overview on the use case clusters.

A detailed description of the above mentioned use cases indicating smart objects and platforms involved, stakeholders and their benefits as well as the flow of events and services involved is included in the template of Annex Part 2 of the document D2.2.a.
5.2 Smart Parking (SP)

“Smart Parking” will be applied in all three pilot sites and showcases interoperability at European level. It demonstrates parking related data sourced locally and service provision via the BIG IoT API in all three pilots.

SP use cases offer effective navigation to parking spots based on availability and distance, taking into account the current traffic conditions and parking prices. This involves new parking spot observing smart objects.

SP services are highly transferable cross-pilot and can be developed for private end users as well as public administrations.

The services include Parking Spot Availability, Prediction of Parking Spot Availability, Parking Reservation, Route to Parking Spot, Check-in / Payment and Check-out / Payment as well as Parking Enforcement.4

The following table shows the relevant use cases within the use case cluster Smart Parking. Use cases ranked with high priority for implementation are highlighted in light blue.

<table>
<thead>
<tr>
<th>Smart Parking Use Cases</th>
<th>NG-Pilot</th>
<th>BCN-Pilot</th>
<th>PIE-Pilot</th>
</tr>
</thead>
<tbody>
<tr>
<td>Find Free Parking Spot (App based)</td>
<td>SP-NG-01</td>
<td>SP-BCN-01</td>
<td>SP-PIE-01</td>
</tr>
<tr>
<td>Find Free Parking Spot (with Car integration)</td>
<td>SP-NG-02</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Predict Parking Space Availability</td>
<td>SP-NG-03</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Find Probable Parking Area</td>
<td></td>
<td>SP-BCN-02</td>
<td></td>
</tr>
<tr>
<td>Reserve Parking Spot</td>
<td>SP-NG-04</td>
<td>SP-BCN-03</td>
<td></td>
</tr>
<tr>
<td>Route to Parking Spot</td>
<td>SP-NG-05</td>
<td>SP-BCN-04</td>
<td>SP-PIE-04</td>
</tr>
<tr>
<td>Check-in</td>
<td></td>
<td>SC-BCN-05</td>
<td></td>
</tr>
<tr>
<td>Check-out</td>
<td></td>
<td>SP-BCN-06</td>
<td></td>
</tr>
<tr>
<td>Pay for Stay</td>
<td>SP-NG-06</td>
<td>SP-BCN-07</td>
<td></td>
</tr>
<tr>
<td>Monitor Parking Spot Area From Desk</td>
<td></td>
<td></td>
<td>SP-PIE-12</td>
</tr>
<tr>
<td>Monitor Parking Spots, App based</td>
<td></td>
<td></td>
<td>SP-PIE-20</td>
</tr>
<tr>
<td>High priority use cases are highlighted in blue.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4 Use cases and services for public administrations focusing on enforcement are subject to current political guidelines and require intensive approval procedures. Therefore, use cases addressing enforcement activities may be technically realized as a prototype in a future iteration phase. An in-situ demonstration of the use case, however, is out of project scope.
Tab. 2 Use Cases in Use Case Cluster Smart Parking

Fig. 10 Overview Use Case Cluster: Smart Parking
5.3 Smart Traffic Management (STM)

Traffic Information Center Operators will be able to get information and to monitor abnormal conditions related with traffic status or pollution, based on real time data obtained by different devices (e.g. air quality sensors of smart cars, low cost air quality stations, WIFI/BT detectors, etc.).

On the basis of traffic and environment monitoring, traffic recommendations will be issued to improve city conditions and reduce pollution.

The services include Traffic Monitoring, Traffic Recommendations Management and Environment Monitoring.

The following table shows the relevant use cases within the use case cluster Smart Traffic Management. Use cases ranked with a high priority for implementation are highlighted in light blue.

<table>
<thead>
<tr>
<th>Smart Traffic Management [STM]</th>
<th>NG-Pilot</th>
<th>BCN-Pilot</th>
<th>PIE-Pilot</th>
</tr>
</thead>
<tbody>
<tr>
<td>Get Traffic Information</td>
<td></td>
<td>STM-BCN-01</td>
<td>STM-PIE-01</td>
</tr>
<tr>
<td>Monitor Traffic Alarms</td>
<td></td>
<td>STM-BCN-02</td>
<td>STM-PIE-02</td>
</tr>
<tr>
<td>Get Travel Times between two points</td>
<td></td>
<td>STM-BCN-03</td>
<td></td>
</tr>
<tr>
<td>Monitor Environment Alarms</td>
<td></td>
<td>STM-BCN-04</td>
<td>STM-PIE-04</td>
</tr>
<tr>
<td>Set Environment Recommendations</td>
<td></td>
<td>STM-BCN-05</td>
<td></td>
</tr>
<tr>
<td>Get Environment Recommendations</td>
<td></td>
<td>STM-BCN-06</td>
<td></td>
</tr>
<tr>
<td>Get Air Quality Conditions</td>
<td></td>
<td></td>
<td>STM-PIE-03</td>
</tr>
<tr>
<td>High priority use cases are highlighted in blue.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Tab. 3 Use Cases in Use Case Cluster Smart Traffic Management
Fig. 11 Overview Use Case Cluster: Smart Traffic Management
5.4 Public Transport Optimization (PTO)

The target of this use case cluster is to optimize public transportation, both from the perspective of the public transport user, but also from an administrative point of view. This means that both the usage of public transportation is optimized, in terms of selection and guidance, and the assignment of resources in public transport system. This is done based on information about the users of the transport systems, particularly the number of users. This information is extracted from different systems, depending on availability. But also live information about location of e.g. buses is provided to users to enhance the public transportation experience.

The services include People Density Estimation on Bus, People Density Estimation in Area and Live Bus Position; Multimodal Routing.

The following table shows the relevant use cases within the use case cluster Public Transport Optimization. Use cases ranked with high priority for implementation are highlighted in light blue.

<table>
<thead>
<tr>
<th>Public Transport Optimization</th>
<th>NG-Pilot</th>
<th>BCN-Pilot</th>
<th>PIE-Pilot</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optimize public transport resources</td>
<td>PTO-NG-01</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Optimize public transport selection/guidance</td>
<td>PTO-NG-02</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Optimize end-user experience when arriving at public transport stop</td>
<td>PTO-NG-03</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Optimize end-user experience when taking public transport</td>
<td>PTO-NG-04</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Live bus tracking</td>
<td>PTO-NG-06</td>
<td>PTO-BCN-06</td>
<td></td>
</tr>
<tr>
<td>People density estimation based on smart buses</td>
<td>PTO-NG-07</td>
<td>PTO-BCN-07</td>
<td></td>
</tr>
<tr>
<td>Identification of people flow along bus line</td>
<td>PTO-NG-08</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Creating a model for prediction of bus utilization</td>
<td>PTO-NG-09</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Tab. 4 Use Cases in Use Case Cluster Public Transport Optimization
Fig. 12  Overview Use Case Cluster: Public Transport Optimization
5.5 Healthy Bike Navigation (HBN)

Two use case clusters on bike mobility have been planned to be realized within BIG IoT Pilots: Healthy Bike Navigation and Smart Bike Sharing\(^5\).

The former cluster, Healthy Bike Navigation, is aimed at providing bikers with information about healthier alternative routes. The path is computed taking into account data coming from low cost air quality stations and potentially traffic conditions as observed by traffic counting sensors. Points of interest where environmental data is collected (air quality, traffic) are agreed with the local authorities accordingly to the location of bike paths, crossroads with heavy traffic, bike sharing stations and more.

The services include Environmental Monitoring and Routing (which in turn can potentially use data from traffic sensors).

Through HBN use cases all bikers in Pilot areas will be able to choose wisely their route accordingly to localized measurements of pollutants.

The following table shows the relevant use cases within the use case cluster Healthy Bike Navigation. Use cases ranked with high priority for implementation are highlighted in light blue.

<table>
<thead>
<tr>
<th>Healthy Bike Navigation</th>
<th>NG-Pilot</th>
<th>BCN-Pilot</th>
<th>PIE-Pilot</th>
</tr>
</thead>
<tbody>
<tr>
<td>Find Healthier Route</td>
<td></td>
<td>HBN-PIE-01</td>
<td></td>
</tr>
<tr>
<td>Navigate to Destination through</td>
<td></td>
<td></td>
<td>HBN-PIE-02</td>
</tr>
<tr>
<td>Healthier Route</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

High priority use cases are highlighted in blue.

Tab. 5 Use Cases in Use Case Cluster Healthy Bike Navigation

\(^5\) Smart Bike Sharing is described in the next chapter.
5.6 Smart Bike Sharing (SBS)

Smart Bike Sharing is the second use case cluster on bike mobility. It was originally designed to provide an estimation of bike and dock availability through the analysis of people density estimation data coming through the former project partner Vodafone.

Bike sharing users will be enabled to gather information on the service through a BIG-IoT enabled application. Bikes and docks availability at a given point in time and space will be provided with real-time data.

BIG IoT partners involved in Pilots will develop and operate services that expose bike and/or docks availability through the marketplace.

The following table shows the relevant use cases within the use case cluster Smart Bike Sharing. Use cases ranked with high priority for implementation are highlighted in light blue.

<table>
<thead>
<tr>
<th>Smart Bike Sharing</th>
<th>NG-Pilot</th>
<th>BCN-Pilot</th>
<th>PIE-Pilot</th>
</tr>
</thead>
<tbody>
<tr>
<td>Docks availability</td>
<td></td>
<td>SBS-NG-01</td>
<td>SBS-PIE-01</td>
</tr>
<tr>
<td>Bike Availability</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High priority use cases are highlighted in blue.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Fig. 14 Overview Use Case Cluster: Smart Bike Sharing
5.7 Incentive-Based Green Route Planning (GRP)

The objective of this Use Case Cluster is to incentivize drivers to follow recommendations in order to improve city environment, as for example avoiding driving in polluted areas, using public transport, etc.

Air quality parameters will be monitored through different hardware depending on the Pilot region showing the interoperability introduced by BIG IoT: low cost air quality stations, air quality sensors on connected cars and existing noise sensors. Traffic data comes from heterogeneous sources as well, depending on the selected area.

Participating users will be incentivized to choose alternative routes with an overlay of the environment status on their calculated path to destination.

The Routing Service gathers data from environment and traffic-related Services.

The following table shows the relevant use cases within the use case cluster Incentive-Based Green Route Planning. Use cases ranked with high priority for implementation are highlighted in light blue.

<table>
<thead>
<tr>
<th>Incentive-Based Green Route Planning</th>
<th>NG-Pilot</th>
<th>BCN-Pilot</th>
<th>PIE-Pilot</th>
</tr>
</thead>
<tbody>
<tr>
<td>Find Green Routes</td>
<td></td>
<td>GRP-BCN-01</td>
<td>GRP-PIE-01</td>
</tr>
<tr>
<td>Get Alternative Transport modes</td>
<td></td>
<td>GRP-BCN-02</td>
<td></td>
</tr>
<tr>
<td>Follow Green Recommendations</td>
<td></td>
<td>GRP-BCN-01</td>
<td>GRP-PIE-03</td>
</tr>
</tbody>
</table>

High priority use cases are highlighted in blue.

Tab. 7 Use Cases in Use Case Cluster Incentive Based Green Route Planning
Fig. 15  Overview Use Case Cluster: Incentive-Based Green Route Planning
5.8 Multimodal Route Optimization (MRO)

Multimodal Route Optimization is geared to long distance commuters, based on real time data on public and individual transport and availability of e-charging stations on the corridor between larger cities. It demonstrates the connection of different data sources for seamless mobility towards a chosen destination, offering multimodal options and alternative routes in case of disruptions along the preferred route.

Its services use data from different platforms and make them accessible through the BIG IoT API. They can be further advanced by connecting other clusters such as Smart Parking.

The services include Multimodal Routing, Personalization, Route Monitoring, Detour / Mode Shift Recommendation, Incident Notification and Car Sharing Reservation.

The following table shows the relevant use cases within the use case cluster Multimodal Router Optimization. Use cases ranked with high priority for implementation are highlighted in light blue.

<table>
<thead>
<tr>
<th>Use Case Name</th>
<th>NG-Pilot</th>
<th>BCN-Pilot</th>
<th>PIE-Pilot</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Routing Start to Destination</td>
<td>MRO-NG-01</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Save Route</td>
<td>MRO-NG-02</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Monitor Street Traffic Situation</td>
<td>MRO-NG-03</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Monitor Rail Situation</td>
<td>MRO-NG-04</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Detour</td>
<td>MRO-NG-05</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Find Alternative Car</td>
<td>MRO-NG-06</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reserve Alternative Car</td>
<td>MRO-NG-07</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Check State of Relations/Route</td>
<td>MRO-NG-08</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inform Commuter about Deviation</td>
<td>MRO-NG-09</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

High priority use cases are highlighted in blue.

Tab. 8 Use Cases in Use Case Cluster Multimodal Route Optimization
Fig. 16  Overview Use Case Cluster: Multimodal Routing Optimization
5.9 Smart Charging (SC)

“Smart Charging” will be demonstrated in the Northern Germany Pilot making use of smart objects (e-charging stations) that are available in both pilot sites (Berlin and Wolfsburg).

It aims at providing information on available charging stations and provides routing to charging infrastructure currently offered in each city individually as well as including charging infrastructure in the corridor. The services include Charging Station Availability, Routing to Charging Station, Reserve Charging Station and Pay for Charge.

<table>
<thead>
<tr>
<th>Smart Charging Use Cases</th>
<th>NG-Pilot</th>
<th>BCN-Pilot</th>
<th>PIE-Pilot</th>
</tr>
</thead>
<tbody>
<tr>
<td>Find Free Charging Station</td>
<td>SC-NG-01</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reserve Charging Station</td>
<td>SC-NG-02</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Route To Charging Station</td>
<td>SC-NG-03</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pay For Charge</td>
<td>SC-NG-04</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

High priority use cases are highlighted in blue.

Tab. 9 Use Cases in Use Case Cluster Smart Charging
5.10 Device to Device Communication (D2D)

This use case cluster will support direct interaction between BIG IoT enabled devices (e.g. BEZIRK enabled mobile phone or Raspberry Pi). An initial definition is included in this deliverable, which will be updated and further developed on next releases, as this has been identified as a clear candidate for open calls and hackathons.

Two use cases have been initially defined to allow interaction between pedestrian or bikers and smart traffic lights.

<table>
<thead>
<tr>
<th>Smart Charging Use Cases</th>
<th>NG-Pilot</th>
<th>BCN-Pilot</th>
<th>PIE-Pilot</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pedestrian – Traffic Light Interactions</td>
<td></td>
<td>D2D-BCN-01</td>
<td></td>
</tr>
<tr>
<td>Cycler – Traffic Light Interactions</td>
<td></td>
<td>D2D-BCN-02</td>
<td></td>
</tr>
</tbody>
</table>

High priority use cases are highlighted in blue.

Tab. 10 Use Cases in Use Case Cluster Device 2 Device

Fig. 18 Overview Use Case Cluster: Device to Device
6 Use Case Scenarios

After having defined use cases in the preceding chapters the next step is to show how the defined use cases can be addressed in future applications. Therefore, this chapters outlines use case scenarios that focus on a fictive user/actor and illustrate how this user/actor will interact with a future application.

The following descriptions of use case scenarios are done for

- Pilot specific use case scenarios merging use cases of different clusters in pilot-specific user stories. This is done to show the diversity of use cases based on different smart objects and platforms available in the local sites that can be potentially implemented in future pilot-specific applications.
- Cross-pilot use case scenarios addressing use cases implemented in various pilot sites to outline cross-pilot interoperability in future applications.

6.1 Northern Germany Pilot

6.1.1 Commuter Berlin <-> Wolfsburg

Actor: Benjamin Big
- Role: Frequent Commuter
- Residence: Berlin
- Working in Wolfsburg

Benjamin Big works as a freelancing vehicle engineer for VW and WAG. As a frequent commuter, Benjamin usually boards the ICE, departing at Berlin-Main Station at 07:49am. The train allows him to attend the regular morning meetings at the Wolfsburg Mobility Station at 09:30am as well as checking his e-mails and preparing for the meeting ahead whilst on the way.

Since he needs to commute between Berlin and Wolfsburg at least 3 times a week, he experiences short notice delays, cancellations and changes of schedule quite often and checks in
advance whether any disruptions might cause him to change his travel route. This could mean opting for a later, an earlier or even a different train connection but also choosing his car instead of public transport.

As possible disturbances are manifold, Benjamin was looking for an easier way to keep track on his options and discovered the BIG IoT Commuter App.

After downloading the app and creating a personalized user profile he tries the app by entering his three-times-a-week return trip from Berlin-Mitte to Wolfsburg Mobility Station [MRO-NG-01]. From the modal and multi modal routing results the app provided, Benjamin selected two recommendations to be saved in his personal account [MRO-NG-02]:

1. His preferred connection with his own electric car to Berlin-Main Station, with Deutsche Bahn (DB) to Wolfsburg Main Station and from there to the Mobility Station via electric Carsharing car.
2. His alternative connection with his own car via highway A2, from Berlin to Wolfsburg.

Today, Benjamin has to attend a regular meeting in Wolfsburg regarding the upcoming release of a new range of electric cars. The meeting starts at 9.30am.

The Alarm goes off at 06:30 in the morning which gives him enough time to get ready and catch his usual train at 07:49am. Via push-message the app notifies him [MRO-NG-09] that the trains are running on time and no disruptions can be detected along the corridor to Wolfsburg [MRO-NG-04] as well as on his preferred route to the Berlin Main Station [MRO-NG-03].

While having his morning coffee, Benjamin remembers that his car needs charging. He opens the app again and looks for available parking spots with charging infrastructure close to the main station. The system checks, based on parking spot detection, which parking spots are currently free (and for which no reservations are pending for the requested timeframe); [SC-NG-01]. He finds a spot that is available until his return at 5 pm and reserves it straight away [SC-NG-02] so he can focus on driving while being routed by the app [SC-NG-03]. Once he arrives at his reserved sparking spot, he plugs his car in to the charge column and proceeds to the station.

His train arrives on time and Benjamin continues his journey to Wolfsburg. While on the train he has time to check on Wolfsburg’s bus schedule to get from the station to his meeting venue. He finds a bus route that stops close to his destination. It’s due to depart shortly
after his train’s arrival so he hurries a little to catch it and he arrives right on time for the meeting to begin.

After a productive 4 hour meeting he uses public transport to get to Wolfsburg Main Station. As a passenger that regularly uses public transport he opens an app, where he is presented with a list of bus lines of Wolfsburg. He selects the bus line of interest, and is presented with a list of stops and a map. He selects a bus stop of interest. From this he can see live information about the next bus arriving at the selected stop [PTO-NG-02]. This information includes indication of where the bus currently is located, if the bus is delayed, an indication of the number of people on the bus, and a forecast of the number of people on the bus when it reaches his stop [PTO-NG-06]. Based on this information he can choose if he takes this bus, if he should switch to take another line, a later bus, or another mode of transportation.

He can also choose to see historical information about the number of people on the bus based on location and time of day. This will allow him to plan ahead, e.g. if he wants to avoid over filled buses he can see at which times of the day the buses are less loaded [PTO-NG-09].

While using the public transport, he connects with a smart device on the bus to get real time information about public transport connections [PTO-NG-04]. When waiting for a bus at the bus stop, he can also connect to a smart device at the bus stop to get live information relevant to the current location [PTO-NG-03].

One quick look at the app [MRO-NG-08] shows him that the next train arriving will be on time and no difficulties along the track have to be expected [MRO-NG-04].

After his arrival at the Berlin main station and returning to his own car he pays [SC-NG-04] for the day’s charging fee. Docking his phone onto the dashboard of his car, the app notifies [MRO-NG-09] Benjamin of a road block on his preferred route home [MRO-NG-03] and offers an alternative [MRO-NG-05].
6.1.2 E-Mobility User

Actor: Benjamin Big

- **Role**: Electric car user
- Residence: Berlin
- Working in Wolfsburg

In the morning of another day, the app notifies him [MRO-NG-09] of major delays in the ICE schedule [MRO-NG-04], so he uses his alternative connection by car. He checks for any troubles along his route [MRO-NG-03; MRO-NG-08] before his departure. As his electric car is fully charged he will only have to recharge during his meeting in Wolfsburg.

Using the app, he finds charging infrastructure close to the meeting venue [SC-NG-01] that will be available for the duration of the meeting. So he reserves it [SC-NG-02] to ensure that he can use it and return to Berlin without delays.

After the meeting Benjamin pays the charging fee [SC-NG-04] and checks again, if any disruptions along his preferred route are to be expected [MRO-NG-03; MRO-NG-08]. Since the highway is clear of any traffic jams or construction sites, his journey home passes uneventfully.

6.1.3 Parking Enforcement Officer

The Parking Enforcement Officer Use Case Scenario (Actor Karl Müller) has been removed due to missing prospects to integrate this in real world environments with local authorities.
6.1.4 Public Transport Manager

Actor: John Bender

• Role: Public Transport Manager
• Residence: Wolfsburg
• Has to optimize usage of PT fleet

John Bender is an employee at the public transport company in Wolfsburg and has a number of various tasks related to resource management of public transport and to monitor the live status of buses. On a monthly basis he must evaluate if the usage of transport resources can be optimized, specifically in terms of if there are routes with too few buses or too small buses, or if there are routes where at certain times the buses are mostly empty. He does this by going to a web page where he is presented with a list of the bus routes in the city. He clicks on one bus line, and is presented with several graphs. Each graph represents the number of people registered on the bus over time, so from early morning to late night. He clicks on one graph that corresponds to the people counted by one sensor on one bus, to get a more detailed view. He clicks on a point on the graph where the number of people is low. The geographical location of the bus corresponding to the selected point on the graph is now presented on a map.

Based on this information he can choose to put in a bigger or smaller bus, or perhaps put in an extra bus at specific times of the day [PTO-NG-01; PTO-NG-09].

On a daily basis he is tasked with monitoring the live status of the buses, both in terms of if the buses do not follow the schedule, and in terms of the load of people on the buses.

He does this by looking at the same web page and selecting a live view. Here he is presented with a map where it is indicated where the buses are located currently. He can now choose to filter for a specific route, which will present him only with the locations of the relevant buses, and their route and where they are currently supposed to be [PTO-NG-06].
Jane is an employee of the city, working with urban planning, and is tasked with optimizing different services provided by the city, e.g. public transport and stops, waste collection, street cleaning, police patrolling, etc.

To do this she must support her knowledge with information about people density in the city at different times. She obtains this information by opening a web page to see a heat map showing the people density in the city.

She can also select to see the map as an animation, indicating the people density over the course of a day. She can now use this information to make informed decisions related to the task at hand [PTO-NG-07].

In connection with a special city wide event the employee of the city is in charge of the overall manning, i.e. service staff, police, checkpoints, other. To do this she needs a live overview of crowd movement in the city to be able to assign or move staff to most relevant areas.

She opens a web page where she can see the current movement of people. She can choose how far back in time she wants to have information (e.g. 10 - 60 min), and based on this, vectors are presented on the map indicating where people are moving from and to.

Based on this she can see if there is a tendency that people are moving through a certain area, or towards a single point (e.g. a stadium), and act accordingly [PTO-NG-08].
6.2 Piedmont Pilot

6.2.1 Public Bike User

**Actor: Giuseppe Verdi**

- **Role:** Public Bike User
- **Residence:** Vercelli
- **Uses public bike for daily mobility**

Giuseppe Verdi works as civil employee at the Municipality of Vercelli and every day he uses a public bike to go to work.

Close to Giuseppe Verdi’s house there are 2 public docks with 9 bikes and every morning he uses the app [SBS-PIE-01] to check in which docks how many bikes are available.

Giuseppe Verdi’s house distances 3 km from his office, and he has to cross the town, but surely he is convinced that this is the greener, the healthier and faster way to go to work. For this he uses the app [HBN-PIE-01] to verify and to navigate [HBN-PIE-02] following the better route.
6.2.2 Traffic Control Center Operator

In Biella, Elsa Morante is a traffic manager where she monitors the traffic and the state of air pollution in the industrial area of the town. For this, she uses the web application that provides information about the congestion of traffic in the busiest crossing points of the city [STM-PIE-01] and that provides information about the air quality, including the industrial area [STM-PIE-03]. Elsa monitors the situation in the area covered by the Traffic Webcams [STM-PIE-02] and in case of abnormal traffic she notifies the police. Elsa monitors the situation in the area covered by the Air Quality Stations in the industrial area [STM-PIE-04] and in case of emissions exceeding limit values she notifies the Regional Agency for the Protection of the Environment (Agenzia Regionale per la Protezione Ambientale - ARPA) of Piedmont.
6.2.3 Delivery Company Driver

Actor: Alessandro Manzoni  
**Role: Delivery Company Employee**  
- Residence: Biella  
- Wants to be green and wants to find a parking place

Actor: Elsa Morante  
**Role: Traffic Control Centre Operator**  
- Residence: Biella  
- Controls traffic and air quality conditions

Alessandro Manzoni is a van driver and today he has to leave from Biella to deliver torcetti (that are the typical cookies of Biella) in Vercelli. To get from Biella to Vercelli it takes 45 minutes, because there is no highway that links the 2 towns. The delivery area in Vercelli lies within the pedestrian area and is accessible only between 8 and 11 a.m. While he is in Vercelli, Alessandro will visit his uncle who is in the hospital this week for the yearly check-up. The visiting hours are between 9 and 11 a.m.

Alessandro leaves home at 7 a.m. and goes to the torcetti factory to load the van. For this he uses the app [GRP-PIE-01] to check the best route and to increase his rank to be the greenest driver of his company. [GRP-PIE-03]

At 7.30 a.m. Alessandro drives from Biella to Vercelli and when he reaches the pedestrian area entrance he uses the app [SP-PIE-01] to find and to reach [SP-PIE-04] the nearest free parking spot to deliver his goods.

Alessandro parks the van at 8.30 a.m. and it takes him 30 minutes to deliver torcetti in 2 shops. This is also the average turnaround time of the parking spot [SP-PIE-12].

Alessandro performs delivery and then checks if there are public buses to go to the hospital taking into account that he can leave his van in the parking stall for at most 1 hour. He verifies that the bus has just passed [GRP-PIE-02] and the next will come in 1 hour.
After that Alessandro checks if there are free parking spots in the hospital area using [SP-PIE-20] and he verifies that there is a good turnover so he has a good probability to find free spots.

The hospital is in the opposite direction of the pedestrian area. To go there, Alessandro checks the greener route with the app [GRP-PIE-01].

All Alessandro’s movements in the parking spots are monitored in an anonymous way by the web application that Elsa Morante uses on her desk [SP-PIE-12].
6.3 Barcelona Pilot

6.3.1 Incentives for Connected Car User

Susana Ventura is a Wildlife biologist and she is commuting in her Connected Car from her residence in Mataró to her job in Barcelona. Roberto Sala - a Traffic Information Centre Manager - decides to issue a recommendation through the Barcelona Control Centre [STM-BCN-05]. While driving, the Traffic Recommendation appears in Susana’s app as it’s affecting her route to work: “High pollution! Public transport is encouraged” [STM-BCN-06]. She decides to follow the recommendation. To do that, she has to park and take a bus or the metro so she uses her app for finding the nearest parking [SP-BCN-01]. She decides which parking to go to and asks for a route to get there [SP-BCN-04]. When Susana reaches the parking, she checks-in with her app [SP-BCN-05]. Then she asks her phone app for the best public transportation route to her workplace [GRP-BCN-02]. The app tracks her route with public transport and when she reaches her destination the app gives her some points for following the green route [GRP-BCN-03].

In Fig. 19 a graphical illustration of the use case scenario is shown.
Susana is driving her Smart Car through the city of Barcelona.

Roberto issues a Recommendation through the Barcelona Control Centre.

Her app tells Susana of the Traffic Recommendation.

High pollution area in Gran Via. Driving not recommended.

The Recommendation suggests taking public transportation.

Routing to nearest parking spot.

She decides to follow the city’s recommendation and asks the app for the nearest parking.

When Susana reaches the parking she checks-in.

Then she checks her phone app for public transportation to her original destination.

The app tracks her route in order to give her incentives.

The app gives her some points for following the green route.

Good job, Susana!

Fig. 19  Graphical Illustration of Incentives for Connected Car Users
6.4 Smart Parking in Northern Germany – Piedmont – Barcelona

Actors: Pol and Isabella
- **Role:** frequent car users
- **Residence:** Badalona
- **Young urban professionals travelling all over Europe**

Pol and Isabella live just outside Barcelona’s city borders and commute to their workplace in the city everyday by their own car. As they often meet friends in the evening at different locations, they regularly use the BIG IoT App to find a parking spot [SP-BCN-01] close to that day’s venue. Whenever they can, they reserve that space [SP-BCN-03] and let the app route [SP-BCN-04] them to the destination.

They also like travelling Europe driving their car. So, whenever they go on a trip they use the app at their destination, the same way they would at home, to find [SP-NG-01, SP-PIE-01], reserve [SP-NG-04] and get routed [SP-NG-05, SP-PIE-04] to the chosen space.

6.5 Smart Traffic Management in Piedmont and Barcelona

**Actor 1: Elsa Morante**
- **Role:** Traffic Control Centre Operator
- **Residence:** Biella
- **Controls traffic and air quality conditions**

**Actor 2: Roberto Sala**
- **Role:** Traffic Control Centre Manager
- **Residence:** Barcelona
- **Informs his fellow citizens on traffic and environment situation**
In Biella, Elsa Morante is a traffic manager where she monitors the traffic and the state of air pollution in the industrial area of the town. For this, she uses the web application that provides information about the congestion of traffic in the busiest crossing points of the city [STM-PIE-01] and that provides information about the air quality, including the industrial area [STM-PIE-03]. Elsa monitors the traffic and in case of abnormal situation [STM-PIE-02] she notifies the police. Elsa monitors the air quality and in case of emissions exceeding limit values in the industrial area or in town alert [STM-PIE-04] she notifies the Regional Agency for the Protection of the Environment (Agenzia Regionale per la Protezione Ambientale - ARPA) of Piedmont.

ARPA will cross check the information with readings from their expensive (but sparse) instruments, historical series and provide indications on the need to take corrective actions.

In Barcelona Roberto Sala is a Traffic Manager at the Traffic Information Center. Like every day, while drinking his morning coffee, he queries the Traffic Application - provided by Ice-Cold Robot Solutions- for information about travel time and speeds in Barcelona to have a general overview. To do so he selects an area in the city and a color-coded map is shown [STM-BCN-01]. Then he defines the alarms to be triggered when a low speed threshold is reached [STM-BCN-02] or when noise levels are too high [STM-BCN-04].

Meanwhile, in Biella, Elsa Morante monitors the air quality. An air-quality threshold she defined last fortnight is active [STM-PIE-04] in her Transportation Management Application - provided by Ice-Cold Robot Solutions and Greentech Services.

She decides to check the status of the city [STM-PIE-01] and inform the City Council Transport Manager about the situation.

At the same time, a noise pollution alarm for Barcelona City Centre is triggered and shown in the Traffic Control Centre screen [STM-BCN-04]. Roberto checks travel times in main links of Barcelona [STM-BCN-03], which are also shown in the website, before defining some traffic recommendations as for example to avoid the City Centre [STM-BCN-05] in order to reduce noise levels in that area.
Roberto is on his job as a Traffic Control Centre Manager. During his day he has the need to know the status of the city network. He selects a specific area in the city to be queried. Meanwhile in Biella, Elsa Morante is on her job. A notification is pushed to her application. The alarm says that the threshold she defined has been reached. At the same time, Roberto is looking at travel times. Finally, he defines some traffic recommendations. Nice job, Elsa and Roberto!

Fig. 20  Graphical Illustration of Smart Traffic Management in Barcelona and Piedmont
7 Interoperability in Use Cases

As already mentioned in section 2.2, the aspect of interoperability is of specific importance for defining the BIG IoT use cases. It has to be ensured that the use cases defined for the pilots are suitable to show interoperability across platforms and pilots. To do this, a definition of the relevant interoperability patterns is needed and provided in the remainder of this section. The various aspects of interoperability described in the following were referenced in the pilot use case clusters to show if and to what extent the pilot use case clusters address the interoperability patterns for the first iteration.

Project Definition of Interoperability

Interoperability relates to the syntax as well as to the semantics of interfaces. Syntactic interoperability can be reached through clearly defined and agreed data and interface formats as well as encodings. Semantic interoperability can be achieved through commonly agreed information models (e.g. defined with ontologies) used as part of the interfaces and exchanged data.

In the following, generic interoperability patterns for IoT ecosystems were identified, that the project targets to support in order to achieve the goal of lowering market entry barriers for developers. The five identified interoperability patterns are:

1. Cross Platform Access
2. Cross Application Domain Access
3. Platform Independence
4. Platform-Scale Independence
5. Higher-level Service Facades

The patterns are described in the following and summarized in Fig. 21.

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6 The five interoperability patterns describe the up-to-date state of work and may be modified according to the overall project development in coming iteration stages.
The first pattern, “**Cross Platform Access**” (Fig. 21, a), is the fundamental characteristic of an interoperable IoT ecosystem. The pattern entails that an application or service accesses resources (information or functions) from multiple platforms through the same interface specification. For example, this can mean that an “air quality monitoring” application would access multiple air quality related platforms to gather information, e.g. on different air quality indicators, such as NOx, CO, or O3, from separate platforms. The challenge of realizing this pattern lays in allowing applications or services to discover platforms with relevant information, and enabling platforms that are potentially from different providers to have the same interface and use the same formats to communicate data.

The second pattern “**Cross Application Domain Access**” (Fig. 21, b) extends the “Cross Platform Access” pattern. Services/applications access information and functions not only from multiple platforms, but also from platforms which host information from different verticals or application domains. As semantic descriptions of the information sources of a platform can be accessed through the common platform interface (provided by using the BIG IoT API), the integration of such (originally heterogeneous) data into one service/application becomes possible. An application that gathers data from different domains, could e.g. access air quality information, such as O3, and traffic monitoring information, such as average speed, to provide healthy bicycle routes with cleaner air.

The third pattern “**Platform Independence**” (Fig. 21, c) represents another basic characteristic of an interoperable IoT ecosystem. It entails that the identical application or service can be used on top of two different IoT platforms (e.g. in different regions). This can be achieved by allowing an application/service to discover relevant IoT platforms and to interact with the different platforms in a uniform manner. For example, these can be two deployments of a “smart parking” service used for two different geographic regions (e.g. Barcelona and London), which have their own platforms with information about parking spots. Realizing platform independence is particularly challenging, when the information provided by the two platforms is created by different kinds of things. For example, in case of parking information, the information on spot availability could be generated by radar-based sensors mounted on street lamp as well as ultrasound-based sensors in the ground.

The fourth “**Platform-Scale Independence**” pattern (Fig. 21, d) focuses on integrating platforms of different scale. So called *server-level platforms* are platforms with many devices connected (e.g. a cloud platform) and typically host a vast amount of data, whereas *device-
level platforms grant direct access to devices (e.g. a mobile device or an edge gateway) and typically host small amounts of data. By implementing this pattern, the platform hides its scale towards connecting services or applications. Data from device-level as well as data collected by server-level platforms can be equally used by services/applications. For example, an application displays information on air quality monitoring to the user (e.g. as visualizations on a map). On the one hand, the application could allow accessing aggregated information such as the computed air quality index for a certain region from a server-level IoT platform.

On the other hand, the application may additionally enable to access data directly from air quality stations (i.e., device-level platforms), e.g. to display time series from unadulterated data.

Finally, the fifth pattern “Higher-level Service Facades” (Fig. 21, e) extends the interoperability requirements from platforms to higher-level services. The idea is that not only platforms but also services offer information and functions via the common BIG IoT API. Thereby, a service acts as a façade towards an IoT platform and accesses the offered information or functions to provide value-added functionalities. For example, an air quality viewer application can on the one hand access a platform P1 that provides already aggregated air quality data. On the other hand, the application can access a service that aggregates air quality data from platform P2, e.g. because P2 does not have the capabilities to perform data aggregation or host long-term time series data.
Fig. 21 The five patterns of interoperability: a) “Cross Platform Access”, b) “Cross Application Domain Access”, c) “Platform Independence”, d) “Platform-Scale Independence”, and e) “Higher-level Service Facades” Pattern
8 Conclusion and Outlook

D2.2.b offers an updated list of BIG IoT use cases and includes pilot requirements for the planned Open Calls.

A list of beneficial contributions from the Open Calls to the BIG IoT project is provided in Part I of the document and can be used for the further Open Call tender activities. To assure a consistent development throughout the pilot implementations and coming Open Call activities, focus is put on mobility and environment issues that are of relevance for the pilot cities and that are aligned with the mobility agendas of the pilot cities.

Moreover, consistency is assured by the chosen two step approach: Open Call I focuses on including new platforms to extend data offerings that are most relevant for the pilot use cases. Open Call II expects contributors to make use of these additional offerings and the offerings already incorporated by the pilot partners to provide new services and applications.

Part II updates the pilot use cases with respect to the amendment caused by Vodafone’s exit of the project. Vodafone inputs are being replaced by new data offerings strengthening the cross-pilot objectives of BIG IoT. Thus, bike sharing offerings will be additionally provided for the Northern German and Barcelona pilot. Public Transport Optimization, originally foreseen for Northern Germany only, will be supported by data offerings of Barcelona. The use case cluster Smart Charging is boosted by additional data offerings of Barcelona. And new data offerings on parking spots in Wolfsburg will be included and will strengthen the cross pilot Smart Parking use case. The updated overview on use case clusters addressed by the pilots or supported with data offerings is shown Fig. 22.
The use cases defined meet the overall requirements to enable interoperability (BIG IoT ecosystem use cases) and to showcase interoperability addressing specific local demands for mobility services (BIG IoT pilot use cases). Given the iterative approach of the project the use case inventory will be finalized in upcoming D2.2.c.

The described BIG IoT ecosystem use cases are a set of high-priority use cases that have been elaborated based on the results of the definition of the high-level architecture (T2.4).

As a result of the pilot discussion the deliverable D2.2.b captures use cases of the following use case clusters: Smart Parking, Smart Traffic Management, Public Transport Optimization, Healthy Bike Navigation, Smart Bike Sharing, Incentive-Based Green Route Planning, Multi-modal Route Optimization, Smart Charging and Device-to-Device Communication.

The presented use cases set ground for the pilot specifications (services and applications) that are in progress within WP 5. Based on a ranking of use cases presented in this document WP 5, Task 5.1 Pilot Specification has elaborated a refined timeline for the realization of use cases and corresponding services for the iteration phase 1-3 reflecting the general project progress and pilot specific plans for the implementation of smart objects and BIG IoT services.
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