Symbiosis of smart objects across IoT environments

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Initial Report on Use Cases

The symbIoTe Consortium

Intracom SA Telecom Solutions, ICOM, Greece
Sveučiliste u Zagrebu Fakultet elektrotehnike i računarstva, UNIZG-FER, Croatia
AIT Austrian Institute of Technology GmbH, AIT, Austria
Nextworks Srl, NXW, Italy
Consorzio Nazionale Interuniversitario per le Telecomunicazioni, CNIT, Italy
ATOS Spain SA, ATOS, Spain
University of Vienna, Faculty of Computer Science, UNIVIE, Austria
Unidata S.p.A., UNIDATA, Italy
Sensing & Control System S.L., S&C, Spain
Fraunhofer IOSB, IOSB, Germany
Ubiwhere, Lda, UW, Portugal
VIPnet, d.o.o, VIP, Croatia
Instytut Chemii Bioorganicznej Polskiej Akademii Nauk, PSNC, Poland
NA.VI.GO. SCARL, NAVIGO, Italy
ATOS Wordline International, WLI, Spain

For more information on this document or the symbIoTe project, please contact:
Sergios Soursos, INTRACOM TELECOM, souse@intracom-telecom.com

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Editor(s): Gerhard Dünnebeil, AIT

E-mail: Gerhard.Duennebeil@ait.ac.at

Author(s): Mario Drobic, Ivan Gojmerac, Jasmin Pielorz and Refiz Duro, AIT; Aleksandar Antonić, UNIZG-FER; Ricardo Vitorino, UW; Reinhard Herzog, IOSB; Toni Paradell, ATOS/WLI; Michele Bertolacci, NAVIGO; Gianluca Insolvibile, Matteo Pardi; NXW.

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1 Executive Summary

With the purpose of fostering the development of an open IoT ecosystem and market, the H2020 project symbIoTe will provide an abstraction layer for various existing IoT platforms as its primary objective. Furthermore, symbIoTe will also pursue the challenging task of implementing IoT platforms federation, enabling the platforms to mutually interoperate, collaborate, share resources for the mutual benefit, and to support the migration of smart objects between various IoT domains and platforms.

The deliverable D1.1 is one of the first steps in achieving the symbIoTe goals and the first outcome of Task T1.1 ("Use Case Specifications") that is concerned with the detailed description of the use cases of symbIoTe. The deliverable provides the initial description of five use cases that will be pursued within the project, with the objective of demonstrating a running prototype for each use case within a realistic, real-world environment. The descriptions are provided jointly by all symbIoTe partners, thereby exploiting consortium's expertise in different, but complementary domains.

The identified five use cases are:

- The *Smart Residence* use case, in which symbIoTe will primarily enable automatic discovery and configuration of different devices and IoT platforms in homes and offices. This use case furthermore aims to integrate smart health services in the home domain. Such enablement and connectivity will provide residents with medication intake reminders, information on vital health signs, or allow for energy saving and comfortable indoor environment by controlling the temperature, fans, or light. The Smart Residence use case exposes the potential of the symbIoTe middleware to realize the interoperability of collected deployments in smart (indoor) spaces.
- The *Smart Mobility and Ecological Routing* use case treats the issues related to air quality and inefficient transport in urban areas, thereby showing how symbIoTe can assist in providing air quality measurements together with available traffic data acquired through several IoT platforms. Roads and paths are then automatically classified to the benefit of users such as pedestrians, joggers, cyclists and motorists who are hence provided with the best routes. The use case highlights how symbIoTe will facilitate interoperability of cooperative IoT platforms at the application domain.
- The *Smart University Campus* use case highlights how two different campuses belonging to different universities can interoperate regardless of different management systems and/using IoT platforms, and provide services to exchange students (e.g., booking a room). The Smart University Campus use case showcases how symbIoTe allows for a federation of IoT platforms in public and collaborative environments to enable a uniform user experience across domains.
- The *Smart Stadium* use case will demonstrate an integrated management system for sport stadiums to enable visitor and staff with a stadium application for enhanced visitor experience and to carry out management activities (e.g., parking booking, health assistance, etc.). The use case presents an integration of location indoor platforms with various context-based information services, thereby demonstrating platform interoperability facilitated by symbIoTe.

- The *Smart Yachting* use case with involves two scenarios with services such as assistance for booking the mooring place and identification of fault and maintenance conditions on board. The use case showcases how symbIoTe makes the interoperability of cooperative platforms at the application domain possible and functional, while simultaneously incorporating requirements related to timeliness and safety.

Based on these initial use case descriptions, in the upcoming period the H2020 symbIoTe project will define the main requirements for its system architecture. Furthermore, the use case descriptions identify the key stakeholders, enabling the subsequent analysis of their business relationships as well as market opportunities. This will allow for an even more detailed specification of use cases that will be reported on in deliverable D1.3 ("Final Specification of Use Cases and Initial Report on Business Models").

2 Introduction

2.1 symbIoTe

In a world of smart networked devices and wearables as well as sensors and actuators, which blend with the surrounding environment to provide daily life services, transparent and secure access to and usage of the available resources across various IoT domains is crucial to satisfy the needs of an increasingly connected society. Users are in demand of novel applications that simplify their daily activities in various situations and environments. Some examples of such situations and environments are home or office, when commuting, or at airports/train stations, and during their leisure activities such as visiting stadiums or shopping malls. Following such demands, new requirements have emerged due to the growing number of broadband users worldwide and lower entry barriers for non-technical users to become content and service providers, and due to the available IoT platforms and services on the market.

The current situation, however, is that of fragmented IoT ecosystems. This is best depicted by a series of vertical solutions, which on the one hand integrate connected objects within local environments (e.g., home, office, etc.) that we call smart spaces, and on the other hand connect smart spaces with back-end cloud hosting software components, which are often proprietary. The vertical solution implies restrictions to the ecosystem that is developed around a single platform, thereby limiting access to all other IoT ecosystems. Interoperability and IoT federations are thus needed to achieve collaboration and access to services and resources provided by the different IoT platforms.

Figure 1 shows an example of IoT ecosystems powered by three different platforms: *Platform 1* focuses on integrating Smart Home environments; *Platform 2* is tailored to the needs of office and Smart Campus environments, while *Platform 3* focuses on providing solutions for public spaces. There are numerous commercial offerings in the form of services and applications in these domains on the market. Infrastructure providers are at the beginning of the value chain by setting up devices and gateways in smart spaces, IoT platform developers maintain and sell the platforms, cloud and IoT service providers host the platforms, while application developers/providers build innovative web and mobile applications on top the platforms and infrastructure. End users interact either directly with infrastructure providers and use the provided applications for their infrastructure, or with IoT service providers who offer bundled service. Telecom operators are in the pole position to expand their service portfolio with IoT services and to act as infrastructure providers by expanding their existing infrastructure with IoT resources. It is clear that application developers and providers are locked in with a platform and need to adjust their solutions for each new platform and underlying infrastructure, while infrastructure providers cannot offer their resources to multiple IoT service providers.

symbIoTe comes to remedy this fragmented environment by providing an abstraction layer for a “unified view” on various platforms and their resources in a way that platform resources are transparent to application designers and developers. In addition, symbIoTe also implements IoT platform federations so that they can securely interoperate, collaborate and share resources for the mutual benefit, and what is more, support the migration of smart objects between various IoT domains and platforms, i.e., “smart object roaming” (Figure 1).

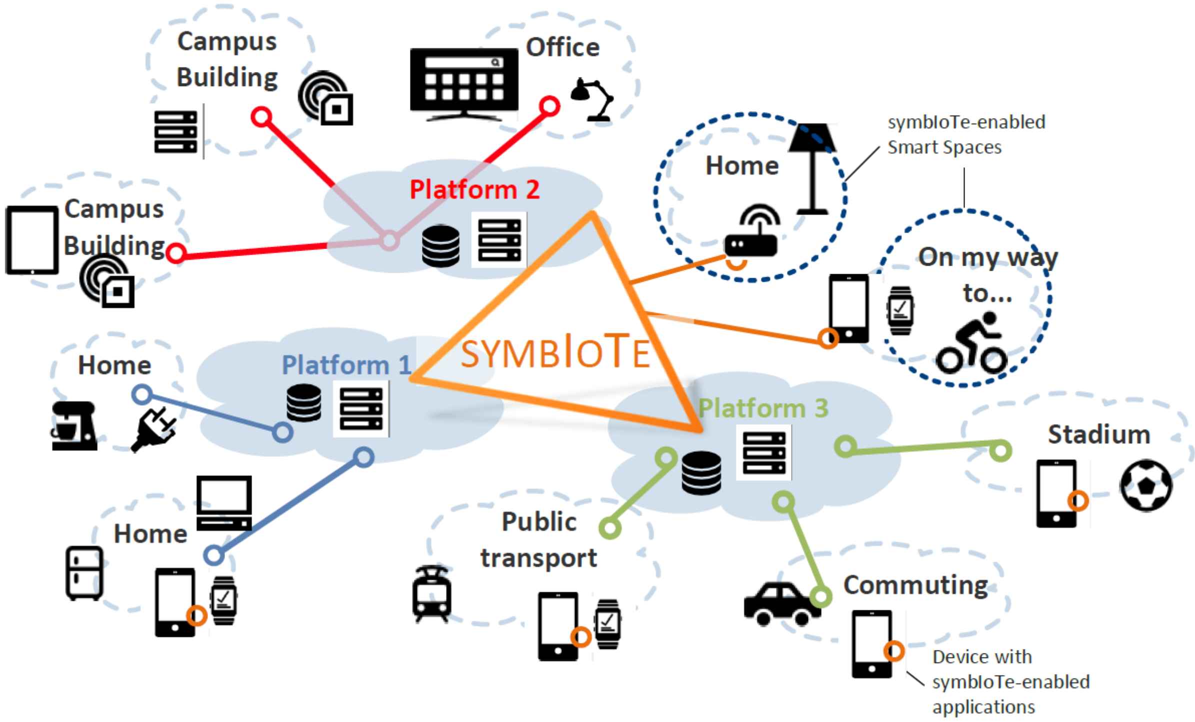

Figure 1: symbIoTe integrates different IoT islands and ecosystems

2.2 Purpose of the Document

The purpose of the deliverable D1.1 “Initial Report on Use Cases” document is to report on the identification and description of symbIoTe use cases to be delivered by the project. Moreover, the document will serve as a basis and reference for specification of system requirements and system architecture. This process will include, however, a two-step approach: an initial use case description (this document), and an update and finalisation of use case description (to be provided in a follow-up deliverable). This final version of the document will then lay out also the surrounding ecosystem of the use cases and identify relevant platforms that could benefit from the federation provided by symbIoTe.

The current deliverable provides initial use cases at the application level, covering applications scenarios in the smart residence, smart mobility and ecological routing, smart campus, smart stadium and smart yachting domain. An introduction and general overview are given in Chapters 2 and 3, respectively, the specifics of identified use cases are provided in Chapters 4-8, and conclusion and the next steps in Chapter 9.

2.3 Document Scope

This document reports on the work accomplished so far on the use case definitions, which relates to two other tasks in the project. These tasks are T1.2 “Business Models and Innovation” and T1.4 “System Architecture”. The findings in these tasks will be reported in separate deliverables.

3 Vision and Synopsis of Use Cases

3.1 symbIoTe Vision

symbIoTe use cases are targeting typical every day environments, both indoor and outdoor, to assist people seamlessly during their daily activities. These can range from homes, offices and public spaces (such as campus, stadium or marine environment), to smart mobility solutions that assist travellers and commuters. The diversity of the environments is optimal to showcase symbIoTe in action since it spans over several different IoT installations, which are currently isolated and managed by different platforms and infrastructure providers. In contrast to the current situation, when a user has to start and use various applications at home, on public transportation, at the university, among others, symbIoTe will provide an entirely new type of experience, which will allow users to interact with resources in their environment in an intuitive way oblivious to the underlying technologies . As additional support, users will be provided with a true virtual personal assistant with unique characteristics to suit the needs of students or elderly, football fans or yachtsmen, while developers will be able to build innovative applications that blend in with the environment to create a new symbIoTe playground for innovative applications developers.

In the following, we provide a short user story illustrating the vision of one of the use cases in the smart city environment.

Anna is a graduate student in computer science and likes to spend her spare time with outdoor activities such as biking or inline skating. Since she intends to take her final exams, soon, her last few weeks were governed by a tight schedule. Today, she is waking up from the smell of freshly brewed coffee brewed by her smart coffee machine automatically when her smartphone indicated a light sleep phase. While enjoying her coffee and eating cornflakes, she consults her home multimedia display in order to check on the news and the weather. Learning about the beautiful late-spring weather forecast, Anna spontaneously decides to take her bicycle to reach the lecture hall at the campus. After taking a shower at her preferred water temperature as predicted by the Smart residence system, she consults her Smart Mobility application in order to calculate the ecologically preferable route to the campus. The system suggests taking the bicycle on the longer path through the park to avoid the current high NOx levels in the city centre as reported by the smart pollution sensors attached to the city's bicycle and tram fleet. Following this recommendation happily, Anna books a slot for a bicycle-rack and a room for her learning group later in the afternoon via the Smart Campus app. Both reservations become immediately visible on the smart ink displays on the rack and the door of the reserved room. Thinking about rewarding herself by taking off the evening from studying, Anna leaves her apartment whistling.

Richard is a retired architect and suffers from high blood pressure. He is a supporter of the local football team and shares his passion with his grandchild Anna. In order to improve his health condition, he has recently started a yoga class and decided to devote more time to gardening. After a good night's sleep, Richard is woken up by the automatic blinds mechanism in his apartment, triggered by his smart bracelet, which reports the optimal moment to the smart residence system based on his sleep-cycle parameters. The same *bracelet also records Richard's blood pressure and heart frequency and notifies his doctor directly in case the system detects anomalies in these time series. Today, the smart residence system consults Richard's calendar and recommends Richard to undertake outdoor activities in order to improve on his activity profile. Furthermore, a suggestion is given that there are still tickets available for a late afternoon match in the football stadium, which brings Richard immediately to the idea of inviting his football-enthusiastic granddaughter Anna to join him there. He immediately proceeds by sending Anna the corresponding invitation via their joint back-end cloud calendar, and after receiving Anna's delighted confirmation, he proceeds by buying the tickets. After receiving her electronic copy of the ticket via the Smart Stadium system, Anna makes sure to reserve a bicycle-rack there, while Richard schedules a just-in-time route suggestion for his commute to the Stadium in the late afternoon.*

In this user story, many different systems and infrastructures play a role. Today these systems co-exist, but only rarely co-operate. Any application built upon one or more of these systems needs to know everything about all involved systems. Resources available in one system are not available for apps that do not know about coexisting infrastructures.

The vision of symbIoTe is to build a framework of libraries and services which is capable of integrating as many different existing (and future) systems as possible to make applications benefit from as many IoT objects in their scope as possible, no matter which system they support.

3.2 The Use Cases in the Context of symbIoTe

The objectives of symbIoTe are to provide an abstraction layer for various existing IoT platforms and to pursue IoT platform federation, interoperability, collaboration, resource sharing, and the migration of smart objects between various IoT domains and platforms. The use cases described in this document will thereby be of high relevance throughout the lifecycle of the symbIoTe project. In its first phase, the use cases serve as a basis for the definition of detailed requirements, based on which the symbIoTe architecture will be specified. In the latter stages of the project, the symbIoTe use cases will be the vehicle for the real-life testing and demonstration of the symbIoTe system prototype, highlighting the benefits of symbIoTe especially in the context of applications, which require either information from, or the actuation of various *things* via multiple platforms that may be technologically diverse. In the rest of the present section, we provide a first high-level description of the five selected symbIoTe use cases that will be specified in detail in the remainder of this document.

3.3 Smart Residence

The smart residence use case is comprised of two parts: first, it addresses the area of smart living, and second the area of Ambient Assistant Living (AAL).

The smart living use case scenario mainly involves the residential automation systems, which have the role to take control of many different environment functions. Hence, applications include lighting, climate and shades, media distribution, safety & security, communications, environment and systems monitoring, energy management. The use case focuses on what automation gives to a user in terms of energy saving and devices adaption.

Two scenarios will be described:

- Scenario 1 is about enjoying the smart control of lighting, shades and climate, in order to reduce house energy consumption;
- Scenario 2 will instead show the ability of different smart devices to inter-relate and change their behaviour according to predefined rules.

The AAL use case scenario makes use of smart health sensors and telehealth platforms to support elderly people in their effort to live an independent life. The use cases focus on elderly people suffering from chronic diseases, and support a scenario where residents are provided with context-aware and personalized health services at home.

In symbIoTe project vision, the smart living platform and AAL platform can interact in order to merge their features; so in user's view, a smart residence has the ability to create a comfortable, safe and helpful environment.

3.4 Smart Mobility and Ecological Routing

Environment pollution and air quality, together with ecological means of transportation are true concerns for cities all over Europe. Since the European Union's (EU) transport policy aims to foster clean, safe and efficient travel throughout Europe and one of the main objectives of the European Commission (EC), by 2050, is "to have significantly reduced those CO2 emissions and made inroads into tackling congestion and environmental pollution".

The Smart Mobility and Ecological Routing Use Case intends to collect air quality data from multiple IoT platforms in different countries and use such measurements for runners, joggers and cyclists to plan the best route for their objectives. Following the same approach, traffic and parking measurement events can be used to classify roads and provide most efficient routes for drivers.

Data acquisition will happen from sources of reasonably different nature using various protocols from systems with very different architectures (stationary air quality stations versus mobile sensors). Any application working on this data must handle these differences if working without symbIoTe software. This use case will try to show how a seamless integration is possible nevertheless.

Due to the nature of routing algorithms, the projected functionality is not able to work on individual sensor readings without extensive pre-processing. This pre-processing can take place in a special architectural part of the symbIoTe architecture, in the (currently) so-called "application enablers". For this reason, the routing use case is also a good driver and guideline for the planning, design and development of such extensions of the symbIoTe software.

3.5 EduCampus

Modern universities are nowadays in global competition for the best students, respected teachers and innovative researchers. A major asset in this competition is an attractive and inviting campus that supports the people. To increase the campus attractiveness universities, provide innovative services like course information and registration, campus navigation, building and room information and registration and even authentication, authorization and payment with the aim to provide the best learning, living and working environment on their campus.

While universities are doing their best to enhance their campus, students are also encouraged to be mobile and to extend their educational career over more than just one university. As nowadays it is common to gain international experience during one's studies, especially within the EU as the Bologna Process being widely implemented lowers the barriers for such international studies massively, interoperability of such campus services constitutes another valuable asset for universities. Therefore, the *"Educational Campus Service Federation"* (EduCampus) use case aims at supporting universities in cooperating with each other and in building interoperable remote campus services. To achieve these goals this use case will implement two exemplary campus services, a campus navigation service and a room reservation service, as a collaborative service between two universities, the Karlsruhe Institute of Technology (KIT) and the Université Pierre et Marie Curie (UPMC).

The Educational Campus Federation Service aims to support the cooperation of universities by simplifying the establishment of interoperability between remote campus services. Assets like identity cards or service clients shall be usable in remote campus environments, without being reconfigured or even replaced. Currently, reuse of existing applications in different administrational contexts like different universities is only possible by close collaboration of the different administrational bodies and a tight coupling of their information systems which can be overcome by using symbIoTe as a decoupling layer. This could lower the expenses necessary to enable collaboration between universities on a technical or rather user/service-centred level. If more universities adapt this concept a new level of user-experience for exchange students could be reached and thereby strengthen all participating universities in the international competition to attract students as well as raising the level of education by lowering the barrier for students to gain international experience.

3.6 Smart Stadium

Stadiums are not anymore the place where you go just to watch your favourite sport match. Instead, new Smart Stadiums can provide you with a complete experience around the sport event, which starts even much before you arrive to the stadium, and continues when you are back at home. Stadium managers are perfectly aware of the direct and indirect benefits that they can get through the provision of those added value services that enhance the fan experience.

However, the provision of those services will require the use of several technologies based on different IoT infrastructures installed in the stadium, perfectly integrated and powered through symbIoTe-enabled applications. In order to showcase the different technologies involved and how they take advantage of symbIoTe developments, the Smart Stadium use case is focused on the enhanced stadium visitor experience in the following areas:

- Indoor location services: take advantage of the specific location of the visitor to make specific promotions, or provide location-based information.
- Information on available services, offered by the stadium manager: which services are available, their location, how and when to reach them, their conditions and cost.

- Alerts and Promotional platforms: third parties operating the added value services have the possibility to make general promotions, or specifically and contextually driven campaigns. In addition to the direct information in the different applications, visitors may be made aware of these promotions through alert systems.
- Remote ordering services: visitors may send orders to the providers of the added value services, which receive them and process in advance. These services are key to optimize the stadium operation, for example by dramatically reducing the queues of people trying to access the added value service.
- Monitoring services: for example, visitors are given access to specific services based on cams, which require authorised and/or paid access.

3.7 Smart Yachting

There are about 5000 motor yachts in the class over 24 meters length all over the European part of the Mediterranean, and approximately 3 million below the 24 meters length. The port is an organization/authority and public space where the demand/offer within the supply chain of the boating/marine sector are executed for two key processes:

- the upkeep, supply and refit, generally issued by the boats and possibly based on monitoring data automatically collected by on-board systems and
- the assignment of mooring spaces with local (port) localization information (distances, coordinates, depths, etc.).

The Smart Yachting use case envisions to automate the information processes between the boat and the mainland, and to allow the user on a boat to identify automatically the territorial subjects (companies). This will allow for addressing the needs of, e.g., edge detection, and – on the other hand – allow the port authority to automatically send various territory information to the boat (e.g., during the mooring phase).

From an IoT integration perspective, this scenario represents a critical context of smart objects interoperation, which is typically solved with custom system-to-system interfacing. This is quite limited in the extent of applicability to the multiple choices of control platforms on board and on the mainland in the port area, e.g., to interact/integrate information kiosks, multiple localization sensors in the port area, etc. Therefore, the main challenges involved in the Smart Yachting UC are the mooring services and automated supply chain.

Mooring Services

Enhanced information for mooring services from Port Authorities (or those who have the competence of berthing boats on the port): automated communication for requesting a berth reservation based on the length of the boat, engaging the platform dedicated to the Port Authority (Navigo Digital) and send / receive information / basic documents for the berthing procedure.

Automated Supply Chain

Development of the engagement / communication system between the specifics detected by Symphony on the ship (failures / spare parts, supplies) and the service platform offered and refit (market place) in the marina or harbour.

Thanks to the smart yachting solutions, symbIoTe will be opening the doors to the extremely interesting market of the blue economy and maritime transports. Europe is turning its attention on this strategic asset: the sea and in particular, the Mediterranean Sea becomes very interesting through its high value of its costal territories clusters.

A yacht is a high tech product representing the excellence of the mainland industry and yacht owners are attracted to top excellences port services.

The symbIoTe applications will find in smart yachting a high value way of diffusion and an improved venue of integration with other developing application business case

4 Smart Residence

4.1 Overview

Residential automation systems are getting increasingly popular in homes and offices to take control of many different environment functions. Applications include lighting, climate and shades, media distribution, safety & security, communications, environment and systems monitoring, energy management. Each of these application fields traditionally has its own standards and protocols, which result in complex design, usage and maintenance processes to be managed. Usually, this also implies that each service works independently of all the others. Finally, services whose application back-end cannot be efficiently moved to the Cloud require dedicated local hardware, which adds up to the complexity and power consumption of the system.

Depending on context and usage scenario, dynamically discovered functions will be presented on different devices (e.g., smart phones, TV screens, touch panels, smart objects), instantiated in a local/remote Cloud and finally executed by the appropriate physical devices (e.g., light switches, speakers, displays, motor shades).

From a smart local Internet of Everything (IoE) perspective, cross-domain services will be enabled by exploiting devices belonging to different subsystems. For example, detection of a user's smart phone presence, rather than knowledge of the currently set security program, can be used to determine the appropriate context ("User at home" vs. "Empty home"). Depending on the context, the same volumetric sensor can be used for security purposes or for light/climate regulation (comfort and energy saving), energy policies can be modified to switch on/off lights, phones and access points when nobody is at home, user-generated media can be stored on the local Network Attached Service (NAS), and so on.

The Smart Residence use cases are focused on demonstrating the capability of the architectural framework to support a true integration among several different subsystems: Cyber Physical Systems (CPS) devices, both market products and prototypes developed within the project, are part of a common IoT infrastructure and data model, which allows for:

- Dynamic discovery of available functions and controllers
- Smart user interaction (i.e., by means of gestures, voice control, proximity detection)
- Dynamic composition of basic CPS functions to provide multiple services as an overlay atop the physical devices
- Transparent adaptation to different CPS devices, regardless of protocol, brand and model (seamless integration of protocols like KNX/Konnex, Z-Wave, ZigBee)

4.1.1 The Challenge

A quick overview of the currently available products and technologies (both on the mainstream market, and within the DIY – Do It Yourself "makers" communities) reveals that the IoT ecosphere is fragmented and devoid of a unifying paradigm at the interconnection, semantic data model and functional level.

For each specific application and functional context, both proper and de facto standards and protocols exist in different market segments, alongside with proprietary protocols and custom-made solutions.

Residential and office automation (i.e., lighting, thermostats and HVAC – Heating, Ventilation and Air Conditioning, motorized shades, curtains and blinds, sprinkler systems, and so forth) is based on standards and de facto standards (e.g. , Konnex/KNX) dictated by reference brands on the market; there is no “inter-standard” common object model to describe devices and events.

Each automation function, indeed, quite always brings its own world of field buses, standards and protocols to be dealt with by a system integrator. The resulting “integrated” systems are quite always not integrated at all, each particular subsystem being limited in the exchange of data and functionality with the others.

Other focal points are the integration with existing and emerging standards (from Konnex/EIBus to DLNA/UPnP, COAP LWM2M, IP Smart Objects – IPSO --), seamless exploitation of diverse local area / personal area connectivity media ZigBee, Z-Wave, Bluetooth LE, and a distributed execution of the platform middleware across any locally available devices (e.g. , mobile devices, residential devices, local routers).

One of the main challenges will be the creation of a generalized abstract model for all the Inter Connected Objects (sensors, lights, motors, door locks, actuators, etc.) APIs (Application Programming Interface), and to implement context-driven decisions/actions. For example, the user’s smartphone interacts with the indoor localization system and auto-configures itself as a remote control to open the house gate; it then interacts with intelligent connected objects (ICOs) in the house and auto-reconfigures itself as a remote control for a Smart TV, the lighting system, etc.

4.1.2 symbIoTe Innovations

Additional symbIoTe innovations will involve an automatic resource discovery mechanism for dynamic configuration of available services: this may be needed, for example, when a user brings home a ZigBee light that creates a new light function or a symbIoTe-enabled Network-Attached Storage (NAS) that enables both a new storage function and a new processing resource.

The presence of a domain-specific high-level Application Programming Interface (API) enabler, in the health/monitoring area, will provide services on top of sensors such as activity trackers, sleep sensors, blood pressure meters and glucose meters. For example, a mobile application could be developed for elderly people, with both textual and visual feedback on their health status, which allows context-driven sharing of their health data. At the wireless medium layer, there is the possibility to integrate low power devices and multi-hop connectivity solutions (i.e., connectivity chains); multi-tenancy, traffic isolation, and support for legacy devices (backward compatibility) could be another option.

- Automatic resource discovery for dynamic configuration of available services. Needed when a user brings home a Zigbee light, which creates a new light function or a symbIoTe-enabled Network-Attached Storage (NAS) that enables both a new storage function and a new processing resource;

- Seamless multi-protocol adaptation through protocol gateways (either physical, e.g., the TarquinIoT Home Gateway provided by symbIoTe partner UNIDATA, or software based), which are in reach of the existing local Cloud.
- Development of domain-specific high-level Application Programming Interface (API) (enabler) in the health-monitoring area, which provides services on top of sensors such as activity trackers, sleep sensors, blood pressure meters and glucose meters, while taking particular measures to ensure user privacy, security and data fusion on a cross-system level.
- At the wireless medium layer, development of new technologies for enabling the coordination of radio technologies and network protocols that support dynamic and cognitive access to the medium. The integration of low power devices requires investigation on multi-hop connectivity solutions (i.e., connectivity chains), while constantly addressing multi-tenancy requirements, such as traffic isolation, and accommodating legacy devices for backward compatibility.
- Adaptation of the emerging programmable interfaces, which allow wireless cards to modify on-the-fly the MAC protocol (e.g., WMP) to provide connectivity as a service while completely hiding the problems of channel resource sharing, channel quality fluctuations, interference management, etc. to application developers.

4.1.3 Objectives

One of the objectives of the use case is to demonstrate IoT interoperability of smart devices/things in the same domain. Some sample scenarios are presented, from detection of user's presence to appropriate context setting, so the home behaviour will change accordingly to the circumstances.

4.2 High Level Definition

Three scenarios directly related to sub-use cases will be presented for a smart home:

- Energy saving scenario: whenever the user is in the room, temperature and lux level is kept to a predefined comfort value by controlling a dimmer light and an automated curtain. This particular scenario demonstrates interoperability between virtual objects belonging to different systems and protocol domains: the anti-intrusion system (having its own proprietary control unit), the lighting system, and lux sensors, curtain motors, fan coils.
- Dynamic interface adaptation: the user's control interface, represented by an app on his smartphone, will automatically reconfigure according to the controllable cyber-physical systems in range (e.g., TV remote command, and adaptive light switch). This scenario demonstrates the ability of different CPSs to inter-relate and change their behaviour according to predefined rules.
- Ambient Assisted Living (AAL): the user gets reminders for medication intake and medical measurements into his home, a smart lighting system helps him to prevent falls at night, environmental measurements (e.g. gait sensor in the floor) are used to measure the users performance and detect critical situations. This scenario demonstrated the interoperability of smart-home platforms with tele-medical

platforms. It uses available smart-home sensors to enhance the user-experience. Furthermore, concepts for a flexible interaction between personal spaces (e.g. smartphone) into shared spaces (living space) are explored to provide the user with personalized and context-aware health services at home.

4.2.1 Application Level Use Case Diagram

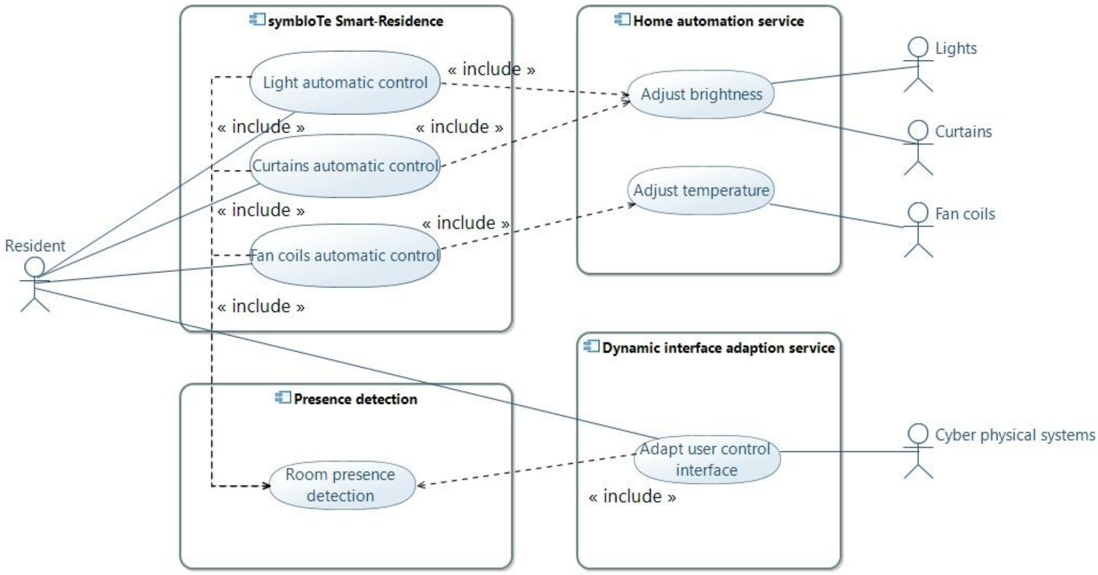

Figure 2: Application Level use case diagram for energy saving scenario and dynamic interface adaptation

The main focus of the Smart Residence use case is to demonstrate how smart devices (IoT things) can interact in the same domain. Both use case scenarios will focus on symbIoTe's capability to adjust devices behaviour according to user presence, following predefined rules and creating a pleasant ambience.

Regarding the energy saving scenario it is described how the automatic controls of lights, curtains and fan coils interacts with the presence detection system, to automatic adjust brightness and temperature level, in order to keep a comfortable environment and to save energy.

In the dynamic interface adaptation scenario, instead, user control interfaces are adapted dynamically, basing on the cyber physical devices in range.

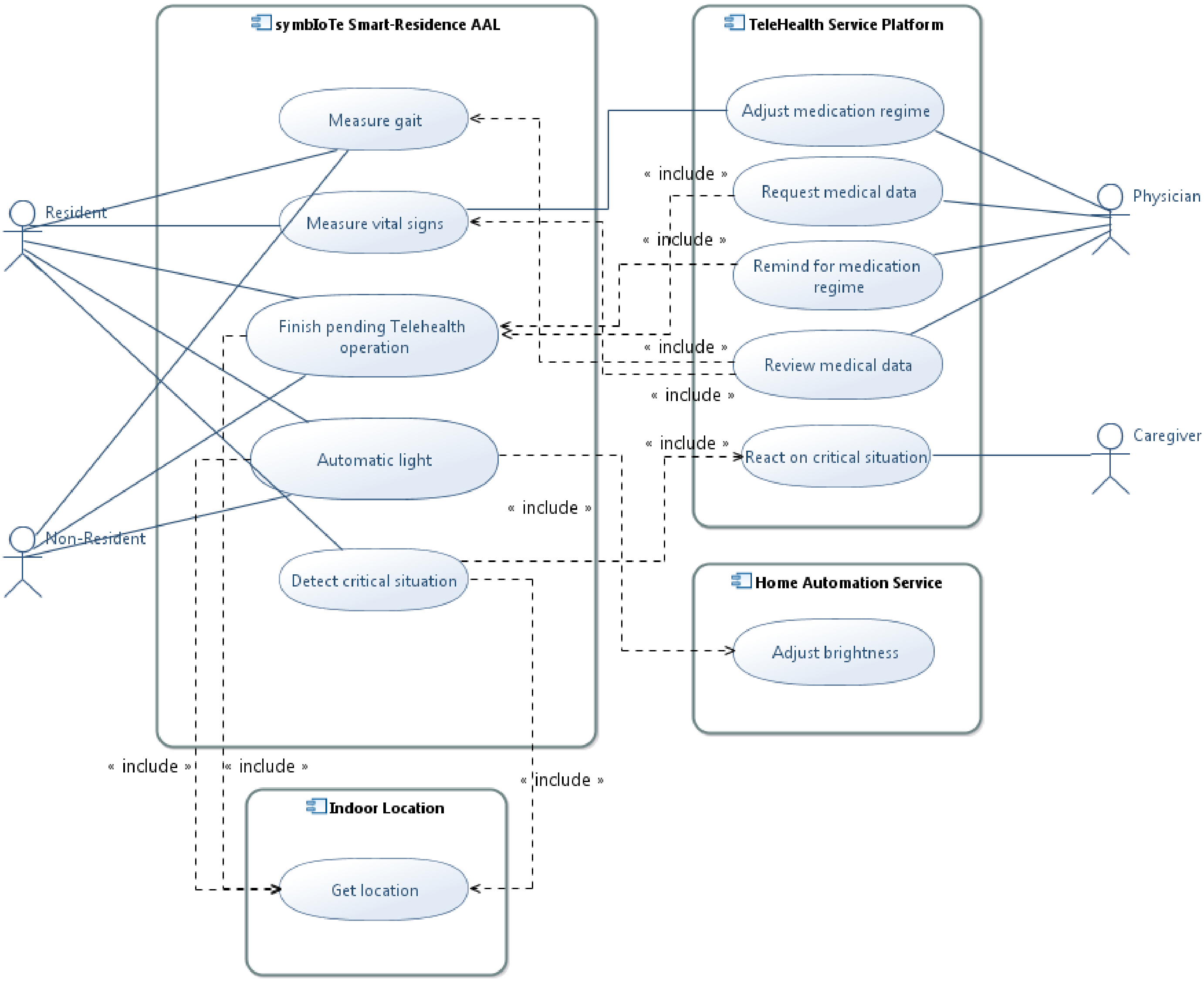

Figure 3: Application Level use case diagram for Ambient Assisted Living (AAL)

The main focus of the AAL sub-use cases is to provide end-users with personalized and context-aware health services at home. These sub-use cases make use of various existing platforms (e.g., fitness trackers, smart medication pills) where symbIoTe serves as interoperability layer to tie these platforms together.

The use cases are comprised of typical scenarios relevant for elderly people (subsequently named "residents") living at home. Firstly, tracking of medication intake using a smart pill box ("remind for medication regime") and tracking vital parameters such as blood pressure ("measure gait"; "measure vital signs") allow supervision of health status. Moreover, as falls are common in elderly people an additional use-case is planned to include detections of critical situations such as falls ("detect critical situation"). Further, automatic adjustment of the environment ("automatic light") should help to prevent critical situations in the first place. In order to make these use-cases personalized, the integration of a telehealth platform is planned where users are remotely supervised by a physician. Finally, indoor location is used to provide context-awareness of services. These sub-use cases are described in more detail in following sections.

4.2.2 Actors

Resident

Follows daily routine; controls home environment; calls for help in case of emergency; takes medication;

Lights

House lightning system

Curtains

House motorized curtain system

Fan Coils

House fan coils

Cyber Physical Systems

Mobile robotics and electronics transported by humans (e.g. smartphones)

Caregiver

Provides support; checks status of user; replies to emergency calls;

Physician

Watches vital signs; provides medication recommendations;

Non-Resident

A visitor in a symbIoTe enabled home interacting with the environment

4.2.3 Subsystems

Home Automation Service

A platform capable of controlling and adjusting brightness and temperature in the house. The platform can also provide services to notify the user (e.g. notification, reminder, etc.).

Dynamic Interface Adaption Service

A platform capable of dynamically reconfiguring a user interface device, according to cyber physical systems in range.

Telehealth Service Platform

A platform capable of collecting and storing health-related information from various users. Physicians and caregivers are able to review data on this platform and to get in touch with the elderly people.

Indoor Localization Platform / Presence Detection

The indoor localization platform provides information on the user's position within the smart residence. This can be either information on the concrete position within a room, the room the user is in, or information if the user is present at all.

Health Sensors Platform

The health sensor platform collects data from different health related sensors. They offer APIs to access the collected data. Using symbIoTe, these platforms will be tied together.

4.3 Sub-Use Cases

Luke is a 45-year-old senior engineer living with his wife Alice, a 42-year-old lawyer, and their two young children, Lucy and Oliver, which are respectively 6 and 9 years old, in a symbIoTe enabled smart home near the city.

A typical day starts with the whole family getting up about 7am, preparing themselves before going to work (or school). When the alarm clock rings, lux level is managed to a predefined comfort value, by controlling dimmer lights and automated curtains; then Luke and Alice move to the next room, waking up their children, and beginning to prepare breakfast in the kitchen. When they enter in a room, virtual objects (belonging to different system and protocol domains) are combined to keep temperature and lights to values, according to the selected scenario. After preparing, at the time they all leave the house, the smart system recognises the departure and modifies levels to “empty home” new schema. This will be translated into a switching off lights and fan coil and setting all devices in energy saving mode.

In the afternoon, Lucy and Oliver come back home from school, with the young 21-year-old babysitter Emily. Emily, like almost every person of the same age, is very familiar with the use of smartphones and tablets, and is allowed to use the home tablet. With the symbIoTe compliant app, the home tablet can be used from the girl as an interface, which will automatically reconfigure according to the controllable cyber-physical systems (CPS) in range (e.g., TV remote command, adaptive light switch). So depending on the room where Emily is, and the devices in the sensing area, she is able to interact with the smart home. In the meanwhile, of course, the home has automatically come back to the “user-at-home” situation, regulating again dimmer lights and temperature at the comfort values.

These examples show the potentiality of a smart home, and the variety of functions that can be conceived and implemented under a symbIoTe environment.

The sub-use cases that allow this scenario to play out are described in the following tables.

4.3.1 Energy Saving

Description	Whenever the user is in the room, temperature and lux levels are kept to a predefined comfort value by controlling a dimmer light, automated curtain and the fan coil, using different systems and protocol domains.
Trigger	The resident enters the room
Pre-Conditions	**Pre-condition 1** Room has a predefined comfort scenario registered into the system (set of light dimmer values, curtains opening and temperature) **Pre-condition 2** Room is equipped with the necessary devices (the anti-intrusion

	system, the lighting system, lux sensors, curtain motors, fan coils.
Involved Actors	Resident, lights, curtains, fan coils
Sub-Use Cases Involved	None.
Subsystems Involved	None.
Process Flow	1. The resident enters the room 2. The anti-intrusion system detects the presence of a person in the room 3. The system reads comfort values to set 4. The lightning system and curtain motors are activated 5. The lux sensors collect data in order to keep the comfort lightning values stable 6. The fan coils are set to the predefined scenario value
Alternative Scenarios	1. Scenario registered fan coil failure that make the temperature impossible to reach the comfort value. The symbIoTe system could trigger next empty rooms fan coil in order to drive the temperature to the desired value.

4.3.2 Dynamic Interface Adaptation

Description	The user's control interface, represented by an app on his smartphone for example, will automatically reconfigure according to the controllable CPS in range.
Trigger	There is no specific trigger, the user control interface is continuously aware of the controllable devices.
Pre-Conditions	**Pre-condition 1** The devices are integrated into the (symbIoTe) system in order to be detected and controlled from the user control interface. **Pre-condition 2** The smartphone works as the user control interface by a dedicated installed application.
Involved Actors	Resident
Sub-Use Cases Involved	None.
Subsystems Involved	None.
Process Flow	1. The resident enters in a room

	2. The symbIoTe system informs the user control interface of the controllable devices 3. The user control interface is reconfigured to show and manage the devices
Alternative Scenarios	1. One of the controllable devices usually detected in a room is unplugged or broken, so the user control interface application cannot find it. Instead of simply showing only found devices, the system could keep a map of the house, with the devices per-room. Based on a set of "usual" CPSs found (i.e., in the living room there are the TV and the home hi-fi), it can recognize the room where the resident is and this lack of detection could be notified to the user.

Claire is a 79-year old retired secretary living with her husband in some urban symbIoTe-enabled smart home. Claire suffers from chronic heart failure and is on a strict regimen of medication prescribed by her doctor. Her husband, John, 81 years old, is a retired engineer who recently experienced a fall. He is now ordered to perform regular exercises, while his fall-risk is monitored by a general practitioner (physician).

A typical day starts with John getting up early around 6am. He enters the kitchen, where he left a tablet on the kitchen table last night. When John enters the kitchen, the tablet reminds him (using audio output) to have a walk on the smart carpet in the bathroom measuring his gait. When he enters the bathroom, the smart carpet automatically recognizes that he has entered the room, John performs the short walk and the results are correctly assigned to his personal health data. 2 hours later Claire wakes up, goes into the bathroom, where she is instantly reminded to take her medication by her smartwatch, which is using the information from the symbIoTe enabled home to identify the best suitable time and location to do that. As Claire has a smart pill box, she is also reminded, that she left the pills in the sleeping room last night. She also steps on the smart carpet during her morning routine and is then asked if she wants to add the measurements to her health data, as she is not required to record it.

In the afternoon Bob, an old school friend of Claire, swings by at their place to play cards. His location-based smartphone recognizes the smart tablet in Claire's living room as a suitable device to complete the request of Bob's physician to answer some questions about his current wellbeing, which are overdue for some days now. Bob is answering these simple questions on the large and easy to use tablet while chatting with Claire saying what an exciting time it is to be living in. In the meantime, the symbIoTe enabled home has detected the presence of several persons in the living room and automatically adjusts the room temperature by 2°C to ensure a comfortable environment.

In the evening, Claire leaves the house for a walk in order try a new commercially available activity tracker (given to her by her son) while John stays at home. He takes a long bath, longer than usual, and the symbIoTe system is unsure, if something happened to him. Recognizing that the tablet is still in the bathroom, it delivers a message and John answers that everything is OK. An hour later, Claire returns from her walk and the wristband automatically synchronised data from here outdoor activity with the symbIoTe system.

After having a long and activity-packed day, Claire and John go to sleep. John wakes up in the middle of the night, in order to go to the bathroom. symbIoTe automatically detects this and turns on night lights in the house.

This story line can be broken down into the use cases described in the following sub-use cases.

The sub-use cases that allow this scenario to play out are described in the following tables.

4.3.3 Measure Vital Signs

Description	Claire, because of her diagnosed chronic heart failure needs to record her blood pressure several times a day. Therefore, she is using a blood pressure meter, which can be automatically read out by her smart phone. An app on the phone keeps track of her readings and transmits the data automatically to a telehealth web platform, where her physician can analyse the data and adjust her medication regime accordingly.
Trigger	The resident (Claire) starts the use case independently at certain times a day, arranged by her physician.
Pre-Conditions	**Pre-condition 1** The resident (Claire) is registered at the web platform to record her medical data and is equipped with the equipment (blood pressure meter, weight scale) to keep track of her vital signs. **Pre-condition 2** The physician is registered for the telehealth scenario at the web platform to view the resident's (Claire) data.
Involved Actors	Resident Physician
Sub-Use Cases Involved	None.
Subsystems Involved	None.
Process Flow	1. The resident performs a measurement of her vital signs (e.g., blood pressure, body weight, heart rate) 2. The resident transmits the medical data using a smart phone app 3. The app acknowledges the reception of the data and transmits them to the web platform 4. The physician independently reviews the resident's vital signs and acts accordingly
Alternative Scenarios	1. The resident did not record her vital signs during an extended period of time. Then the physician could trigger an extra use case

	reminding the resident to follow their arranged schema. 2. A non-residential user having a smart phone enters the home. symbIoTe recognizes the context and is aware that a questionnaire (scheduled by a physician) is pending for the users. The non-residential user enters the living room where the tablet is available. symbIoTe sends a notification to the smart phone of the non-residential user reminding him, that he can use the tablet to finish the questionnaire. The non-residential user then uses the tablet to complete the questionnaire.

4.3.4 Medication Intake Reminder

Description	Medication reminders are used to ensure medication intake compliance among residents. symbIoTe and its attached subsystems know the medication schedule of the residents and use tablets, smart watches and smart phones to remind of timely medication intake, dosage, and where to find the medication. The smart pill box is detecting the medication intake.
Trigger	Reminders are triggered depending on current time and location of the user within the house.
Pre-Conditions	**Pre-condition 1** Resident is registered for the telehealth scenario and is equipped with respective devices **Pre-condition 2** Physician is registered for the telehealth scenario **Pre-condition 3** A medication intake profile is defined for the resident. **Pre-condition 4** symbIoTe and attached subsystems recognize that the resident has not taken the medication yet.
Involved Actors	Resident symbIoTe system
Sub-Use Cases Involved	None.
Subsystems Involved	None.
Process Flow	1. The symbIoTe system checks medication schedule on a regular basis. If a resident has not taken his/her medication yet, it generates a short text message containing (a) the name of the medication, (b) the dosage and (c) the location of the medication. 2. The symbIoTe then determines the best place and device to deliver

	the message. It determines where the user is and where the devices are currently located. Moreover, it determines the best time (within a given timeframe) to deliver the message. 3. The symbIoTe system delivers the message on the appropriate device. 4. The resident can then either (a) acknowledge the message or (b) ask to be reminded later. 5. The smart pillbox is recording the event.
Alternative Scenarios	1. If a user decides to be reminded later, the symbIoTe system will again try to deliver the message an hour later. However, if it is detected, that the resident is leaving the house, a message will be sent (either on the smart phone or the smart watch) not to forget the pills.

4.3.5 Automatic Light

Description	Resident (John) sometimes wakes up in the middle of the night to empty his bladder. To help him to find the bathroom, the lights within the residency are switched on when movement is detected.
Trigger	Triggered by the resident when movement within the symbIoTe residency is detected at a certain time of day (e.g., night).
Pre-Conditions	**Pre-condition 1** Sensors for movement or the presence of persons, like passive infrared or radar detectors, need to be installed in the sleeping room, the hallway and the bathroom. **Pre-condition 2** Remote controllable light switches (e.g., ZigBee, WiFi) must be installed in all areas where automatic light is enabled. **Pre-condition 3** Light switches need to be controllable by the symbIoTe system
Involved Actors	Resident symbIoTe
Sub-Use Cases Involved	None.
Subsystems Involved	None.
Process Flow	1. Resident is moving during night within the symbIoTe home 2. symbIoTe switches on the lights where movement is detected
Alternative	1. The automatic lights within the symbIoTe home can be used to

Scenarios	simulate resident presence, if the home is vacant over a longer period to reduce the risk of burglary.

4.3.6 Measure Gait

Description	Some sensors within the house are not directly attached to a given user. These sensors (such as the smart rug) depend on context provided by symbIoTe to assign measurements to a particular resident/non-resident correctly.
Trigger	This use-use case is triggered by a resident entering a specific room within the house.
Pre-Conditions	**Pre-condition 1** The resident's user profile must indicate, that the resident is required to measure gait on a regular basis.
Involved Actors	Resident Non-Resident
Sub-Use Cases Involved	None.
Subsystems Involved	None.
Process Flow	1. The resident enters the bathroom. 2. The symbIoTe system recognizes that the current resident is required to record a daily gait profile using the smart rug. It detects an appropriate device close by and reminds the resident to step on the gait. 3. The resident steps on the rug, recordings are done and stored within the symbIoTe system.
Alternative Scenarios	1. A resident, not required to record gait measurements is entering the bathroom. He/she steps on the rug. symbIoTe detects the recordings and asks the resident if he/she wants to add the recordings to the personal health profile. The resident might approve or disapprove. 2. Analogously to alternative scenario (1) a non-resident might enter the bathroom. Having his/her smart phone in his pocket, he/she is recognized as "symbIoTe" user and again is asked if he/she wants to add the measurement to the personal health profile.

4.3.7 Detect Critical Situation

Description	A critical situation might occur, if a resident falls while being at home and no help is immediately available.
Trigger	The use case is triggered by the symbIoTe system itself when it

	recognizes that a critical situation might have occurred.
Pre-Conditions	**Pre-condition 1** A fall sensor that a resident might wear has detected a fall. **Pre-condition 2** The symbIoTe system has recognizes an unusual movement pattern for the resident within the house.
Involved Actors	Resident Non- symbIoTe system
Sub-Use Cases Involved	None.
Subsystems Involved	None.
Process Flow	1. The resident enters the bathroom and slips on the wet floor. 2. The symbIoTe system recognizes that the resident has entered the bathroom but has not left it for an hour. 3. It generates a message asking if everything is all right and detects an appropriate device to deliver the message. If no device can be detected, a warning message is generated for (a) a caregiver and (b) a relative as defined in the user profile for the resident. 4. If an appropriate device could be detected, it is delivered. 5. The resident can then ask to state an emergency for (a) a care giver or (b) a relative or just state that no fall has occurred
Alternative Scenarios	1. The resident wears a fall-detecting sensor. Again, he/she enters the bathroom and slips on the wet floor. The sensor detects the fall and notifies the symbIoTe system automatically, which then promptly informs (a) a caregiver or (b) a relative as defined in the user profile.

4.4 Assumptions

The detailed implementation of all use cases may vary depending on the availability of chosen technologies within symbIoTe.

Detecting the location of objects can be done using a newly developed sensor (http://www.getpixie.com), which is available starting in June 2016. Providing medication reminders with a note on where to find the medication will be strongly dependent on how well these sensors work and how accessible the underlying data is to the symbIoTe system. In case these sensors do not work as expected, alternatives will be considered and evaluated. However, if no alternatives can be found, the medication reminder use case can still be implemented using information on the medication schedule, indoor/outdoor location of the resident as described.

5 Smart Mobility and Ecological Routing

5.1 Overview

The *Smart Mobility and Ecological Urban Routing* Use Case aims at addressing the problem of inefficient transportation and poor air quality that many European cities face nowadays. This use case will offer the ecologically most preferable routes for motorists, bicyclists, and pedestrians based on the available traffic and environmental data acquired through multiple platforms. For air quality monitoring, the data obtained by in-situ environmental monitoring stations can be combined and enriched by the data readings collected by wearable sensors and mobile devices (the mobile crowd sensing approach) to provide enriched environmental measurements, which are dense both in space and time. At the same time, the routing planner takes mobility information, such as traffic measurements related to road traffic congestion and parking spaces occupancy offered by fixed sensors, as input data for the ecologically preferable route calculation.

5.1.1 The Challenge

Air pollution is a severe threat in urban environments, with a significant adverse impact on human health. Therefore, the air quality monitoring is essential, especially in larger cities where pedestrians and cyclists are frequently exposed to harmful gasses. Since this pollution is location-dependent and varying over time (e.g. , highly congested roads and industrial zones increase the concentration of toxic gasses), the air quality monitoring should occur in multiple city areas, for extended periods of time, which is not feasible with static meteorological stations, but can be accomplished by involving citizens. The city inhabitants can participate in the process by carrying wearable sensors capable of monitoring the air quality while moving around the city. This way, the high-quality measurements produced by in-situ stations are enriched by lower-quality measurements provided by wearable sensors, which gives us the power to estimate personal exposure levels to pollutant gasses for both pedestrians and cyclists.

The main challenges linked to this approach are:

- The likely need for calibrating and recalibrating the wearable air quality sensors;
- An insufficient number of measurements to determine individual exposure levels to pollutant gasses (mobile crowd sensing requires an active and dedicated participation).

Mobile crowd sensing is, by all means, a community-driven use case, which cannot exist without a dedicated group of users working as data providers. The sensor data acquisition process is comparable to the location-tagging process, similar to the one from the OpenStreetMap (OSM) project whereas the mobile sensor data exposes specific characteristics compared to fixed sensors such as volatile locations, short validity period, the need for a timestamp, large volume, etc.

5.1.2 symbIoTe Innovations

The use case will showcase platform interoperability primarily within the application domain, assuming that the networks contributing with the necessary sensor data are Level

1 symbIoTe-compliant and identify business models requiring bartering and trading of resources, which may also lack IoT platform federations (Level 2 symbIoTe-compliant).

The technical innovations provided by this use case are the following:

- Provision of an environment integrating heterogeneous air quality and transportation data from various platforms for green routing applications;
- Provision of a symbIoTe enabler for air quality monitoring;
- Implementation of high-level symbIoTe API for ecological routing calculations;
- Calibration algorithms for mobile sensors.

5.1.3 Objectives

The Smart Mobility and Ecological Routing use case serves as proof-of-concept for symbIoTe enabled interoperability in the application and cloud domain. Cooperation between platforms provides benefit to end users when they use such enriched service compared to traditional service provided by a single platform. The use case demonstrates the ability to re-use data from individual platforms deployed in urban area to make a new service adapted to specific user context. The air quality enabler provided in the use case can serve as mock-up for creating another enabler for different application domain.

5.2 High-Level Definition

Tom is a 30-year old engineer that has recently bought symbIoTe-compliant gadgets (a smartphone and environmental sensor) so that he can actively contribute to a citizen-driven air quality monitoring campaign in his city. He regularly drives his bike to and back from work, and provides air quality measurements made by his sensor while he is cruising throughout the city on the bike. The sensor measures concentrations of CO and NO_2 gases, temperature, humidity and atmospheric pressure and reports measurements to a symbIoTe-compliant IoT platform by using Tom's smartphone application. In addition, Tom can serve as a sensor, playing the human-as-a-sensor role, by annotating the OpenCyclistMap to update information about construction works or traffic jams regarding his daily routes.

In the meantime, Mary, a 25-year old employee of the Ministry of Environmental and Nature Protection, would like to benefit from the green campaign for air quality monitoring. She does not have an air quality sensor like Tom, but she uses the symbIoTe application for *green* route calculation while traveling to work by bike. The green routing application combines data obtained from various symbIoTe-compliant platforms (based on the data provided by Tom and static environmental stations) to calculate an appropriate route for Mary. The application re-routes Mary on-the-fly according to newly received data regarding air quality and notifications provided by other users regarding construction works on her bike trail.

Since Tom and Mary are childhood friends, they have arranged to meet their friends from the old neighbourhood. Mary will organize the event in the old neighbourhood, but it has changed a lot in the last years and she does not know which coffee shop to choose. She uses a symbIoTe-enabled mobile application that provides a list of potentially interesting points of interests based on her preferences. She asks the application to suggest a coffee shop that is for non-smokers and has silent music playing because they will talk a lot. After finding an appropriate place, she sends the coordinates to her friends. Tom will arrive to the coffee shop by bike using the green route suggested by his symbIoTe-enabled app, while their friend Chris will arrive by car. Chris has recently bought a new hybrid car equipped with various sensors so he contributes with data about air quality on city roads while driving to the meeting place. The symbIoTe routing application finds the fastest route for him since he is late.

5.2.1 Application Level Use Case Diagram

The Smart Mobility and Ecological Urban Routing Use Case focuses on urban environments, which involve a significant number of end-end users, vast amount of points of interest and uncountable possibilities of routes throughout the city. With the proper incentives, a high number of end users can collaborate as data providers, creating an environment densely populated by sensor data from large urban areas. Such sensor-enriched urban areas will allow the symbIoTe ecosystem to offer smart contextual services to the end-end users, based on their preferences.

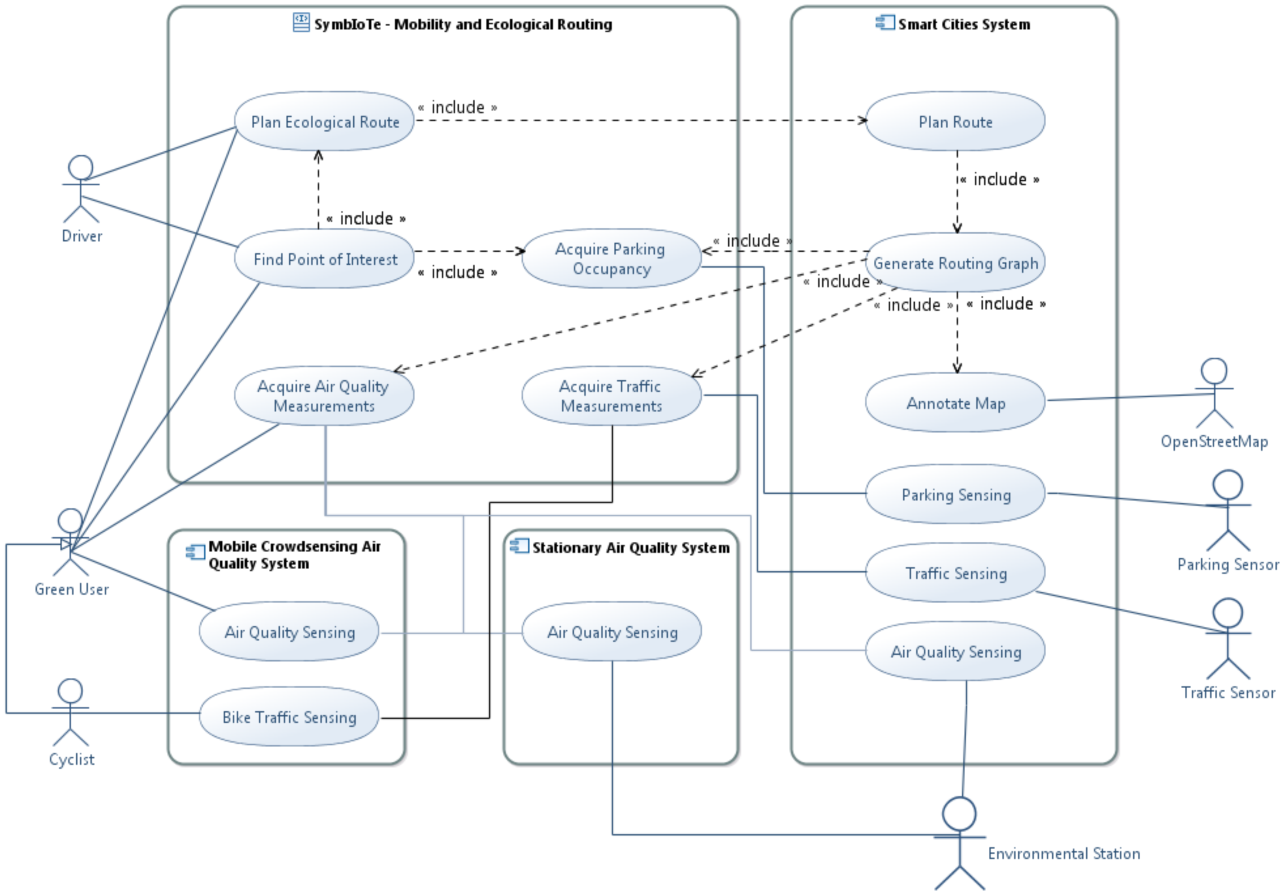

Figure 4: Smart Mobility and Ecological Routing Use Case

The following main sub-use cases have been identified:

1. The three "Data Acquisition" sub-use cases ("Data" being Air Quality measurements, Traffic measurements and Parking occupancy) relate to the functionality needed to acquire sensor data, which serves as input to the symbIoTe ecosystem. This information can be obtained either from static or mobile sensors

(except for parking occupancy, which come exclusively from static sensors), parsed and processed by multiple symbIoTe-compliant IoT platforms (subsystems) deployed in different cities. The sub-use cases can be extended with two additional features: periodic acquisition (done at regular intervals) and on-demand acquisition, which is performed on demand or triggered by external events (e.g., manual input from end-end users).

2. The "Calculation of Green Route" sub-use case is the principal in this scenario, which is responsible for providing the best route between two points, taking into account the impact on the users' health. An end user can set personal preferences, which influence the journey planning (e.g., "find me a way that favours a bicycle path through parks and roads without cars"). This symbIoTe-compliant service invokes the original journey planner available in the Smart Cities Backend as a Service Platform, which will generate a routing graph taking into account the city or region's OSM data, the air quality measurements from symbIoTe interoperability layer as well as Parking and Traffic, if available.
3. The sub-use case entitled "Point of Interest Searching" is an additional sub-use case driven by data collected through subsystems of the symbIoTe ecosystem. It provides the functionality to find a point of interest according to user's current preferences (e.g., find a nearby bar that is not smoky and has user rating above average). This sub-use case can be seen as an upgrade of the "simple" routing sub-use case when a user knows the desired end point. It is particularly attractive to tourists who should first identify the wanted destination, and then plan the ecologically most efficient route towards them, in agreement with their personal preferences.

5.2.2 Actors

Here are described the relevant Actors for the Smart Mobility and Ecological Urban Routing Use Case, their expectations about the project and respective active involvement in the scenarios. Noting that actors may represent roles played by human users, (external) hardware like sensors, or other subjects and that an actor does not necessarily represent a specific physical entity but merely a particular facet (i.e., "role") of some entity that is relevant to the specification of its associated use cases. Thus, a single physical instance may play the role of several different actors and, conversely, a given actor may be played by multiple different instances.

Data Producer

Data producers can either be fixed stations (or antennas) or wearable sensors for air quality monitoring, carried by pedestrians or cyclists who may want to share the data they acquire with many platforms. They should have access to a common interface to publish the data, regardless of their location and the collected attributes.

Data Consumer

Data consumers are also pedestrians and cyclists who want to plan the most ecological routes, since they are conscious about their wellbeing (or might suffer from respiratory issues) and want to avoid areas with severe impact on their health. They should have access to a mobile application capable of planning these itineraries in different pilot areas, notwithstanding the data producer platforms.

5.2.3 Subsystems

The number of used subsystems is not predefined, since one of the sub-use cases is focused on acquisition of data and can be extended with subsystems that are symbIoTe compliant and serve as data sources (for air quality, parking or traffic data).

Mobile Crowdsensing Air Quality Platform (OpenIoT)

The OpenIoT platform is an open-source Cloud platform for the Internet of Things, developed in the scope of the FP7 OpenIoT project. It manages the registration, data acquisition and deployment of different sensors using the Semantic Web technologies and the SSN ontology, thus enabling the semantic unification of diverse data and IoT applications in the Cloud. In addition, OpenIoT offers support for discovering and collecting data in a crowd sensing fashion from wearable sensors through a Cloud-based Publish/Subscribe Middleware. The crowd sensing air quality service operates on the data gathered solely through OpenIoT, while symbIoTe platform federations offer the service a potentially added value derived from the information obtained from other platforms. For example, the OpenIoT platform could trade its mobile air quality data for data acquired by in-situ stations, having this high-quality air quality information applied for the calibration of wearable sensors.

Stationary Air Quality Platform (UWEDAT)

The cities of Zagreb and Vienna operate Air Quality Measurement Networks, whose data is typically collected from fixed stations. EU directives and related legislation require this data to be of high quality (little measurement errors, high availability, etc.), more reliable than the data collected from wearable mobile stations. An example of cooperation between subsystems within the symbIoTe ecosystem is presented when the air quality data collected by UWEDAT can serve for the following purposes: complement the mobile data and improve its accuracy by helping to eliminate certain measurement errors.

UWEDAT is designed to tap into quite different systems and will be used in this use case to bridge between the individual systems in Zagreb and Vienna and make the data available for the symbIoTe ecosystem.

Smart Cities Mobility Backend as a Service Platform (Ubiwhere MBaaS)

Currently, Ubiwhere's middleware platform is ready to gather data from hardware sensors, which provide information about parking, traffic, and air quality, through HTTP, CoAP, LwM2M and other interfaces and using multiple standards (such as FIWARE's NGSI-9/10). The journey planner offered by Ubiwhere's mobility backend as a service allows route planning using different means of transportation, such as public transit vehicles, bicycles, trucks and regular private cars. Even though the middleware platform allows the data, which had been collected, parsed and stored for usage by external applications via well-structured RESTful interfaces, the journey planner is yet not taking into account sensors data in the efficient routing algorithm. With symbIoTe and this use case, it will be possible to integrate the two components and provide best routes using a particular type of vehicle and avoiding polluted areas or with no parking occupancy near the destination.

Third-Party System (OpenStreetMap)

A third-party system that provides the essential datasets as input for the routing and discovering points of interest use cases. It also stores annotations on a map made by human actors, which enables the classification of ways with environmental measurements and, therefore, the use cases.

5.3 Sub-Use Cases

The following sub-use cases are driven by a potentially large user base connected to multiple IoT platforms that cooperate at the level 1, according to the defined symbIoTe compliance levels. The synergy, achieved by the cooperation of platforms, provides added value to all stakeholders involved in service realization, especially to end users allowing them to use the service regardless of data origin and current IoT service provider.

5.3.1 Data Acquisition

Description	The sub-use case focuses on the collection and handling of environmental and air quality sensor data from (urban) environments of interest to end users. The data readings can be obtained from multiple sources, which can cooperate to achieve the goal of minimal resource consumption while maintaining a required level of data quality. More precisely, the sub-use case focuses on urban environments where users with smartphones and wearable sensors collect data about the air quality around them. The complexity of the sub-use case stems from the required cooperation between users that originate from different platforms, i.e., to overcome boundaries of each platform for the task of distributed data collection. Representatives of data acquisition actors in the physical world are pedestrians, cyclists, car drivers, public transport vehicles or fixed environmental stations. We can group these actors by their mobility into two groups: a sensor with a fixed location or a mobile sensor. The mobility characteristic and sensing capabilities are the two most important features that each sensor is offering to its own platform and to all other symbIoTe compliant platforms.
Trigger	The data acquisition process can be driven by data requests from other users or platforms (preferably from all symbIoTe compliant platforms) or by a contributing user. Thus, we can identify three different subtypes of contributions: periodic, ad-hoc or on-demand. A periodic data acquisition process senses the environment in regular intervals, which can be predefined or changed *on-the-fly* by a platform (e.g., a fixed environmental station). The ad-hoc actor sends data as a reply to a platform request (e.g., a mobile user that sends air quality data for some low populated area) while the on-demand actor sends data when it thinks it is suitable (e.g., a user marks a point of interest on a map).

Pre-Conditions	**Pre-condition 1** Hardware For a user to contribute, it needs to have a proper equipment to perform air quality measurements and send it to a platform. Currently, we do not distinguish between the *home* platform (i.e. a platform where a user is normally connected), and some other symbIoTe compliant platform that actually use sensed data. The equipment should be (pre-) calibrated, because levels of Quality of Service (QoS) can be introduced, with the goal to favour sensors (i.e., users), which contribute sensor data of better quality. **Pre-condition 2** User willingness to contribute sensor data A user needs to be willing to contribute his data, potentially renouncing part of their privacy (some anonymization is expected, but user privacy concerns are possible). In order to increase user willingness to participate in mobile crowd sensing activities, platforms can use specific incentive mechanisms (e.g., mobile users can be motivated to cover areas, which are insufficiently populated with data in exchange of a monetary compensation or loyalty programme). An important additional factor is the energy efficiency (at both the wearable sensor and mobile phone level) because users would be less keen to contribute data if it drains too much energy from their devices (especially smartphones).
Involved Actors	A single actor is involved in the sub-use case: the data producer. The data producer role includes all users willing to contribute information: pedestrians and cyclists that carry air quality sensors, fixed environmental stations or citizens who are actively involved in the contribution to the community.
Sub-Use Cases Involved	The data acquisition is the most important prerequisite for the following sub-use cases: Calculation of Green Route, Point of Interest Searching and Acquire Air Quality Measurements. All those sub-use cases are driven by data collected in the process of environmental sensing, which can be obtained from static sensors connected to UWEDAT / MBaaS platforms or from mobile sensors connected to the OpenIoT platform. Data acquisition can be performed on-demand (initiated by an actor) or periodically (in a specified time frame).
Subsystems Involved	In this sub-use case, we can identify the following subsystems: the OpenIoT platform and other symbIoTe compliant platforms that request or use sensed data, such as UWEDAT. The subsystems process data in order to facilitate other sub-use cases provided by symbIoTe compliant platforms.
Process Flow	1. User connects to a platform and if necessary turns on sensing device

	2. Platform requests data 3. Device checks if it meets requirements for data acquisition, if so, it starts the process of data acquisition 4. Platform updates data request (e.g. , the sensing frequency, request for new data) 5. User devices periodically send data 6. User spots an event of interest and uploads manually the information about the event 7. User has reached its end destination and stops the process of data acquisition
Alternative Scenarios	1. The most obvious alternative scenario is the case when a user or the equipment cannot produce required data due to loss of hardware ability (e.g., a sensor is not calibrated), change of environment (e.g., a sensor is now in a pocket), low battery level, or the user changes its geographical location, which is not of interest to anyone connected to the symbIoTe ecosystem.

5.3.2 Calculation of Green Route

Description	The green routing service is designed for cyclists and pedestrians in urban environments and enables finding the most suitable routes provided the air quality measurements retrieved from multiple IoT platforms. Thanks to the symbIoTe's interoperability layer, distinct environmental (and other domains) platforms are capable of working as data providers for the journey planner service. The routing service takes the air quality data from IoT platforms when generating the routing graph and returns the ecologically most efficient route between two places, provided an origin and destination point. The source point can either be the user’s current location, detected by a geo-location service (e.g., Global Positioning System - GPS), or a user-defined point either by typing its address or by picking a place on a map. The desired destination can appear by retrieving a location from the map or by searching for a point of interest or address. Fastest and shortest routes can already be calculated by using Ubiwhere's Smart Cities Backend as a Service Platform. Based on OSM data, the routing service is capable of finding the best path taking into account several attributes such as the road properties and the vehicle's characteristics. The image below shows the most suitable route for heavy waste management vehicles to empty three garbage containers in the city of Coimbra, Portugal. Apart from distance and time to reach the destination, we introduce one new parameter based on which the best route is determined – air pollution. The goal of the service is to find an optimal way that minimises the trip distance, duration and exposure to harmful gases. It

	can be useful in cities with low air quality since it advises users to choose routes where the air is less contaminated.
Trigger	Triggered by actor Data Consumer (i.e., Green User, Cyclist or Driver) when the action Calculation of Green Route is chosen.
Pre-Conditions	**Pre-condition 1** Technical pre-conditions In order to enable the green routing service, existing routing APIs need to be integrated with the service, and a mobile application is required to plan the best itineraries regarding the collected air quality measurements. The routing API takes OSM information as the source for finding the best routes according to distance and duration. Additionally, the routing service needs to integrate air-quality data, in real-time, obtained from the symbIoTe-compliant platforms for the designated routes so that the path with the best air quality can be chosen. Within the mobile application, a user needs to be able to choose her/his destination and define several preferences such as the preferred vehicle and route types, while the current user location needs to be recognized thanks to a geo-location service, such as GPS. **Pre-condition 2** Having available air quality data on the observed routes To be able to calculate the Green Route, it needs to be possible to obtain air quality information and link it to roads and streets provided by the OSM provider. This way, when generating the most efficient routing graphs for the different types of vehicles, this timely collected data can be used as a routing cost (just like the length or inclination of a road) when planning the most ecological routes through the proper API. If no data is available for a given point, it shall be provided by an “interpolator which should take all available data into account (mobile and fixed stations) to deduce from available measurements at some points, to the air quality at other locations. Another potential task for this interpolator might be to assess (and probably rectify) data from mobile sensors. This assessment (and potentially rectification) can be done using data from the fixed stations, which is usually of several magnitudes better quality than data from the mobile sensors.
Involved Actors	Data consumers – cyclists and pedestrians
Sub-Use Cases Involved	Data Acquisition, Calculate route
Subsystems Involved	The subsystems required for the sub-use case is the Smart Cities Mobility Backend as a Service, provided by Ubiwhere, that allows the ecological routing through a symbIoTe-compliant service, which takes into account the air quality measurements collected by symbIoTe-level 1 IoT platforms mentioned in the Data Acquisition sub-use case.

Process Flow	1. Data consumer (cyclist or pedestrian, user from now on) opens her/his mobile application 2. User shares his location with the mobile application or defines an origin point from the map or by address / Point of Interest lookup 3. User sets a destination on the map or by searching for an address or Point of Interest 4. Air quality data is fetched from server and attached to OSM data as tags linked to the Ways (roads, streets, etc.) 5. Routing engine generates a new graph of the city with the most recent collected air-quality measurements 6. Routing algorithm finds a couple of appropriate routes using the new tags as routing cost 7. The route with best air quality is shown to the user on the map and directions list
Alternative Scenarios	1. Routing algorithms find only one route (there is no choice) a. Only one route is chosen 2. There is no air quality data for the chosen routes a. Best route is chosen by taking into account only distance and duration

5.3.3 Point of Interest Searching

Description	Public places often have different characteristics, e.g., parks or cafés have different levels of noise or air quality, which influences the choice of a meeting location or location for relaxing, reading etc. In some occasions people prefer quiet places, e.g., for conversations, while in some other occasions they could prefer louder music. Point of Interest Searching sub-use case suggests a Point of Interest (POI) to a user based on type (e.g., bar, restaurant, city park, library, paring lot) and the preferred features such as level of noise, level of air quality or parking availability nearby. The list of POIs is obtained from the OSM, while the additional features are gathered from various symbIoTe compliant platforms (i.e., the symbIoTe ecosystem) that contain data of interest. When a user selects a point of interest, the routing application from the symbIoTe ecosystem can offer routing to the POI or to the nearest parking spot available depending on user context. Since the sub-use case is driven by volunteer user contributions to acquire features for a POI, which can be highly volatile in time, a user can also contribute to improve the service by providing his/her own measurements while he is visiting/using a POI (e.g., indicate the noise level at the POI).
Trigger	Triggered by all actors (Cyclists, Green User and Driver) when the action Point of Interest Searching is chosen.

Pre-Conditions	**Pre-condition 1** Technical pre-conditions User needs a mobile application that offers a selection filter for points of interests, which takes into account additional features (e.g., noise level, parking availability) beyond simple filtering by the POI type. Additional features of POI vary in time, based on the POI type and user context so the application needs to include all relevant information (i.e., the actor, user preferences) to suggest a list of POIs. Additionally, the service needs to be integrated with the routing service and parking possibilities so that the best route and POI is chosen. **Pre-condition 2** Having available a list of points of interest Without the points of interest list, the application would not be able to find locations according to user interests. An open-source solution would be convenient where the list is populated and maintained by volunteer users in crowdsourcing fashion, e.g., to use the data from OSM or Foursquare. **Pre-condition 3** Having available additional features for points of interest Additional features provided by all users (through the Data Acquisition sub-use case) are value-adding parameters for this service. Those parameters can be defined by all users, not predefining all possible features because different users may find different things important to contribute (e.g., some users can report that construction work is nearby with a lot of dust while the other will point out that music is too loud to have a conversation). These parameters enable better matching of locations to user needs. If these parameters are not available, the locations can be found only by type, without the possibility to suggest the most appropriate location according to user preferences. The level 1 of symbIoTe compliance provides support for cooperation.
Involved Actors	The sub-use case involves two types of actors: data consumers, which are human users in urban environment (cyclists, green user and car driver) and data sources, which feed data to the ecosystem such as: traffic and/or parking sensors, environmental stations or third-party systems like OSM.
Sub-Use Cases Involved	Data Acquisition, Calculation of Green Route, Plan Route
Subsystems Involved	The Point of Interest Seraching sub-use case is driven by the integrated data from multiple symbIoTe platforms: 1) Mobile Crowdsensing Air Quality Platform provides air quality readings and bike traffic data made by volunteers; 2) Stationary Air Quality Platform gathers data from static environmental stations; 3) Smart Cities

	Mobility Backend as a Service Platform supports routing and feeds the sub-use case with data from urban areas.
Process Flow	1. A user (Green User, Cyclists, Car Driver) specifies the point of interest: type of location (bar, restaurant, city park, library), and additional parameter (e.g. , noise level) 2. The service finds a list of specified locations 3. A user chooses one of the locations from the list 4. The Calculation of Green Route suggests the appropriate route to the POI.
Alternative Scenarios	1. There is no data about a point of interest specified by user a. The POI is offered to a user with a label that data about additional features do not exist. 2. There is no parking availability nearby 3. The POI is presented with a lower score

6 EduCampus – Educational Campus Service Federation

6.1 Overview

6.1.1 The Challenge

The current situation with campus services is that they are proprietary and usually closed systems for each university. Sometimes even proprietary hardware like identity cards are used. Doing some parts of one's studies abroad introduces a lot of administrational overhead, burdening the universities as well as the students. Often special digital services of the university abroad cannot even be accessed. Therefore, to make universities more attractive to visiting people, like the participants in EU student exchange programmes like SOKRATES, ERASMUS or TEMPUS, it is essential to lower the administrational overhead and to make access to digital campus services more convenient.

Students are bonded to their home university by being initially equipped with assets like identity cards, authentication accounts and sometimes even electronic devices like smartphones, tablets or even laptops to access the campus services. When participating in a student exchange program, the student has to replace all these assets, and start in a remote campus from the beginning. This is time consuming in the best case, in some cases it is error-prone and causes additional administration expenses when exchanging course qualification data, and sometimes all of this is frustrating.

6.1.2 symbIoTe Innovations

The Educational Campus Federation Service aims to support the cooperation of universities by simplifying the establishment of interoperability between remote campus services. Assets like identity cards or service clients shall be usable in remote campus environments, without being reconfigured or even replaced. Currently, reuse of existing applications in different administrational contexts like different universities is only possible by close collaboration of the different administrational bodies and a tight coupling of their information systems which can be overcome by using symbIoTe as a decoupling layer. This could lower the expenses necessary to enable collaboration between universities on a technical or rather user/service-centred level. If more universities adapt this concept a new level of user-experience for exchange students could be reached and thereby strengthen all participating universities in the international competition to attract students as well as raising the level of education by lowering the barrier for students to gain international experience.

6.1.3 Objectives

The objectives of the EduCampus use case are:

- Security, access scopes and identity management: Accessing resources within a campus requires authorization and access control. Especially when resources from one campus are made available to external users from associated campuses. The modelling of access scopes and identity declarations will be a focus area.

- Realistic cross-platform deployments: In the EduCampus use case, the facility management systems from the KIT and the UPMC will be associated and deployments within the departments of the IOSB, KIT and UPMC are planned.
- Open source and standardization: All the developments within the EduCampus shall be useable without limitations by universities and service partners. The open source model will be applied for all core elements of the framework, in order to guarantee the openness, the extendibility and transparency of the resulting solution.

6.2 *High Level Definition*

6.2.1 Application Level Use Case Diagram

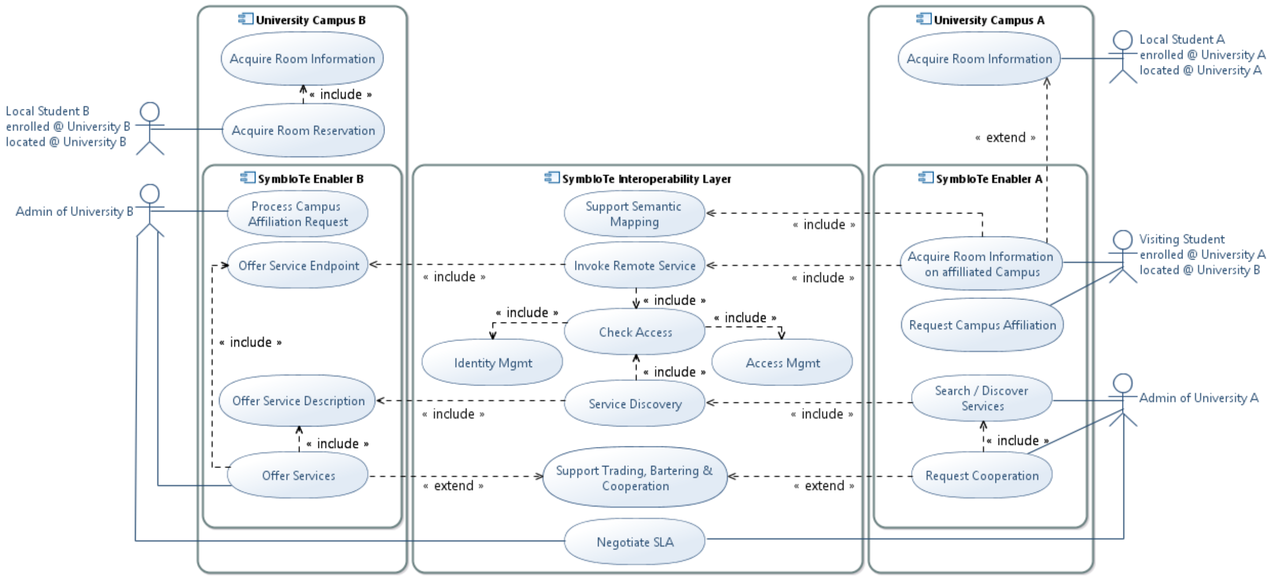

Figure 5: Application Level EduCampus Use Case Diagram

6.2.2 Actors

Local Student A

Local Student A is a student enrolled at university A and physically located at the campus of university A.

Local Student B

Local Student B is a student enrolled at university B and physically located at the campus of university B.

Visiting Student

A Visiting Student is a student enrolled at university A, but is physically located at the campus of university B. His university also offers services available via website or smartphone app like acquiring a room reservation. He expects to be able to use his room reservation app provided by his home university on the visited campus just as he is at his home campus.

Admin of University A

The Admin of University A represents the campus administration for university A. He will search and discover services of remote universities and he will initiate a cooperation between universities by requesting a cooperation. He will also be involved in the negotiation of service level agreements (SLA).

Admin of University B

The Admin of University B represents the campus administration for university B. He will offer services for visiting students and it will process the campus affiliation request of a visiting student. He will also be involved the negotiation of SLAs.

6.2.3 Subsystems

University Campus A

The University Campus A subsystem is an abstraction of the IT infrastructure deployed at the campus of university A, where a Visiting Student is enrolled, which is planning to visit a remote university. The University Campus A offers a room reservation service, which includes also a room information service.

For administration purposes, the University Campus A offers services to initiate campus bonding/affiliation requests for exchange students.

University Campus B

The University Campus B subsumes the whole IT infrastructure from the university campus B, which the guest student enrolled at University A plans to visit. The service provided by University B, is similar but not identically to the services of University A. In University Campus B a room information service is provided for the local students. This is a functional subset of the room reservation service from University Campus A.

For the university administration, the University Campus B offers services to offer and to describe student services.

symbIoTe Interoperability Layer

The symbIoTe Interoperability Layer represents the symbIoTe functionality used in this use case. This covers support for trading, bartering and cooperation mechanisms, to negotiate a SLAs as well as the functionality to support semantic mapping.

The symbIoTe Interoperability Layer contains only application agonistic services being used by extensions made within the applications.

symbIoTe Enabler A

symbIoTe Enabler A is a subsystem of University Campus A and contains use case specific extension to the services offered by University Campus A to achieve symbIoTe compliance. This comprises an extended version of the Acquire Room Information sub-use case, which can be used on an affiliated campus as well as sub-use cases supporting the initiation of the cooperation between the two universities like Search / Discover Services and Request Cooperation.

symbIoTe Enabler B

symbIoTe Enabler B is a subsystem of University Campus B and contains sub-use case specific extension to the services offered by University Campus B to achieve symbIoTe compliance. For University Campus B this comprises sub-use cases supporting the remote discovery and invocation of local services like Offer Service Endpoint and Offer Service Description.

6.3 Sub-Use Cases

Dave is a student enrolled at Karlsruhe Institute of Technology (KIT). He is participating in a student exchange program with Université University Pierre and Marie Curie (UMPC) for two months and therefore just moved to Paris.

On his first day on the UPMC campus, he wants to use his KIT campus navigation app to navigate on the UPMC campus. Therefore, he requests to be bonded with the UPMC campus as a guest, which is granted by a person in charge at UPMC. Now he can use his KIT campus navigation app to find rooms and navigate on the UPMC campus.

After finding the building of his exchange faculty, he wants to enter it but it is secured with an access control mechanism. He authenticates himself using his RFID student card from KIT and as he is bonded with the UPMC campus and has the needed access rights, he has granted access.

Inside the faculty building, Dave now wants to find a free working place. He starts his KIT workplace service app, which now displays free workspaces at the building in which he is currently located. He finds a free working space close to him and the app navigates him there. Arrived there he confirms his presence by scanning his KIT student card.

His new friend Pascale is surprised that Dave could do this room information search with his KIT app, because at UPMC there is normally a web-terminal used for this and it has a slightly different concept of a workspaces.

As Dave arrives back at his home university in Karlsruhe he changes his bonding back to the KIT campus and can use his KIT navigation and workplace service as usual.

The sub-use cases that allow this scenario to play out are described in the following tables.

6.3.1 Acquire Room Information

Description	In this sub-use case, the actor acquires information about a specific room within a building associated to a university campus. The room information must contain the identification of the room and the identification of the building. The room identification must be unique inside in relation to its building.
Trigger	A Local Students request room information via website or smartphone app.

Pre-Conditions	**Pre-condition 1** The calling actor needs to be enrolled as a student at the local university. **Pre-condition 2** Information on available rooms, buildings and their location need to be present in the system.
Involved Actors	Local Student
Sub-Use Cases Involved	There are no dependencies.
Subsystems Involved	University Campus A University Campus B
Process Flow	1. Local Student request room information for his local campus via website or smartphone app. 2. The IT system of his local university provides this information.
Alternative Scenarios	None.

6.3.2 Acquire Room Reservation

Description	The Local Student enrolled at university B wants to make a room reservation on his local campus. He specifies the room and the building and requests a reservation for a certain time span.
Trigger	Triggered by Local Student when making a room reservation.
Pre-Conditions	**Pre-condition 1** The desired room must not be already reserved by another user for the requested time span.
Involved Actors	Local Student
Sub-Use Cases Involved	Acquire Room Reservation
Subsystems Involved	University Campus B
Process Flow	1. A Local Student wants to make a room reservation. 2. He is provided with room information of available rooms. 3. He chooses the desired room and a desired time span. 4. He requests reservation. 5. System sends notification whether the reservation was successful or not.

Alternative Scenarios	None.

6.3.3 Process Campus Affiliation Request

Description	This sub-use case describes the processing of a campus affiliation request by the Admin of University B.
Trigger	The sub-use case can be triggered by Admin of University B when he opens a view of the currently not processed campus affiliation requests or indirectly by Visiting Student whose execution of the Request Campus Affiliation sub-use case triggers a notification of Admin of University B.
Pre-Conditions	**Pre-condition 1** An SLA must be successfully negotiated between the Admin of University Campus A and B.
Involved Actors	Admin of University B Visiting Student
Sub-Use Cases Involved	Negotiate Service Level Agreement
Subsystems Involved	symbIoTe Enabler B
Process Flow	1. Admin of University B is presented campus affiliation requests. 2. Admin of University B accepts the affiliation request. 3. The decision will be forwarded to Visiting Student. After a SLA is successfully negotiated by the symbIoTe Interoperability Layer, the Admin of University B is presented the campus affiliation request together with the negotiated SLA. He checks if the request is valid and then manually accepts the request. This information will be forwarded to the Visiting Student.
Alternative Scenarios	1. If the SLA is not defined prior to execution, the request cannot be accepted. 2. Admin of University B rejects the affiliation request. The Visiting Student who sent the request is notified and will receive detailed information on the reason for the rejection.

6.3.4 Offer Services

Description	With this sub-use case, all services usable by visiting students are offered to federated universities. The offerings are announced by using the symbIoTe Interoperability Layer.
Trigger	Triggered manually by Admin of University B when the university decides to offer their services through symbIoTe.

Pre-Conditions	**Pre-condition 1** For services to offer there must be a valid Service Description in a symbIoTe compliant / understandable format. **Pre-condition 2** The service must be hosted and the Service Endpoint must be publically reachable.
Involved Actors	Admin of University B
Sub-Use Cases Involved	Offer Service Description Offer Service Endpoint Support Trading, Bartering & Cooperation
Subsystems Involved	symbIoTe Enabler B symbIoTe Interoperability Layer
Process Flow	1. University B decides to offer their services through symbIoTe. 2. Admin of University B creates a service description for services to offer and Offer Service Description sub-use case is executed. 3. Offer Service Endpoint sub-use case is executed. 4. University B now offers their services in a symbIoTe complaint way.
Alternative Scenarios	None.

6.3.5 Offer Service Description

Description	This sub-use case describes how a service description is offered in a symbIoTe compliant way.
Trigger	Execution of sub-use case Offer Services.
Pre-Conditions	**Pre-condition 1** The service description must be present in a symbIoTe compliant format.
Involved Actors	Admin of University B
Sub-Use Cases Involved	Service Discovery
Subsystems Involved	symbIoTe Enabler B symbIoTe Interoperability Layer
Process Flow	1. Admin of University B wants to offer service descriptions of local services. 2. He announces the service description.
Alternative	1. If a non-symbIoTe compliant service description is provided than

Scenarios	that service cannot be discovered by other platforms via the Service Discovery sub-use case.

6.3.6 Offer Service Endpoint

Description	This sub-use case describes the offering of a service endpoint in a symbIoTe compliant manner.
Trigger	The sub-use case is triggered whenever Admin of University B executes the Offer Services sub-use case.
Pre-Conditions	**Pre-condition 1** The desired service must be hosted on a publicly available Endpoint.
Involved Actors	Admin of University B
Sub-Use Cases Involved	None.
Subsystems Involved	symbIoTe Enabler B
Process Flow	1. Admin of University B wants to offer a service endpoint for a local service. 2. He announces the service endpoint through symbIoTe.
Alternative Scenarios	None.

6.3.7 Acquire Room Information on affiliated Campus

Description	This sub-use case extends the “Acquire Room Information” case, by allowing its usage as a Visiting Student on an affiliated campus.
Trigger	A Visiting Student enrolled at university A but physically located at the campus of university B wants to get information about available rooms on campus B.

Pre-Conditions	**Pre-condition 1** For the Visiting Student to use services of University Campus B respectively symbIoTe Enabler B there must be a valid SLA between University Campus A and University Campus B. **Pre-condition 2** Visiting Student must be affiliated with University Campus B. This includes that he previously executed the Request Campus Affiliation sub-use case and Admin of University B accepted this request by executing the Process Campus Affiliation Request sub-use case. **Pre-condition 3** Admin of University B must have executed the Offer Services sub-use case exposing the room information service in a symbIoTe compliant way. **Pre-condition 4** Admin of University A must have discovered a service offered by university B by executing the Search / Discover Services sub-use case, which provides the data necessary to fulfil the requested functionality. The two services (the desired and the remotely discovered one) need to be semantically aligned. **Pre-condition 5** Visiting Student has to have sufficient access rights to invoke the corresponding service of symbIoTe Enabler B.
Involved Actors	Visiting Student
Sub-Use Cases Involved	Acquire Room Reservation Support Semantic Mapping Invoke Remote Service
Subsystems Involved	symbIoTe Enabler B symbIoTe Interoperability Layer
Process Flow	1. Visiting Student is physically located at campus B and wants to use the website / smartphone app provided by university A to find a room on campus B. 2. After starting the app, the system realizes that it needs to invoke a remote service offered by campus B to execute the request. 3. The symbIoTe Interoperability Layer check the access rights of Visiting Student based on Identity and Access Management. 4. The remote service is invoke using the semantic mapping information. 5. The Visiting Student is presented the results in the normal fashion

	of his app.
Alternative Scenarios	1. The Visiting Student may not have sufficient access rights to execute invoke the remote service and therefore will be given a notification stating this.

6.3.8 Request Campus Affiliation

Description	The Request Campus Affiliation sub-use case describes the service offered to the Visiting Student by the University Campus A. This allows the Visiting Student to request affiliation to the visiting University Campus B, as soon as the affiliation request has been processed and granted.
Trigger	Triggered by Visiting Student when manually requested via website or smartphone app (usually before starting or at the beginning of a student exchange programme).
Pre-Conditions	**Pre-condition 1** University A and B must have reached a valid SLA. **Pre-condition 2** The Visiting User has to be enrolled at university A to have access to this service.
Involved Actors	Visiting Student
Sub-Use Cases Involved	None.
Subsystems Involved	symbIoTe Enabler B
Process Flow	1. Visiting Student is enrolled at university A. 2. He wants to affiliate himself with university B by executing the sub-use case Request Campus Affiliation. 3. As soon as Admin of University B executes the sub-use case Process Campus Affiliation Request, the Visiting Student is notified of the result.
Alternative Scenarios	1. If the Visiting Student request affiliation with a campus that is not symbIoTe compliant his request will automatically be rejected and provided a message that the university does not support this functionality. 2. Admin of University B rejects the affiliation reject of the Visiting Student. Then the Visiting Student will be notified and receive a short description of the reason.

6.3.9 Search / Discovery Service

Description	In this sub-use case the Admin of University A may search or may be informed about services offered by other universities.
Trigger	Triggered by Admin of University A when searching for available services from other universities or by the symbIoTe Interoperability Layer when new services become available.
Pre-Conditions	**Pre-condition 1** University Campus a needs to be able to use the symbIoTe API to discover services. **Pre-condition 2** Admin of University A can only discover services according to his own access rights.
Involved Actors	Admin of University A
Sub-Use Cases Involved	Service Discovery
Subsystems Involved	symbIoTe Enabler A symbIoTe Interoperability Layer
Process Flow	1. Admin of University A opens a website allowing him to search for available services. 2. He enters the search conditions and starts the search. 3. symbIoTe Interoperability Layer processes the search request and provides only results compliant with the access rights of Admin of University A. 4. Admin of University A is presented the results on the website.
Alternative Scenarios	1. symbIoTe enabler A does not implement the symbIoTe API and therefore cannot execute any sub-use case within the symbIoTe Interoperability Layer.

6.3.10 Request Cooperation

Description	This sub-use case describes how the Admin of University A wants to request the start of a cooperation with university B.
Trigger	Triggered by Admin of University A when wanting to start a cooperation with another university.
Pre-Conditions	**Pre-condition 1** The partner requested cooperation with needs to offer services in a symbIoTe compliant way.
Involved Actors	Admin of University A

Sub-Use Cases Involved	Search / Discover Services Support Trading, Bartering & Cooperation
Subsystems Involved	symbIoTe Enabler A symbIoTe Interoperability Layer
Process Flow	1. Admin of University A wants to start a cooperation with another university. 2. He executes the sub-use case Search / Discover Service to find available services provided by other universities. 3. After deciding which university he would like to cooperate with, he initiates the cooperation request by using the functionality provided by the Support Trading, Bartering & Cooperation sub-use case.
Alternative Scenarios	None.

6.3.11 Support Semantic Mapping

Description	This sub-use case offers application-agnostic support for semantic mapping different services to another.
Trigger	Triggered by the attempt to invoke a remote service, which needs to be mapped to own representations.
Pre-Conditions	**Pre-condition 1** To support semantic mapping there must be at least some kind of semantic similarity between the two resources to be mapped.
Involved Actors	Visiting Student
Sub-Use Cases Involved	None.
Subsystems Involved	symbIoTe Interoperability Layer
Process Flow	1. Services supporting semantic mapping are offered.
Alternative Scenarios	1. If the two resources requested to be mapped to not have any semantic similarity than the sub-use case will not be able to support mapping.

6.3.12 Invoke Remote Service

Description	This sub-use case supports the service forwarding from one symbIoTe client to another. The remote Service must be interoperable to the local service.

Trigger	Visiting student requests room information from the affiliated campus.
Pre-Conditions	**Pre-condition 1** Services can only be invoked with sufficient access rights. **Pre-condition 2** Visiting student must be affiliated with University Campus B.
Involved Actors	Visiting Student
Sub-Use Cases Involved	Offer Service Endpoint Check Access
Subsystems Involved	symbIoTe Interoperability Layer symbIoTe Enabler B
Process Flow	1. A user provides his credentials. 2. He requests invocation of a remote service. 3. symbIoTe Interoperability Layer checks his access rights based on his credentials. 4. The remote service is invoked and the result is forwarded to the requester
Alternative Scenarios	1. The user requesting the invocation of a remote service does not have the needed access rights and therefore execution is denied and the user is given a suitable notification.

6.3.13 Check Access

Description	This sub-use case provides an application-agnostic access control service.
Trigger	Triggered by the Invoke Remote Service sub-use case and the Service Discovery sub-use case.
Pre-Conditions	None.
Involved Actors	Visiting Student Admin of University A
Sub-Use Cases Involved	Identity Management Access Management
Subsystems	symbIoTe Interoperability Layer

Involved	
Process Flow	1. Perform access control check given requested resource and credentials.
Alternative Scenarios	None.

6.3.14 Identity Management

Description	This sub-use case provides application-agnostic identity management functionality.
Trigger	Triggered by the Check Access sub-use case.
Pre-Conditions	None.
Involved Actors	Visiting Student Admin of University A
Sub-Use Cases Involved	None.
Subsystems Involved	symbIoTe Interoperability Layer
Process Flow	1. Realize identity management given provided credentials.
Alternative Scenarios	None.

6.3.15 Access Management

Description	This sub-use case provides application-agnostic access management.
Trigger	Triggered by the Invoke Remote Service sub-use case and the Service Discovery sub-use case.
Pre-Conditions	**Pre-condition 1** To be able to check for access rights the requesting user must provide valid credentials. **Pre-condition 2** In order to provide access management there must be information about access restrictions to individual resources available.
Involved Actors	Visiting Student

	Admin of University A
Sub-Use Cases Involved	None.
Subsystems Involved	symbIoTe Interoperability Layer
Process Flow	1. Provided requested resource and validated identity of the requesting user the access is granted based on the underlying restrictions.
Alternative Scenarios	1. If the access rights of the requested user are not sufficient, the access is denied.

6.3.16 Service Discovery

Description	This sub-use case provides an application agnostic discovery service for services.
Trigger	Triggered by Admin of University A by executing the Search / Discover Services sub-use case.
Pre-Conditions	**Pre-condition 1** In order to successfully discover services there must be at least one service offered by any system.
Involved Actors	Admin of University A
Sub-Use Cases Involved	Offer Service Description
Subsystems Involved	symbIoTe Interoperability Layer Offer Service Description Check Access
Process Flow	1. Admin of University A searches for services by executing the Search / Discover Services sub-use case. 2. According to the access rights provided by Admin of University A provides information about available services.
Alternative Scenarios	None.

6.3.17 Support Trading, Bartering & Cooperation

Description	This sub-use case provides application-agnostic support for trading, bartering and cooperation of different IoT platforms.
Trigger	Triggered by Admin of University A when executing the Request Cooperation sub-use case and Admin of University B when executing

	the Offer Services sub-use case.
Pre-Conditions	None.
Involved Actors	Admin of University A Admin of University B
Sub-Use Cases Involved	None.
Subsystems Involved	symbIoTe Enabler A symbIoTe Enabler B
Process Flow	1. Provide general support function for implementing trading, bartering and cooperation.
Alternative Scenarios	None.

6.3.18 Negotiate Service Level Agreement

Description	This sub-use case describes the process of negotiating a SLA for the usage of (specific) services between the University Campus A and University Campus B via the bartering, trading and collaboration functionality of the symbIoTe Interoperability Layer.
Trigger	Triggered by Admin of University A.
Pre-Conditions	**Pre-condition 1** The sub-use case Request Cooperation must have to be executed before.
Involved Actors	Admin of University A Admin of University B
Sub-Use Cases Involved	None.
Subsystems Involved	symbIoTe Interoperability Layer
Process Flow	1. Admin of University A executes the Request Cooperation sub-use case. 2. Admin of University A and Admin of University B negotiate a SLA. 3. SLA is accepted by both sides.
Alternative Scenarios	1. Negotiation could fail. In this case, no services can be exchanged in the future.

7 Smart Stadium

7.1 Overview

New technologies are creating a unique opportunity for innovative added value services in stadiums that may revolutionise how stadium managers understand their business, including the whole ecosystem of service providers around them, and providing an enhanced visitor experience at the same time that they can be key for stadium business sustainability. The Smart Stadium use case will focus on those services that will benefit most from the integration of different IoT technologies, and which will provide a clear benefit to both the stadium visitor and the stadium manager.

7.1.1 The Challenge

Stadiums are large and complex infrastructures with a very peculiar characteristic; typically they are intensively used for relatively short periods of time, while they remain quite inactive for the rest of the time. This means that all resources (human, services, technologies, etc) must be dimensioned to work smoothly and generate business during those peak times, while they do not generate unnecessary costs during the (long) inactivity periods. Challenges for Smart Stadium solutions can be analysed at two different levels: Business challenges and Technological challenges.

Business challenges

Several aspects of business operation with which stadium managers are concerned are:

- Revenues are today essentially coming from ticket sales, but in many cases ticket prices must be kept low to ensure high attendance. Hence, those revenues need to be complemented with sales of other services, most of them on-site since it is then when fans may be more open to extra expenditures.
- Stadium managers need a better knowledge of visitors profile; when, where and which activities they wish to perform, experiences to have, or services to consume, in order to provide visitors with an enhanced experience, which encourages them to continue using stadium services.
- Stadium managers also need to be in full control of everything that is happening at their stadium, all service providers (food, merchandising, etc), emergency services (security, health assistance. etc), maintenance services, own staff, other added value services (parking, lost&found), or even also journalists or VIPs. Even more, stadium managers also need information about the surroundings of the stadium and any other information that may be related to them, ranging from weather forecasts to traffic conditions, public transportation, nearby parking areas, or emergency and security public services.
- Stadium managers need integrated information, provided for example through dashboards, heat maps, or other graphical representations, which gives them a clear view on how the stadium infrastructure and services are performing, as well as the results of adopted measures.

Note that these challenges can easily be extended to further "stadium-like" scenarios, e.g., open-air festivals featuring concerts, theatre or opera performances. Here, additional business challenges may arise from the interaction between stadium manager and performers with their specific artistic requirements.

7.1.2 symbIoTe Innovations

The use case will showcase platform interoperability primarily within the application domain, assuming that the networks contributing with the necessary sensor data are Level 1 symbIoTe-compliant.

The innovations from the business perspective provided by this use case are the following:

- Give stadium manager total control and deep insight into brand-fan, fan-fan and fan-sponsor engagement that is optimized to drive sales, sponsorship revenue and higher quality brand relationships.
- Help stadium manager craft the customer experience, leverage fans investment in their brand, and engage them in the moment wherever they are.

The technical innovations provided by this use case are the following:

- Provision of a symbIoTe-enabled stadium app, which seamlessly integrates services from four underlying IoT platforms.
- Provision of indoor location services in a high-density environment.
- Multi-tenant services on top of several independent infrastructures.
- symbIoTe-enabled privacy and security services.

7.1.3 Objectives

The main objective of the Smart Stadium use case is to provide added value services to stadium visitors that:

- will improve the visitors' experience (*social objective*);
- will enable new services provided by third parties (mostly SMEs), thus creating an ecosystem around the stadium (*socio-economical objective*)
- will complement the stadium manager business model (*business objective*);
- will be easily replicable to other stadiums (*business objective*); and
- will take advantage of the stadium IoT infrastructure (*technological objective*).

7.2 High Level Definition

7.2.1 Application Level Use Case Diagram

The following application level diagram describes the Application Level of the Smart Stadium Use Case with all involved actors and Use cases, while the following four diagrams describe the four subsystems and system boundaries.

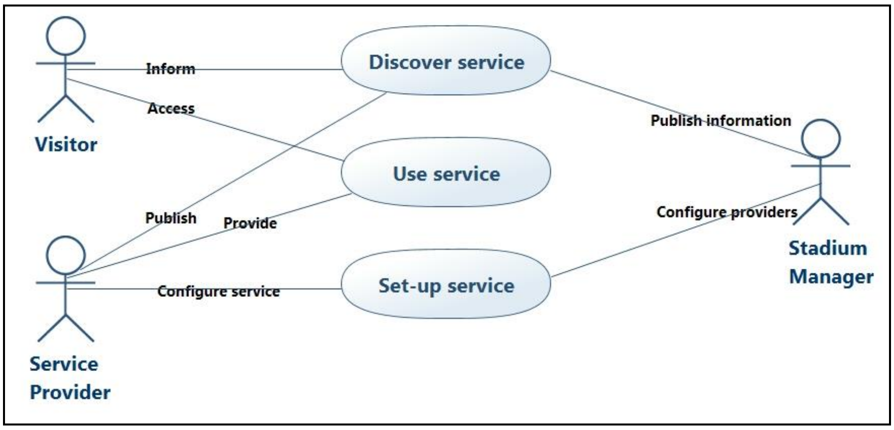

Figure 6: Application level Use Case Diagram for Smart Stadium

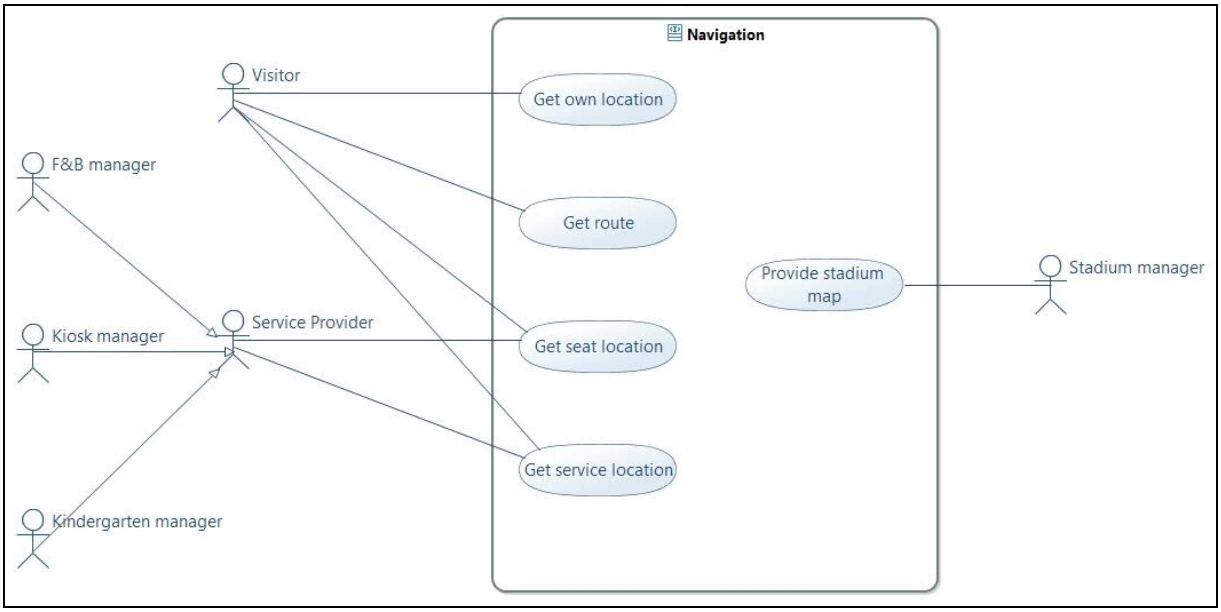

Figure 7: Details of the Navigation Use Case

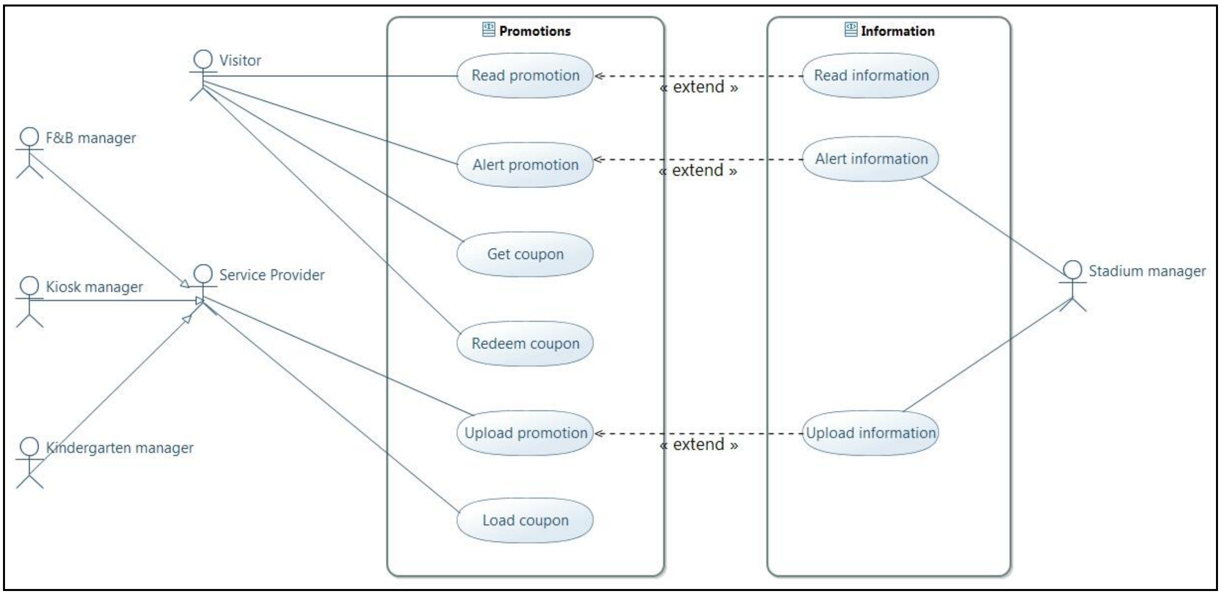

Figure 8: Promotion Use Case

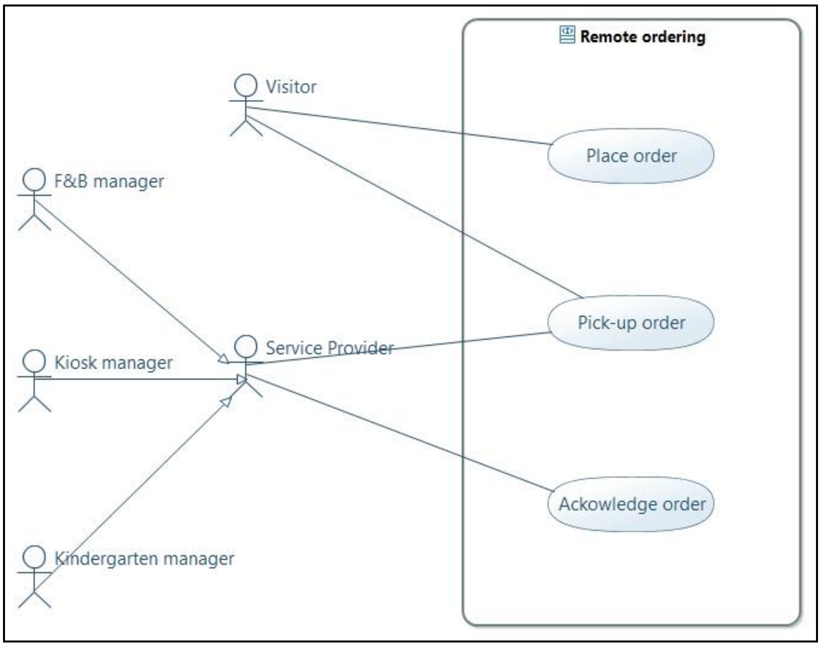

Figure 9: Remote Ordering Use Case

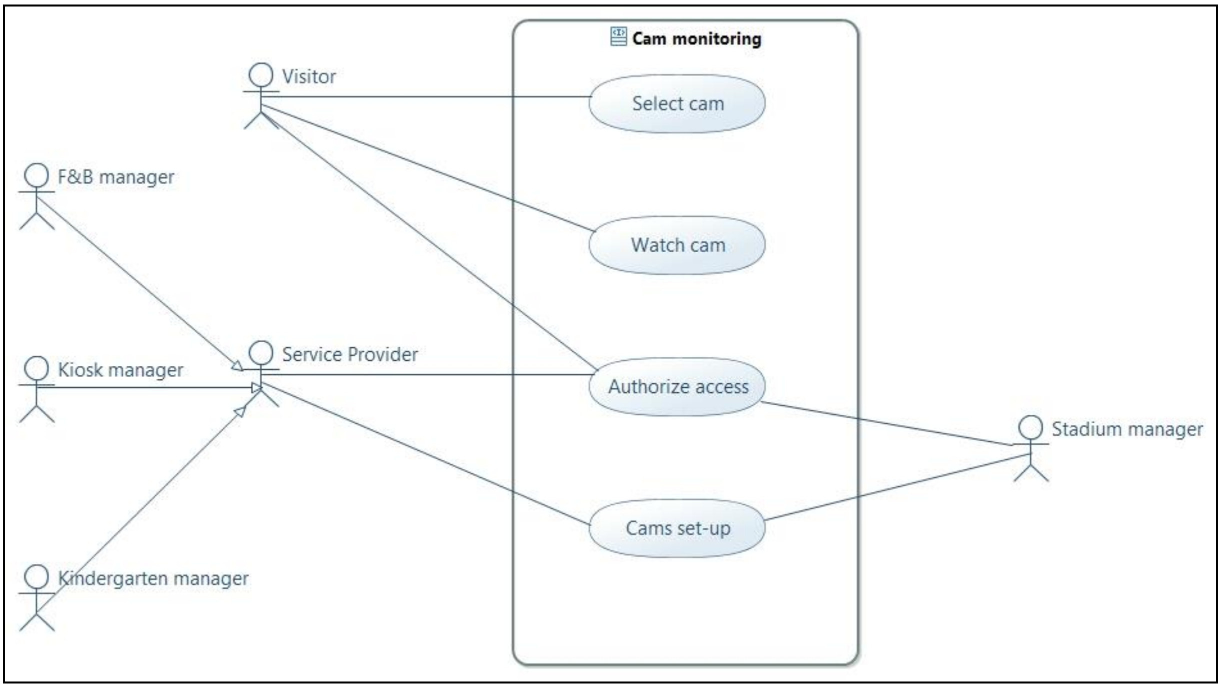

Figure 10: CCTV monitoring Use Case

7.2.2 Actors

Visitors

Visitors are the consumers of all the services provided either directly by the stadium manager, or by service providers licensed by the stadium manager. Most services will require that the visitor owns a smartphone and has downloaded the stadium applications, even if for some few services interaction may take place through other devices, such as interactive information panels.

Service Providers

Services providers provide complementary added value services to stadium visitors, such as food, kindergarten, kiosks, general information, etc. They may be third parties contracted by the stadium manager, or be directly provided by the stadium manager itself. Many different services are considered in Smart Stadium solutions, however for the purpose of symbIoTe, we will consider three different service providers:

- Food and Beverage moving carts
- Kiosks (souvenirs, magazines, newspapers, etc.)
- Kindergarten

Stadium Manager

The stadium manager has the responsibility of managing all stadium services, from the most basic ones (ticketing, access, security…), to the added value services. They setup the stadium infrastructure for service providers.

7.2.3 Subsystems

Description of each involved subsystem identified in the Use Case Diagram described on the used/provided functional aspects or features (no technical description or system architecture)

Navigation Platform

This subsystem provides all the indoor location functions with two different and independent approaches:

- “Push” approach. Location of an active mobile device, the device itself gets its own location, which may be voluntarily shared through the platform in order to get location-based added value services.
- “Pull” approach. Location of a passive object, such as for example a food & beverage moving cart, which has been equipped with a transmission device, for example a beacon, thus allowing the stadium infrastructure infer its location.

Promotion and Information Platform

This subsystem aims at interacting with visitors, providing them information coming from the stadium manager, promotions coming from services providers, or alerts coming from any of them. The interaction with the visitors may take place either directly on their smartphone through the stadium app, or on information screens or interactive panels placed throughout the stadium.

Remote Ordering Platform

The remote ordering subsystem aims at interacting with visitors through the stadium app, usually to place orders, and with service providers through specific devices located at their place. In some cases, visitors may also interact with those specific devices, for example taking advantage of specific services such as discount coupons redemption.

Cam Monitoring Platform

This subsystem allows visitors selecting and viewing video images from specific cams placed throughout the stadium. This service requires that security mechanisms are in place, such as authenticated access.

7.3 Sub-Use Cases

Today the city football team is playing a very important match in their large stadium against one of the most important teams in the country. The stadium is very crowded, in fact completely full, and the match organizers have contracted many added value service providers to complement their incomes by selling a large diversity of extra services to the stadium visitors, such as food and beverages moving carts, souvenir kiosks, information desks, advertising panels, checkrooms, kindergarten, etc. Most of these services are provided by third parties, and it is essential for them to reach as many customers as possible while optimising all their resources: they must look attractive to visitors, but at the same time, the service must be easy and quick to reach, and delivery must be very efficient. This service optimisation will be achieved thanks to the different IoT infrastructures installed in the stadium, perfectly integrated and powered through symbIoTe-enabled applications.

Family Smith composed of Tom (45) and Alice (42), their children John (10) and Mary (2), are all enthusiastic supporters of their city football team, and today they have come to the city stadium to watch the most important match of the year. In their way to their seats, they find several interactive panels with information about the stadium and many interesting offers. They discover that a kindergarten is available, and Tom uses the symbIoTe-enabled stadium app to know how to get there with Mary, while Alice receives a limited offer of T-shirts of their team from one of the souvenir kiosks, the first twenty ones at half price. She knows that John would love one of his favourite player, so she uses the stadium app to get an electronic coupon that guarantees the discount if redeemed in less than 30 minutes, and with the stadium app immediately purchases the T-shirt with the included discount. While Alice has got the coupon and then purchased the T-shirt, the kiosk owner has received the different orders in his symbIoTe-enabled retailer terminal and prepared John's T-shirt. Now they can go to the kiosk easy to just pick-up the T-shirt with no queues. The stadium app also allows them to find their seats, where they all meet again.

The match is very interesting, but when the first half is almost finished, they are starting to feel thirsty and hungry. They know that there are several moving beverage and food carts around the stadium, but do not know exactly where they can find them and will not have too much time during halftime, so they open their stadium app, look there for the closest cart, and order immediately their drinks and sandwiches. Their order is received at the retailer terminal of the beverage and food cart, where the cart owner acknowledges it, thus automatically generating an electronic ticket in Tom's app, which he will use to pick-up the order.

During the whole match, they have been monitoring what Mary is doing thanks to the cams available at the kindergarten, cams that can only be reached by kids' parents through the symbIoTe-enabled stadium app. Now that the match is over, they are informed through the stadium app that there is a long queue of parents in the kindergarten, so they first have a quick drink at the closest beverage cart before going to pick-up Mary at the kindergarten.

The sub-use cases that allow this scenario to play out are described in the following tables.

7.3.1 Set-up Service

Description	This sub-use case allows the stadium manager and the service providers to establish the initial conditions of all the added value services provided at the stadium.
Trigger	The stadium manager initiates the process, which is continued by service providers.
Pre-Conditions	**Pre-condition 1** All the required hardware devices are already in place: • Beacons and reception devices for the Navigation subsystem have been installed, powered and activated • Information and interactive displays for the Promotion and information subsystem have been connected to the stadium network • Remote ordering devices have been delivered to service providers and are connected to the stadium network • Stadium cams have been configured and connected to the stadium network
Involved Actors	Actors involved in the sub-use case are the stadium manager, who set-ups the stadium infrastructures, and the service providers, who set-up their specific services.
Sub-Use Cases Involved	Once this sub-use case is completed, the other sub-use cases will be activated.
Subsystems Involved	This sub-use case is going to access the four subsystems for their corresponding set-up: • Navigation. • Promotion and Information. • Remote ordering. • Cam monitoring.
Process Flow	1. The stadium manager set-ups the navigation system and provides the stadium map. 2. The stadium manager provides access to the Promotion and Information system to the service providers, and each service provider configures the system for their service. 3. The stadium manager provides access to the Remote ordering system to the service providers, and each service provider

	configures the system for their service. 4. The stadium manager set-ups the Cam monitoring system and assigns specific cams to the corresponding service providers, if it is the case. Each service provider configures each cam for their service.
Alternative Scenarios	None.

7.3.2 Discover Service

Description	This sub-use case focuses on how visitors find out the available services at the stadium, regardless they are first time visitors or regular visitors. For this purpose, visitors are given the tools that will allow them discovering all the added value services available at the stadium and that could be interesting for them, taking into account contextual information such as visitor and/or service location.
Trigger	Discovery may take place either at: • Visitor initiative: the visitor is actively looking for the service, either in the stadium app or in information panels, or • Service provider initiative: service provider announces the service through different means, such as alerts sent to the visitor smartphone, or adds showed at information panels.
Pre-Conditions	**Pre-condition 1** The stadium manager has set-up the stadium infrastructure, has given authorization to service providers and provided them with the means to access and use it. **Pre-condition 2** Service providers have conveniently set-up their services for visitors. **Pre-condition 3** Visitors have downloaded the stadium app in their smartphones (if not, they may still discover services on information panels, but most functions will not be available for them).
Involved Actors	Main actors are visitors, who discover the services, and service providers, who publish and offer those services. Additionally, as a particular case, the stadium manager can also publish general information related to the stadium.
Sub-Use Cases Involved	Once this sub-use case is completed, the visitor will have the option to proceed to the “Use service” sub-use case.
Subsystems	This sub-use case is going to access and use two subsystems:

Involved	• Promotion and Information. Service providers publish the promotions and stadium manager publishes the information that visitors will discover. • Navigation. Location information is used to contextualize service discovery and to complement it with routing information.
Process Flow	1. The service provider uploads a promotion to the promotions platform (or alternatively, the stadium manager uploads general information about the stadium) 2. If it is the case, the service provider may also load discount or offer coupons to the platform that will be put at the disposal of visitors (specific business rules may be applied to decide, select or establish the conditions under which those coupons will be available and to which specific visitors) 3. The visitor gets the promotion, but depending on the trigger, this may happen in two possible ways. 4. Visitor initiative. The visitor opens her stadium app on her smartphone, looks for the specific service and reads the promotion (or information). 5. Service provider initiative. The visitor receives an alert in her smartphone with the promotion (or information). The alert may be conditioned by the own visitor current location, the visitor seat location, and the service location. 6. The visitor gets and reads the promotion. If it is the case, the promotion may include potential discount coupons for the visitor, which are also shown to her.
Alternative Scenarios	If the visitor has not downloaded the stadium app on her smartphone, she still can discover services on the information panels spread throughout the stadium. In this case, step 3 in the previous flow becomes the following: 1. Visitor initiative. The visitor looks for the service in an interactive panel, where she reads the promotion (or information) 2. Service provider initiative. The visitor watches an advertisement in an information panel, where she reads the promotion (or information). The advertisement may be conditioned by the panel location and the service location.

7.3.3 Use Service

Description	This sub-use case provides visitors with the means and tools to access and complete the selected service with all potential options. As previously mentioned, many different services are considered in Smart Stadium solutions, but for the purpose of this sub-use case we will focus on three different services: Food and Beverage moving carts, Kiosks (souvenirs, magazines, newspapers, etc.), and Kindergarten.

Trigger	This sub-use case is started when a visitor who has discovered a service takes an action to select access or acquire the service.
Pre-Conditions	**Pre-condition 1** Visitors have downloaded the stadium app in their smartphones.
Involved Actors	The actors involved in this sub-use case are visitors, who access the services, and service providers, who provide those services.
Sub-Use Cases Involved	None.
Subsystems Involved	This sub-use case is going to access and use four subsystems: • Navigation. Provides the route to the selected service. • Promotion and Information. Visitors get promotions through coupons that can be redeem with the service provider when the service is used. • Remote ordering. Management of the full remote ordering cycle: order placement, acknowledgement, and finally pick-up of the acquired service or product. • Cam monitoring. Provision of the full cam service when required, including authentication and security.
Process Flow	The process flows for the three implemented added value services are: <u>Food and Beverage moving carts</u> 1. Visitor has selected in the stadium app a specific Food and Beverage cart (the closest one, the less busy…) 2. Visitor decides the product that wants to acquire and places an order 3. Food and Beverage manager receives the order in its remote ordering device, acknowledges it and prepares the product 4. Visitor receives the acknowledge to her order, gets the location of the cart and the route to get to it 5. Visitor gets to the cart, validates the order with her smartphone at the remote ordering device and pick-ups the product. <u>Kiosks</u> 1. Visitor has selected a promotion in the stadium app and has got the discount coupon of that promotion 2. Visitor decides to immediately acquire the product, so places a remote order of the product and redeems the coupon in order to get the discount 3. Kiosk manager receives the order in its remote ordering device, acknowledges it and prepares the product 4. Visitor receives the acknowledge from the kiosk, gets its

	location and route to get to it 5. Visitor gets to the kiosk, validates the order with her smartphone at the remote ordering device and pick-ups the product. <u>Kindergarten</u> 1. Visitor has decided to use the kindergarten service for her child and receives the route to the kindergarten of the stadium. 2. Visitor contracts the service and gets from the kindergarten manager an authorization on her smartphone to access the kindergarten cams during her stay at the stadium. 3. The stadium manager is informed that the visitor has been granted access to kindergarten cams. 4. During the stay at the stadium, visitor selects on her smartphone the kindergarten cam that wants to watch, the smartphone opens an encrypted channel and starts receiving in streaming the images from that camera in real-time. 5. When visitor gets back to the kindergarten and pick-ups her child, the kindergarten manager revokes the authorization to access the kindergarten cams
Alternative Scenarios	1. The “Kiosk” scenario is in fact the same scenario as the “Food and beverage” one, but including discount coupons. 2. In the case of open-air concerts or festivals, such services could also relate directly to the performer(s) and/or performance, like, for instance, providing (personalized) subtitles on the smartphones of the audience.

8 Smart Yachting

There are about 5000 motor yachts all over the European part of the Mediterranean in the class over 24 meters length, and approximately 3 million below 24 meters length. The port is an organization/authority and public space where the demand/offer within the supply chain of the boating/marine sector are executed for two key processes

- the upkeep, supply and refit, generally issued by the boats and possibly based on monitoring data automatically collected by on-board systems
- the assignment of mooring spaces along with local (port) localization information (distances, coordinates, depths, etc.)

Many observers and qualified professionals in the field agree that it is crucial to implement smart system that can automate and simplify business decisions in order to simplify and reduce costs for the different processes.

symbIoTe idea is to automate the information processes between the boat and the mainland, and allow the user on a boat to automatically identify the territorial subjects (companies) to address the needs of e.g. , edge detecting, and – on the other hand – allow the port authority to automatically send various territory information to the boat e.g., during the mooring phase.

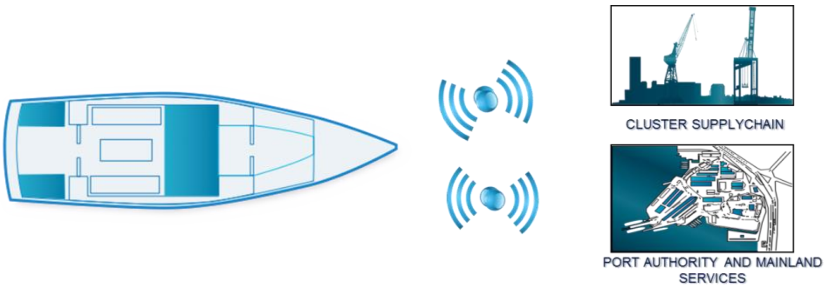

Figure 11: Smart Yachting Use Case Applications

From an IoT integration perspective, this scenario represents a critical context of smart objects interoperation. This is typically solved with custom system-to-system interfacing, which is generally , limited in the extent of applicability to the multiple choices of control platforms on board and on the mainland(e.g., to interact/integrate information kiosks, multiple localization sensors in the port area, etc.).

8.1 Overview

The Smart Yachting idea aims to automate the information processes between a boat and the mainland, specifically, the links between mega yachts, the supply companies of the yachting cluster and port authorities' bureaucracy

8.1.1 The Challenge

The Smart Yachting use case will automate the information processes between a boat and the mainland, to allow users on a boat to identify automatically the territorial subjects (companies) to address the needs for, e.g., edge detection, and – on the other hand – allow the port authority to automatically send various territory information to the boat, e.g., during the mooring phase. From an IoT integration perspective, this scenario represents a critical context for smart object interoperability, which is typically solved with custom system-to-system interfaces. Therefore, the main challenges involved in the Smart Yachting are the following:

- Development of automatic mechanisms for identifying faults and maintenance conditions on board
- Implement open mechanisms for communicating request for upkeep, supply and refit to the port business process platform, in order to activate the supply value-chain on the territory
- Implement open mechanisms for communicating territory information from the mainland to the boat in the mooring phase, and present enriched information on multiple visual devices available on board as part of a Smart Residence product (TV screens, smartphones, etc.)
- Maintain and present different types of context information on different devices (e.g., updated public port information on kiosks, streams from Closed Circuit Television - CCTV, environment sensors, etc.)

8.1.2 symbIoTe Innovations

The use of advanced technologies that in the use of IOT see their natural completion is increasingly popular in the equipment of almost all types of pleasure vessels.It goes hand in hand with the development and digitization of mainland systems.

The connection between these two worlds is typically solved with custom system-to-system interfaces. State of the art approach is limited and cannot be applied to the multiple control platforms on board and in the port area.

An environment will be made available through symbIoTe, which will set the standard for interoperability between airborne systems and ground systems that will simplify:

- the integration between these two worlds,
- the immediate use of information and services and the implementation of Smart eco-systems in the yachting market,
- the communication and integration with other smart systems.

8.1.3 Objectives

Goal: Automate the information processes between yachts and mainland

- User's setting follow-me from the smart yacht to the smart home through the smart port
- Enhanced information for mooring services from Port Authorities
- Automated supply chain activation for refitting, maintenance and yacht services
- Context-driven information on different devices (e.g., updated public port information on kiosks, streams from TVCC, environment sensors, etc.)

From a technological point of view, the main objective is to demonstrate how the symbIoTe approach can support the realization of smart eco-system in the yachting market that can boost the innovation of European marinas in the support interoperable infrastructure on-board and mainland systems. From an economic vision, the main objective is to assess the feasibility an important asset for competitivety of the sector.

8.2 High Level Definition

8.2.1 Application Level Use Case Diagram

High level diagram of the Application Level Use Case with all involved actors, subsystems and system is given in the following two figures.

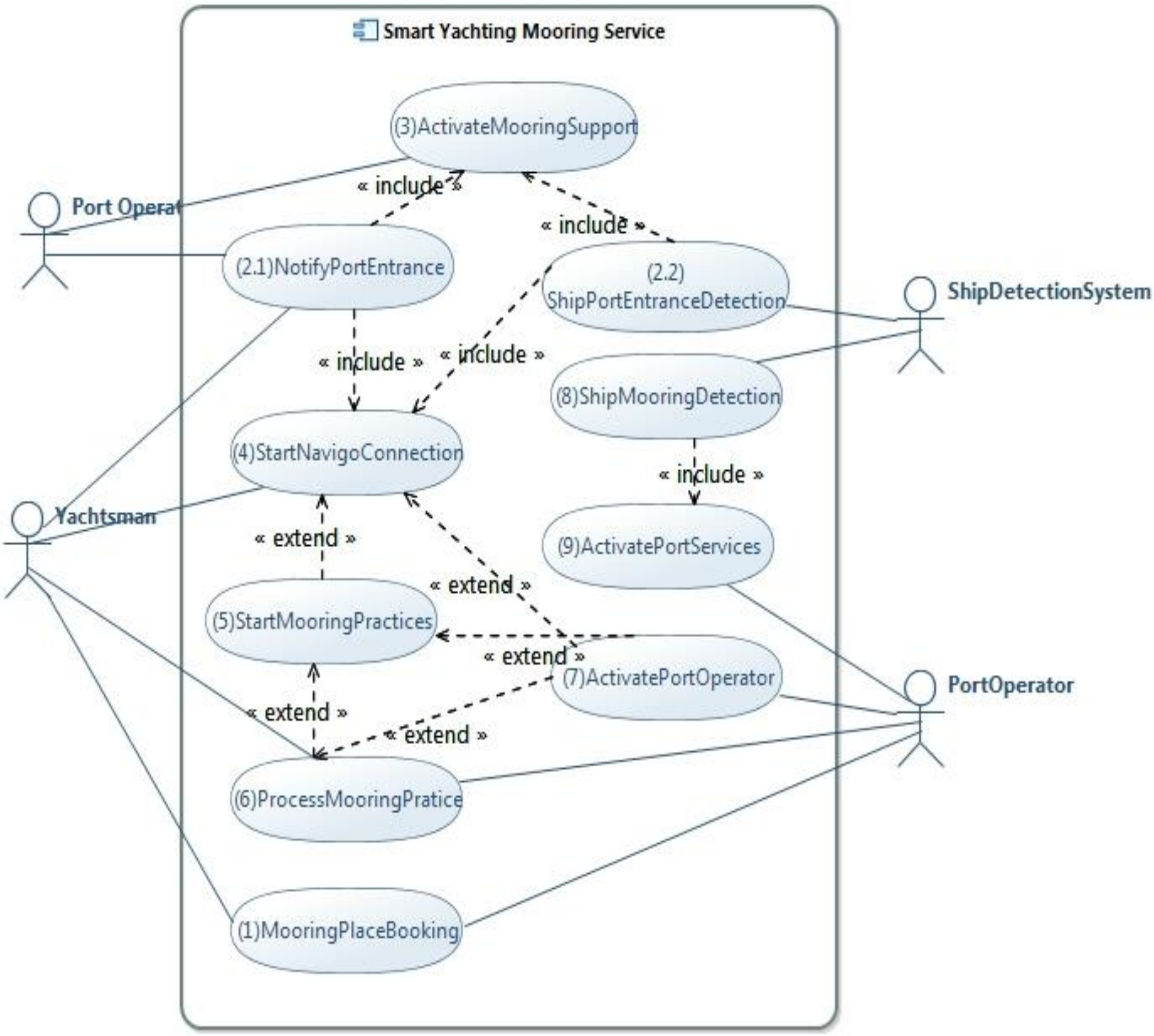

Figure 12: Mooring Use Case

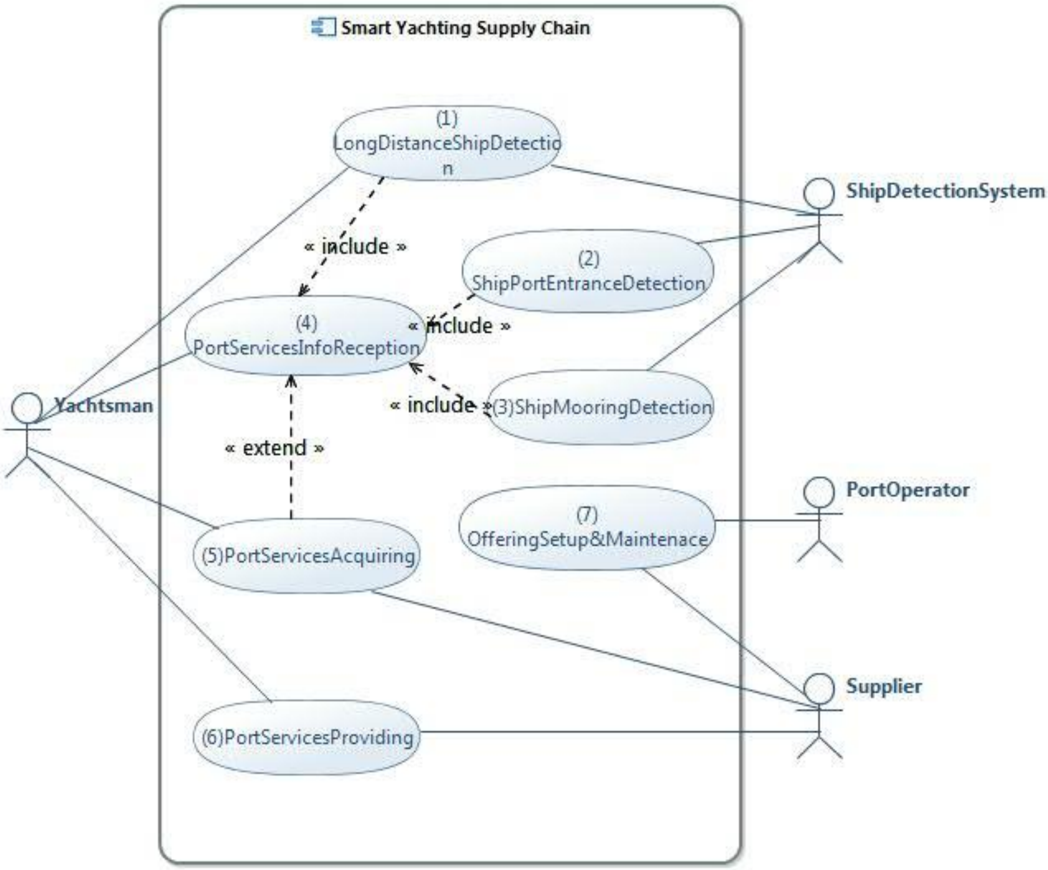

Figure 13: Supply Chain Use Case

8.2.2 Actors

Yachtsman

A person delegate to access the console of the on board system. Yachtsman can be the shipmaster, the skipper, the ship-owner or any sailor in charge. He interacts with the on board system, with the website of the port system in order to evaluate, request or buy supply services.

Supplier

An employee of a supplier firm that has published one or more offerings. Supplier interacts with port system through a web interface in order to provide support or perform specific activities during the supplying process.

Port Operator

A port employee delegate to manage or perform specific activities related to the publishing of the supplier's offering or to the operation of the system.

Ship Detection System

A subsystem, connected to port system, deputed to detect ships as they approach the port within a defined long distance range, at the port entrance and at quay mooring moments. As a ship is detected, the subsystem triggers the start of the automatic processes relevant to the event detected.

8.2.3 Subsystems

Ship Detection System

A subsystem implementing a wide range detection functionality for the detection of ships as they approach the port within a defined long distance range, mid-range detection functionality at the port entrance and a proximity detection functionality at each quay place that are connected to the port system built on Navigo Digitale. Those functionalities could be implemented with algorithms based on the availability of vessel's geo-referencing information and on the availability of an active connection between Navigo Digitale and Symphony through internet, or by other detection solutions relying on identification and positioning sensors of which vessels must be equipped.

8.3 Sub-Use Cases

The Smart Yachting use case will automate the information processes between a vessel and the mainland, to allow users on a vessel to identify automatically the territorial subjects (companies) to address the needs of boat owners on one hand, and on the other, allow the port authority to automatically send various territory information to the vessel. From an IoT integration perspective, this scenario represents a critical context for smart object interoperability, which is typically solved with custom system-to-system interfaces.

The port is an organization/authority and public space where the demand/offer within the supply chain of the vesseling/marine sector are executed for two key processes:

- the assignment of mooring spaces along with local (port) localization information (distances, coordinates, depths, etc.).
- the upkeep, supply and refit, generally issued by the vessels and possibly based on monitoring data automatically collected by on-board systems.

The following sub-use cases cover the process described above, for both scenarios, i.e., the support for mooring of the ship/boat and the detection and identification of the needs of service offers to the ship/boat.

8.3.1 Mooring Place Booking

Description	Before entering the port, the yachtsman contact the port to book the mooring place for his vessel in the desired period. The vessel's identification data are submitted, and the requirements and authorization for the exchange of data needed by the automatic docking procedure are agreed. Navigo Digitale makes available a specific mobile app or a page on the website of the port in order to allow the booking procedure online. If the booking is accomplished offline (e.g., by phone or radio), the port operator who receives the call will carry out the booking procedure built in the Navigo Digitale port system through his console interface.
Trigger	The yachtsman makes a booking.

Pre-Conditions	**Pre-condition 1** In order to accomplish the booking online an internet connection must be made available on the vessel, and a dedicated webpage on the port's website or a specific mobile app. **Pre-condition 2** In order to accomplish the booking offline**,** a booking procedure built in the Navigo Digitale port system must be made available.
Involved Actors	Yachtsman: contacts the port to book the mooring place for his vessel in the desired period. Port Operator: receives the call, in case of offline booking, and carry out the booking procedure built in Navigo Digitale.
Sub-Use Cases Involved	None.
Subsystems Involved	None.
Process Flow	1. The yachtsman accesses the specific mobile app or the website of the port through the console of the vessel's board system Symphony and complete all the steps required to fulfil the booking procedure online. During this process, the ship identification code and other ship's identification data are submitted automatically or manually to Navigo Digitale. 2. The yachtsman receives an email with a confirmation code
Alternative Scenarios	1. The yachtsman contacts the port by phone or radio. The port operator who receives the call will carry out the booking procedure built in Navigo Digitale asking for the required ship's identification data. On positive completion of the booking procedure, the operator communicates to the yachtsman a confirmation code.

8.3.2 Port Entrance Notifying

Description	If the vessel is not equipped with a positioning and identification system compliant with the Ship Detection System of the port, the yachtsman must communicate to the port, online or offline, his port entrance. The vessel is identified and the arrival notification, along with the vessel identification data, are recorded on Navigo Digitale (by the yachtsman or the port operator). The automatic procedures implementing the sub-use cases "Navigo Connection Initiation" and "Mooring Support Activation" are then activated.
Trigger	The yachtsman communicates the vessel's port entrance.

Pre-Conditions	**Pre-condition 1** The vessel is not equipped with a positioning and identification system compliant with the Ship Detection System of the port. **Pre-condition 2** In order to accomplish the port entrance notification online, an internet connection on the vessel must be made available, and a dedicated webpage on the port's website or a specific mobile app. **Pre-condition 3** In order to accomplish the port entrance notification offline, an entrance notification procedure built in the Navigo Digitale port system, must be made available.
Involved Actors	Yachtsman: contacts the port to communicate the vessel port entrance. Port Operator: receives the call, in case of offline communication, and carries out the vessel entrance procedure built in Navigo Digitale.
Sub-Use Cases Involved	Navigo Connection Initiation Mooring Support Activation
Subsystems Involved	None.
Process Flow	1. The yachtsman communicates the vessel port entrance by submitting his booking confirmation code through the specific mobile app or a specific page on the website of the port. 2. Once the arrival notification is recorded on Navigo Digitale, the vessel is identified and the automatic procedures implementing the sub-use cases "Navigo Connection Initiation" and "Mooring Support Activation" are activated.
Alternative Scenarios	1. The yachtsman contacts the port by phone or radio and communicates the vessel port entrance along with its booking confirmation code. The port operator who receives the call will carry out the vessel port entrance procedure built in Navigo Digitale.

8.3.3 Port Entrance Ship Detection

Description	The Ship Detection System detects the vessel at the port entrance, the vessel is identified and the ship identification code provided is recorded on Navigo Digitale. Then the automatic procedures implementing the sub-use cases "Navigo Connection Initiation" and "Mooring Support Activation" are activated.
Trigger	The Ship Detection System detects a vessel when it enters in its detection range.

Pre-Conditions	**Pre-condition 1** An internet connection must be available on the vessel. **Pre-condition 2** The vessel must to be equipped with a compliant positioning and identification system in order to allow automatic port entrance detection.
Involved Actors	Ship Detection System: detects the vessels at the port entrance.
Sub-Use Cases Involved	Navigo Connection Initiation Mooring Support Activation
Subsystems Involved	Ship Detection System
Process Flow	1. The Ship Detection System detects the vessels at the port entrance, the vessel is identified and the ship identification code provided is recorded on Navigo Digitale. Then the automatic procedures implementing the sub-use cases "Navigo Connection Initiation" and "Mooring Support Activation" are activated
Alternative Scenarios	None.

8.3.4 Mooring Support Activation

Description	The mooring support team is alerted in order to help the yachtsman to complete the mooring phase successfully and without problems. The vessel's identification data are also provided.
Trigger	Triggered automatically by Navigo Digitale during the execution of the "Port Entrance Notifying" or "Port Entrance Ship Detection" sub-use cases.
Pre-Conditions	None.
Involved Actors	Port Operator: receive the alert
Sub-Use Cases Involved	None.
Subsystems Involved	None.
Process Flow	1. Navigo Digitale alerts the mooring support team in order to help the yachtsman to complete the mooring phase successfully and without problems. The vessel's identification data are also provided.
Alternative Scenarios	None

8.3.5 Navigo Connection Initiation

Description	It is checked if the vessel corresponding to the code detected by the Ship Detection System, or otherwise notified, is already connected to the Internet and if Navigo Digitale is connected to the vessel's board system Symphony. If Navigo Digitale and Symphony are connected, the automatic procedure implementing the sub-use case "Mooring Practice Initiation" is activated. Otherwise, the relevant exceptions are processed by the activation of a port operator.
Trigger	Triggered by Ship Detection System when the vessels is detected at the port entrance
Pre-Conditions	**Pre-condition 1** A vessel is detected by the Ship Detection System at the moment of its port entrance or the vessel's port entrance has been notified to the port system Navigo Digitale through alternative channels. **Pre-condition 2** An internet connection must be available on the vessel. **Pre-condition 3** The vessel must to be equipped with a compliant positioning and identification system in order to allow automatic port entrance detection.
Involved Actors	Yachtsman: verifies internet connection activation and eventually starts the connection procedure manually in the case that the connection of Symphony with Navigo Digitale has failed its automatic activation. Port Operator: is alerted in case of failure.
Sub-Use Cases Involved	Mooring Practice Initiation Port Operator Activation
Subsystems Involved	None.
Process Flow	1. If the vessel is already connected to the Internet, the connection of Navigo Digitale with the vessel's board system Symphony is checked. If Navigo Digitale and Symphony are not yet connected, it is activated the automatic setup of the connection between the two systems. 2. If Navigo Digitale is connected to the vessel's board system Symphony of the vessel corresponding to the code detected by the Ship Detection System, it is activated the automatic procedure implementing the "Mooring Practice Initiation" sub-use case. 3. Otherwise, the automatic procedure implementing the "Port Operator Activation" sub-use case is activated.
Alternative Scenarios	1. In the case that the connection of Symphony with Navigo Digitale has failed its automatic activation, the yachtsman is alerted by a port operator in order to verify the internet connection activation

	and eventually start the connection procedure manually by using the Symphony console interface.

8.3.6 Mooring Practice Initiation

Description	Navigo Digitale acquires automatically all the needed documents and information from the vessel on board system Symphony and activates the workflow to process the administrative mooring practice. If the documental acquisition fails, the relevant exception are processed by the activation of a port operator.
Trigger	Triggered automatically by Navigo Digitale after the positive checking of connection with Symphony.
Pre-Conditions	**Pre-condition 1** An internet connection must be available on the vessel. **Pre-condition 2** Navigo Digitale and Symphony are connected.
Involved Actors	Yachtsman: verifies documents availability and eventually start the document transfer procedure manually in the case that the documental acquisition has failed its automatic activation. Port Operator: is alerted in case of failure.
Sub-Use Cases Involved	Port Operator Activation
Subsystems Involved	None.
Process Flow	1. Navigo Digitale acquires automatically all the needed documents and information from the vessel on board system Symphony and performs a first check on the documents acquired. 2. If the check is successfully passed, the workflow to process the administrative mooring practice implemented by the "Mooring Practice Process" sub-use case is activated. Otherwise, the automatic procedure implementing the "Port Operator Activation" sub-use case is activated.
Alternative Scenarios	1. If the documents acquisition or the check on the acquired documents fails, a port operator is activated in order to verify with the yachtsman the possibility to complete the online document acquisition manually or to instruct him to issue the administrative mooring practice offline.

8.3.7 Mooring Practice Process

Description	This sub-use case implements the workflow needed to process the administrative mooring practice. The administrative operators in charge of the procedure processing interact with the workflow implemented on Navigo Digitale.
Trigger	Triggered automatically by Navigo Digitale during the execution of the "Mooring Practice Initiation" sub-use case.
Pre-Conditions	**Pre-condition 1** An internet connection must be available on the vessel. **Pre-condition 2** The documental acquisition ended successfully.
Involved Actors	Yachtsman: is notified about the positive or negative conclusion of the administrative mooring practice. Port Operator: the administrative port operators performs all the steps of the mooring practice workflow; an operative port operator is involved in case of negative conclusion in order to instruct the yachtsman to complete the practice offline.
Sub-Use Cases Involved	Port Operator Activation
Subsystems Involved	None.
Process Flow	1. Navigo Digitale implements the entire workflow step needed to carry out the administrative mooring practice. The administrative operators in charge of the procedure processing interact with the workflow implemented on Navigo Digitale. 2. In case of failure, the automatic procedure is activated which implements the "Port Operator Activation" sub-use case in order to instruct the yachtsman to complete the practice offline
Alternative Scenarios	1. If the workflow implementing the administrative mooring practice cannot be completed, an operative port operator is activated in order to instructs the yachtsman to issue the administrative mooring practice offline

8.3.8 Port Operator Activation

Description	This sub-use case checks the conditions for which has been triggered and issues an alert to a port operator along with the relevant instructions and information.
Trigger	Triggered automatically by Navigo Digitale in the following cases: • By "Navigo Connection Initiation" if the connection of Symphony with Navigo Digitale has failed its automatic activation; • By "Mooring Practice Initiation" if the automatic documents

	acquisitions fails or if the administrative mooring practice cannot be activated; • By "Mooring Practice Process" if the administrative mooring practice cannot be completed;
Pre-Conditions	**Pre-condition 1** Some failure in the automatic processes flow. **Pre-condition 2** An internet connection must be available on the vessel.
Involved Actors	Port operator: in order to perform the required action.
Sub-Use Cases Involved	None.
Subsystems Involved	None.
Process Flow	1. In the case where the connection of Symphony with Navigo Digitale has failed its automatic activation a port operator is alerted in order to contact the yachtsman and ask him to verify the vessel internet connection activation and eventually start the connection procedure manually by using the Symphony console interface. Otherwise: 2. In the case that the documents acquisition or the check on the acquired documents needed to activate the administrative mooring practice has failed, a port operator is alerted in order to verify with the yachtsman the possibility to complete the online document acquisition manually or to instruct him to issue the administrative mooring practice offline. Otherwise: 3. In the case that the administrative mooring practice cannot be completed, a port operator is alerted in order to instructs him to issue the administrative mooring practice offline.
Alternative Scenarios	None.

8.3.9 Mooring Ship Detection

Description	The Ship Detection System detects the vessel at the mooring place, the vessel is identified and the automatic procedures implementing the sub-use case "Mooring Services Activation" is activated.
Trigger	Triggered by the Ship Detection System when a vessel is detected at the mooring place

Pre-Conditions	**Pre-condition 1** An internet connection must be available on the vessel. **Pre-condition 2** The vessel must to be equipped with a compliant positioning and identification system in order to allow automatic detection at the mooring place.
Involved Actors	Ship Detection System: detects the vessels at the mooring place
Sub-Use Cases Involved	Port Services Activation
Subsystems Involved	Ship Detection System
Process Flow	1. The Ship Detection System detects the vessels at the mooring place, the vessel is identified and the automatic procedures implementing the sub-use case "Mooring Services Activation" is activated
Alternative Scenarios	None

8.3.10 Mooring Services Activation

Description	Navigo Digitale acquires automatically, from the vessel on board system Symphony, information regarding the vessel requirements for the activation of the mooring services and makes that information available to port operators.
Trigger	Triggered automatically by Navigo Digitale during the execution of the "Ship Mooring Detection" sub-use case.
Pre-Conditions	**Pre-condition 1** An internet connection must be available on the vessel. **Pre-condition 2** The vessel must to be equipped with a compliant positioning and identification system in order to allow automatic detection at the mooring place. **Pre-condition 3** A vessel is detected at the mooring place. **Pre-condition 4** Navigo Digitale and Symphony are connected.
Involved Actors	Port Operator: access vessel's information relevant to mooring services
Sub-Use Cases	None.

Involved	
Subsystems Involved	None.
Process Flow	1. Navigo Digitale acquires automatically, from the vessel on board system Symphony, information regarding the vessel requirements for the activation of the mooring services and makes those information available to port operators
Alternative Scenarios	None.

8.3.11 Long Distance Ship Detection

Description	The Ship Detection System detects the vessel when it approaches the port within a defined long distance range and sends information regarding the port's facilities and suppliers to the vessel's Symphony system by activating the automatic procedure implementing the "Port Services Info Reception" sub-use case.
Trigger	Triggered by the Ship Detection System when a vessel approaches the port within a defined long distance range
Pre-Conditions	**Pre-condition 1** An internet connection must be available on the vessel. **Pre-condition 2** The vessel must be equipped with a compliant positioning and identification system in order to provide geo-referencing information.
Involved Actors	Ship Detection System: detects the vessels when it approaches the port within a defined long distance range. Yachtsman: activates the connection between Navigo Digitale and Symphony through internet
Sub-Use Cases Involved	Port Services Info Reception
Subsystems Involved	Ship Detection System
Process Flow	1. The Yachtsman activates the connection between Navigo Digitale and Symphony through internet and the Ship Detection System detects the vessel when it approaches the port within a defined long distance range. 2. Navigo Digitale acquires from Symphony information relevant to the vessel, and sends information regarding the port's facilities and suppliers to the vessel's Symphony system by activating the automatic procedure implementing the "Port Services Info Reception" sub-use case
Alternative Scenarios	None.

8.3.12 Port Entrance Ship Detection

Description	The Ship Detection System detects the vessel at the port entrance and sends information regarding the port's facilities and suppliers to the vessel's Symphony system by activating the automatic procedure implementing the "Port Services Info Reception" sub-use case.
Trigger	Triggered by the Ship Detection System when a vessel enters its detection range.
Pre-Conditions	**Pre-condition 1** An internet connection must be available on the vessel for active connection between Navigo Digitale and Symphony. **Pre-condition 2** The vessel must be equipped with a compliant positioning and identification system in order to provide geo-referencing information.
Involved Actors	Ship Detection System: detects the vessel at the port entrance
Sub-Use Cases Involved	Port Services Info Reception
Subsystems Involved	Ship Detection System
Process Flow	1. The Ship Detection System detects the vessel at the port entrance and sends information regarding the port's facilities and suppliers to the vessel's Symphony system by activating the automatic procedure implementing the "Port Services Info Reception" use case.
Alternative Scenarios	None.

8.3.13 Ship Mooring Detection

Description	The Ship Detection System detects the vessel at the mooring place and sends information regarding the port's facilities and suppliers to the vessel's Symphony system by activating the automatic procedure implementing the "Port Services Info Reception" use case. In this case, Navigo Digitale knows that the vessel is docked, and the information sent comprise territorial promotion.
Trigger	Triggered by the Ship Detection System when a vessel is detected at the mooring place.
Pre-Conditions	**Pre-condition 1** An internet connection must be available on the vessel for an active connection between Navigo Digitale and Symphony. **Pre-condition 2** The vessel must be equipped with a compliant positioning and identification system in order to provide geo-referencing information.

Involved Actors	Ship Detection System: detects the vessel at the mooring place.
Sub-Use Cases Involved	Port Services Info Reception
Subsystems Involved	Ship Detection System
Process Flow	1. The Ship Detection System detects the vessel at the mooring place and sends information regarding the port's facilities and suppliers to the vessel's Symphony system by activating the automatic procedure implementing the "Port Services Info Reception" sub-use case. In this case Navigo Digitale knows that the vessel is docked, and the information sent comprise territorial promotion
Alternative Scenarios	None.

8.3.14 Port Services Info Reception

Description	Navigo Digitale sends information regarding the port's facilities and suppliers to the vessel's Symphony system. The information sent is made available through the Symphony console and to all the mobile devices connected to board local network through a specific app. The Yachtsman can read the received information and Symphony sends a receipt acknowledge to Navigo Digitale. If the Yachtsman decides to ask for a quotation of any of the promoted services, the automatic procedure implementing the "Port Services Acquisition" sub-use case is activated.
Trigger	Triggered automatically by Navigo Digitale during the execution of the Ship Detection sub-use cases.
Pre-Conditions	**Pre-condition 1** An internet connection must be available on the vessel for an active connection between Navigo Digitale and Symphony. **Pre-condition 2** The vessel must be equipped with a compliant positioning and identification system in order to provide geo-referencing information.
Involved Actors	Yachtsman: reads the received information regarding the port's facilities and suppliers and eventually ask for a quotation
Sub-Use Cases Involved	Port Services Acquisition
Subsystems Involved	None.
Process Flow	1. Navigo Digitale sends information regarding the port's facilities and suppliers to the vessel's Symphony system. The information sent is made available through the Symphony console and to all the mobile devices connected to board local network through a specific

	app. 2. The Yachtsman can read the received information and Symphony sends a receipt acknowledge to Navigo Digitale. If the Yachtsman decides to acquire some of the promoted services it is activated the automatic procedure implementing the "Port Services Acquisition" sub-use case. Otherwise if the Yachtsman doesn't read the provided information or do not decides to acquire any service the process stops at this stage
Alternative Scenarios	None.

8.3.15 Port Services Acquisition

Description	The Yachtsman compiles one or more requests of service following the workflow proposed by Navigo Digitale. The vessel's Symphony system can pre-fill automatically some of the fields of the service request form with information from the board sensors. If the filled electronic form request is confirmed, the services are booked/purchased. Navigo Digitale receives the filled service request form and forwards the requests to the relevant suppliers.
Trigger	Triggered automatically by Navigo Digitale during the execution of the "Port Services Info Reception" sub-use case.
Pre-Conditions	**Pre-condition 1** An internet connection must be available on the vessel. **Pre-condition 2** Navigo Digitale and Symphony are connected.
Involved Actors	Yachtsman: compiles one or more requests for service following the workflow proposed by Navigo Digitale and eventually confirms the filled electronic form request. Supplier: receives the purchasing orders along with the relevant vessel's information needed to provide the supplies.
Sub-Use Cases Involved	None.
Subsystems Involved	None.
Process Flow	1. The Yachtsman compiles one or more requests for service following the workflow proposed by Navigo Digitale. 2. The vessel's Symphony system can pre-fill automatically some of the fields of the service request form with information from the board sensors. If the filled electronic form request is confirmed, the services are booked/purchased. 3. Navigo Digitale receives the filled services request form and forwards the requests to the relevant suppliers. In the case that the

	Yachtsman doesn't confirm the filled electronic form the process stops at this stage
Alternative Scenarios	None.

8.3.16 Port Services Provision

Description	The Supplier communicates to the Yachtsman the order confirmation along with other information relevant to the supply. If the Supplier during the supply provisioning need further information can acquire such information through Navigo Digitale. The information required can be automatically provided by Symphony or can be provided by the Yachtsman following the workflow proposed by Navigo Digitale. When the supplies have been provided and completed, the relevant documentation is automatically exchanged between Symphony and Navigo Digitale and a notification is sent to the Yachtsman. In certain cases, Symphony can perform a check on the vessels components if those have been involved in the supply.
Trigger	Triggered manually by the Supplier
Pre-Conditions	**Pre-condition 1** An internet connection must be available on the vessel for an active connection between Navigo Digitale and Symphony. **Pre-condition 2** The Yachtsman has confirmed a purchasing order. **Pre-condition 3** Some further information are required in order to provide the supply.
Involved Actors	Supplier: activates the request of information. Yachtsman: Receives notifications and eventually follows the workflow proposed by Navigo Digitale in order to provide the requested information.
Sub-Use Cases Involved	None.
Subsystems Involved	None.
Process Flow	1. The Supplier communicates to the Yachtsman the order confirmation along with other information relevant to the supply. If the Supplier during the supply provisioning need further information can acquire such information through Navigo Digitale. 2. The information required can be automatically provided by Symphony or can be provided by the Yachtsman following the workflow proposed by Navigo Digitale. 3. When the supplies have been provided and completed, the relevant documentation is automatically exchanged between Symphony and

	Navigo Digitale and a notification is sent to the Yachtsman. 4. In certain cases Symphony can perform a check on the vessels components if those have been involved in the supply
Alternative Scenarios	None.

8.3.17 Offering Setup & Maintenance

Description	Navigo Digitale provides to the Supplier the interfaces and workflows needed to publish or maintains its offering on Navigo Digitale. The Supplier and the Port operator access Navigo Digitale in order to publish or modify an offering.
Trigger	Triggered manually by the Supplier or by the Port Operator.
Pre-Conditions	**Pre-condition 1** An offering has to be published or modified on Navigo Digitale. **Pre-condition 2** Navigo Digitale makes available specific interfaces and workflows to publish or maintain supplier's offering.
Involved Actors	Supplier: access the interfaces and workflows needed to publish or maintain its offering on Navigo Digitale. Port Operator: access the interfaces and workflows needed to publish or maintain supplier's offering on Navigo Digitale or to perform system administration activities.
Sub-Use Cases Involved	None.
Subsystems Involved	None.
Process Flow	1. The Supplier access Navigo Digitale interfaces and workflows in order to publish or maintains its offering on Navigo Digitale. 2. The Port operator access Navigo Digitale interfaces and workflows in order to publish or maintains supplier's offering on Navigo Digitale, or to perform system administration activities.
Alternative Scenarios	None.

9 Conclusions

The Internet has already evolved into a highly innovative and competitive marketplace for applications, services, and content. Due to the widespread access to the Internet and availability of mobile devices, new requirements have emerged due to the growing number of broadband users worldwide. The users are in demand of novel applications that simplify their daily activities in various situations and environments, being that of a smart home or accessing services when visiting shopping malls and stadiums. Moreover, the lower entry barriers for non-technical users to become content and service providers, and the available IoT platforms and services on the market have also added to the list of requirements and demands.

All these requirements pose new challenges and call for a middleware solution – **symbIoTe** – to offer services (e.g., tracking and correlating health data from different IoT platforms in a smart home environment) and interface points for different use cases, application fields, and services.

In this deliverable D1.1 “Initial Report on Use Cases”, five use cases have been identified and described, with the purpose of designing a middleware to link as many services and IoT areas together as possible. These use cases cover diverse application fields and different IoT installations and platforms, while targeting scenarios in both indoor and outdoor environments in an effort of assisting people in their daily activities.

In the Smart Residence use case, symbIoTe will primarily enable automatic discovery and configuration of devices in homes and offices. The *Ambient Assistant Living* health scenario provides a user with medication reminders, information on vital health signs, or detection of critical situations, to mention a few. In the *Energy Saving* scenario, the system is able to provide a comfortable indoor environment by controlling the temperature, fans, or light. The use case presented exposes the potential of the symbIoTe middleware to realize the interoperability of collected deployments in smart spaces.

Smart Mobility and Ecological Routing use case treats the issues related to bad air quality and inefficient transport in urban areas, thereby showing how symbIoTe can assist in providing air quality measurements together with available traffic data acquired through several IoT platforms. Roads and paths are then automatically classified to the benefit of users such as pedestrians, joggers, cyclists and motorists who are hence provided with the best routes. This use case showcases the interoperability of cooperative platforms at the application domain.

Considering the Smart University Campus use case, a student is able to visit and use the services of a campus belonging to another university, due to connected services between the two campus management systems with different IoT deployments. These services include, among others, acquiring room information and booking a room. Through such defined services and use cases, one is able to showcase IoT platform federations in public and collaborative environments.

Another field of use is the Smart Stadium, where a visitor and the staff as well are provided with the stadium application for enhanced experience or management activities. These include services such as quick stadium access, parking booking, health assistance, etc. The identified use case presents an integration of location indoor platforms with various context-based information services, thereby demonstrating platform interoperability.

The Smart Yachting use case showcases the interoperability of cooperative platforms at the application domain, while also incorporating requirements related to timeliness and safety. The *Smart Mooring Services* scenario involves, among other functionalities, assistance for booking a mooring place, while the *Automated Supply Chain* scenario identifies fault and maintenance conditions on board, while simultaneously offering reparation services.

9.1 Next Steps

The use cases identified in this deliverable D1.1 “Initial Report on Use Cases”, will serve for the initial specification of both functional and non-functional system requirements and symbIoTe system architecture. The requirements will be presented in the upcoming Deliverable D1.2 “Initial Report on System Requirements and Architecture” as part of the Task T1.2. A second iteration of the use cases will follow and will be reported on in the deliverable “D1.3 Final Specification of Use cases and Initial Report on Business Models”. This final version of the use cases will be closely considered in the definition of the symbIoTe requirements, which will in turn serve as the basis for the final specification of the symbIoTe architecture. At the end of the Task T1.2 in M30, a special business model for symbIoTe will be in place, taking into account the current market situation, the stakeholders’ requirements, and offered functions to bring a successful, secure, and trustworthy middleware for IoT on the market.

9.2 Business Relationships and Market Opportunities

The symbIoTe project targets at the incentive compatibility of network management mechanisms for different stakeholders, services, and use cases to ensure QoE-awareness simultaneously with a social awareness (especially regarding user relations and interests). symbIoTe is foreseen as an outstanding middleware that is highly flexible in offering services and interfaces for bringing heterogeneous applications, stakeholders and hardware together, and satisfying their requirements.

symbIoTe will provide (a) practical mechanisms (e.g., authorization, security) that will be prototyped in symbIoTe’s middleware and (b) theoretically justified mechanisms which promote overall efficiency. Especially, the second feature will ensure that self-oriented business entities act in a friction-less manner, enabling other IoT service providers to link to symbIoTe and in this way offer novel or enhanced applications or use-cases. Overall, symbIoTe expects this approach to provide a broadly applicable framework, along with specific mechanisms that will considerably impact the way stakeholders interact to a mutual individual benefit.

10 Acronyms

AAL	Ambient Assisted Living
API	Application Programming Interface
CCTV	Closed Circuit Television aka video surveillance.
CoAP	Constraining Application Protocol
CPS	Cyber Physical Systems. A mechanism controlled or monitored by computer-based algorithms
DIY	Do It Yourself
DLNA	Digital Living Network Alliance
GA	Grant Agreement
GPS	Global Positioning System
GUI	Graphical User Interface
HCI	Human Computer Interaction
HVAC	Heating, Ventilation and Air Conditioning
HTTP	Hypertext Transfer Protocol
ICT	Information and Communication Technology
ICO	Intelligent Connected Object
OSM	Open Street Map
IPSO	IP Smart Object
IoE	Internet of Everything
IoT	Internet of Things
KIT	Karlsruhe Institute of Technology
KNX	Konnex
KPI	Key Performance Indicator
LwM2M	Light Weight Machine to Machine Protocol
MAC	Media Access Control
NAS	Network Attached Service
POI	Point of Interest
POPD	Protection of Personal Data
QoE	Quality of Experience
QoS	Quality of Service
REST	REpresentational State Transfer
RFID	Radio Frequency ID
SLA	Service Level Agreement

symbIoTe	Symbiosis of Smart Objects across IoT Environments
MBaaS	Mobility Backend as a Service Platform
UPMC	Université Pierre et Marie Curie
UPnP	Universal Plug and Play
UWEDAT	Stationary Air Quality Platform
WMP protocol	Wireless MAC Processor
WTP	Willingness To Pay