Symbiosis of smart objects across IoT environments

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Final Specification of Use Cases and Initial Report on Business Models

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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 provides an abstraction layer for various existing IoT platforms as its primary objective towards IoT platform interoperability. Furthermore, symbIoTe pursues the challenging task of implementing IoT platforms federation, enabling the platforms to interoperate, collaborate, share resources for the mutual benefit, and to support the migration of smart objects between various IoT domains and platforms.

In this context, Work Package 1 (WP1), entitled “Ecosystem Definition”, lays the foundations of the symbIoTe project. Therefore, WP1 provides the basis for the rest of the WPs, such as the envisioned use cases, the foreseen market conditions and opportunities, the requirements, and the architectural design of the system. The main identified objectives of WP1 are: (1) Definition of use cases, (2) Identification of current and trending business models, (3) Collection and formulation of the functional and technical requirements of the symbIoTe framework, and (4) design of the overall symbIoTe system architecture.

The first objective has already been initially addressed in deliverable D1.1 [23], where five use cases were identified, and for which an initial description was given. They serve to demonstrate the innovation, strength and potential of symbIoTe. The following highlights for each use case is put forward:

- 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 highlights how symbIoTe will facilitate interoperability of cooperative IoT platforms at the application domain.
- The Smart University Campus use case demonstrates 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 presents an integration of location indoor platforms with various context-based information services, thereby demonstrating platform interoperability facilitated by symbIoTe.
- The Smart Yachting highlights how symbIoTe makes the interoperability of cooperative platforms at the application domain possible and functional, while simultaneously incorporating requirements related to timeliness and safety.

In the current document, these use cases are updated and finalized so as to provide the necessary input to the design and implementation tasks of the project, as well as to serve as the basis of the design of the proof-of-concept trials to be conducted during the 3rd year of the project. In specific, the finalization of use cases includes a thorough description of general settings, showcases and workflows. A showcase identifies and describes (IoT) platforms, sensors and involved actors, while a workflow, as a part of a showcase, describes one specific situation and sequence of activities. Moreover, each use case comes with the set of (technical) requirements identified in D1.2 [24], thereby demonstrating the platform requirements and functionality in individual showcase(s) per use case. This provides a firm frame and guidelines for ongoing and forthcoming activities in the project, especially for IoT platform federation efforts in WP3 and deployments and trials in WP5.

This final specification of use cases aligns with the initial work performed by T1.2 until month 12. During this period, the first two phases as defined by T1.2, namely the "elaboration of current state of the business ecosystems" and the "stakeholder identification", were investigated and initial results are included in this deliverable. T1.2 started with the investigation of different methodologies, such as two-sided markets, tussle analysis, and fundamental business models, in order to identify the essential techniques to perform the envisioned analysis. More specifically, T1.2 analysed the current IoT business ecosystem situation defining the value-creation layers commonly used by IoT applications, followed by identification of relevant business model patterns leading to an initial business option description for symbIoTe. In a second step, T1.2 analysed different existing IoT business models methodologies finding out that most of them are designed for specific application areas and only two out of five are application-independent, namely MOP and CANVAS both including identical building blocks (e.g., key partnerships, revenue streams, cot structure, channels, value proposition). CANVAS is the more accepted business model in economics and therefore, the consortium decided to use CANVAS to identify building blocks for each use case. Those building blocks align with the final specification of the use cases as part of T1.1 and help to identify involved stakeholders in symbIoTe. The result of the CANVAS analysis and the stakeholder identification are used to guide the development of all envisioned services of symbIoTe including platform interoperability, data exchange, and security and privacy support. These findings and results are forwarded to the corresponding work packages responsible for implementation of the middleware solution.

T1.2 will continue its work over the next months to gain a final report on business models and sustainability for symbIoTe. The envisioned investigations will include a tussle and network value analysis building on the CANVAS results, as well as an identification of how symbIoTe can be positioned in existing and emerging IoT business models so as to become a sustainable and viable solution, with the support of exising and/or new stakeholders..

2 Introduction

This section includes a brief introduction to symbIoTe for sake of completeness, identifies the purpose of the document, and maps the included results to the objectives mentioned in the description of action (DoA). Finally, the document structure is explained.

2.1 The symbIoTe vision

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 occur at home or at the office, when commuting, or at airports/train stations, and during leisure activities such as visiting stadiums or shopping malls. Following such demands, new requirements have emerged due to the growing number of IoT 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 are called 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 (Figure 1).

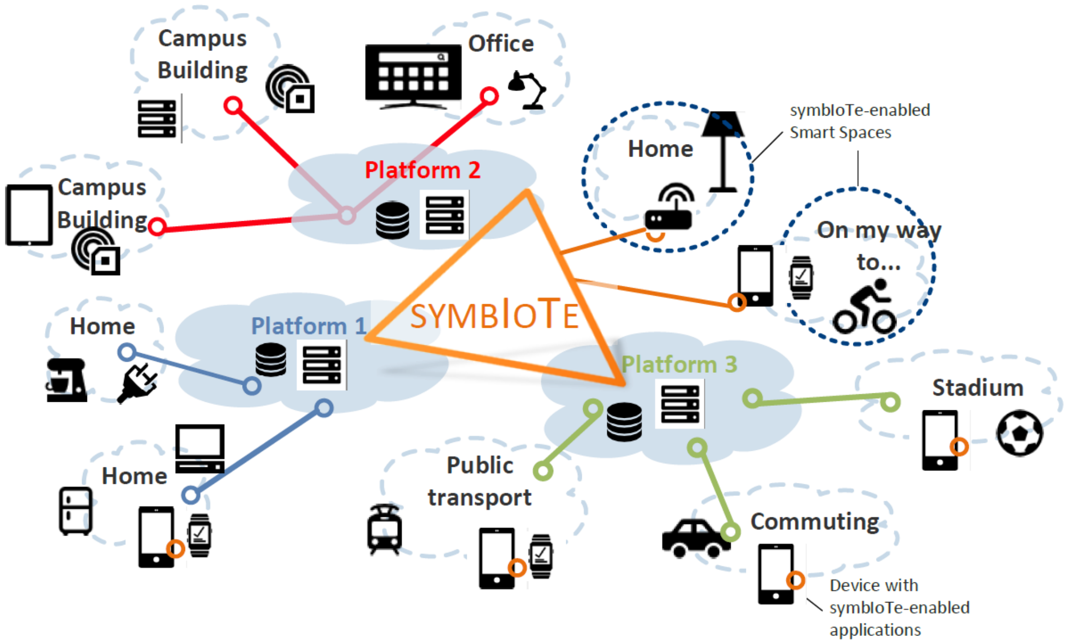

Figure 1: symbIoTe integrates different IoT platforms and ecosystems

2.2 Purpose of the Document and Scope

The purpose of this deliverable is to provide the final description of the use cases, as well as the first report on the findings of the business analysis. D1.3 documents output from Task T1.1 and Task T1.2. It builds upon the findings in D1.1 [23], where five use cases are identified, and for which an initial description was given. In this deliverable, these concepts are now specified in more detail and the respective showcases are identified and specified. Moreover, it uses the outcomes of D1.2 [24], where technical requirements needed for the implementation were identified, and links them to the according use cases. The current document provides a frame for IoT platform federation efforts in WP3 and deployments and trials in WP5. Finally, the initial outcomes of the investigations on business models are documented.

2.3 Task based Objectives

The following sections map the content of this deliverable to the task descriptions in the DoA.

2.3.1 Task 1.1: Use Case specifications

Task 1.1 is concerned with the detailed description of the use cases of symbIoTe. It involves general descriptions of the use cases, and their accompanying showcase(s) and workflow(s) (see Chapter 6). Further activities in the Task 1.1 provide identification of relevant (IoT) platforms, sensors and involved actors. Such description serves to fulfil the objective of providing a firm frame and guidelines to steer the trials and deployments in WP5. All partners involved in the use cases provided the description of the use cases and applications (showcases) jointly. By so, all the different views are captured and taken into account and exploit the consortium's expertise in different, but complementary fields. The Smart Residence use case is developed jointly by AIT and NWX, the Smart Campus use case by IOSB, the Smart Stadium use case by ATOS, Smart Mobility and Ecological Routing jointly by UW, UNIZG-FER and AIT, while Smart Yachting is developed by NAVIGO. The resulting specifications are forwarded to WP3 and WP5 for implementation.

2.3.2 Task 1.2: Business Models and Sustainability

The purpose of Task 1.2 is to encompass the business aspects and consumer needs, framing the development of innovative and sustainable solutions within the context of current industrial strategies and visions surrounding the interoperability of different IoT platforms.

Thus, the objective of Task 1.2 is to obtain insight into the business opportunities and challenges induced by symbIoTe. To achieve this goal Task 1.2 is split into three phases:

- Phase 1 elaborates on the current state of the business ecosystem and its evolvement due to the introduction of the symbIoTe middleware.
- In Phase 2 based on a thorough stakeholder assessment, per-stakeholder value generation scenarios will be derived.
- In Phase 3 a value network analysis will serve the formation of a sustainable ecosystem, which conciliates potentially diverging business interests of stakeholders in a stable long-term setup.

Phase 1 and Phase 2 complement each other by stakeholders defining relevant building blocks for a successful integration of symbIoTe in the current IoT business ecosystem. Phase 3 will build on this outcome and put the user in the centre of the analysis by performing a value network analysis in the upcoming months.

2.4 Document Structure

Section 3 presents an overview of applied methods to perform a business model analysis as part of Task T1.2 addressing the objective in Phase 2. This section introduces Tussle Analysis to identify involved stakeholders, their needs, and resulting tussles when bringing new solutions (e.g., platforms, protocols, algorithms, technology) on the existing market. Furthermore, this section presents the approach of a value network analysis, as well as fundamental business models. Section 3.3 presents fundamental and related work on business models to address Phase 1 in the objectives of Task 1.2. This means an introduction to the theory of two-sided markets is provided and different existing IoT Business Models methodologies are compared to give, at a later point, a recommendation for symbIoTe's business and evolution opportunities. In order to achieve this goal the business model CANVAS was identified as the most promising model that is introduced in detail in Section 3.3.3 and applied by all five use case owners as part of Section 6.

In contrast to Section 3.3 where the focus was on business models from the economic perspective, Section 4 investigates the current state of the IoT business ecosystem looking into existing business models from deployed IoT solutions. A special focus is on the layer structure of the applications supporting digital and physical value-creation and the identification of challenges in IoT business ecosystem as part of Phase 1 of T1.2.

Section 5 takes the identified points from Section 4 to present an initial business opportunity analysis for symbIoTe. This part closes Phase 1 by pointing out the envisioned value creation out of symbIoTe's stakeholder view. Together with results of Phase 2 these business opportunities will be further specified in the upcoming period when the value networks analysis will be performed, leading to a formation of a sustainable ecosystem for symbIoTe to be described in the upcoming deliverable D1.5.

Section 6 presents the final use case specification of all five use cases investigated in symbIoTe. For each use case, a description is presented based on initial description provided in Deliverable D1.1 [23], and includes a detailed specification (e.g., used platforms, sensors, and actors) of envisioned showcases and workflows for each use case, addressing T1.1 open objectives. It is then followed by a CANVAS analysis, which will be updated in the next period due to new developments of the market or feedback by involved stakeholders. Additionally for each use case, a final specification of the showcases is presented as part of Task 1.1.

Section 7 summarizes the findings for Tasks T1.1 and T1.2. Due to the fact that Task T1.2 will continue until month 30, envisioned steps are highlighted to achieve the overall objectives, concluding Phase 2 and performing complete Phase 3.

Section 8 concludes this Deliverable D1.3 having the specific sequence diagrams for each envisioned workflow of presented use cases in the Appendix (cf. Section 11).

3 Methodology

symbIoTe's goal is to overcome the fragmented environment of today's IoT market. In order to achieve this goal a business model for symbIoTe must be recommended during project time. An essential start point is the identification of involved and target stakeholder of symbIoTe, followed by challenges addressed by symbIoTe in special use cases (e.g., secure data exchange, data crawling, device roaming), and resulting spillovers to existing solutions. Different methodologies described in the following are available in research to face those aforementioned tasks: (1) Tussle Analysis, (2) Network Value Analysis, and (3) Business Models. Those are performed by symbIoTe's key industrial partners to identify relevant stakeholders, their needs, and tussles that need to be addressed by symbIoTe to offer successful business opportunities and to be accepted on the IoT market.

3.1 Tussle Analysis

Since the Internet enables the interaction of countless stakeholders of virtually all commercial, industrial, and private sectors, it is a carrier for innumerable conflicting interests. Due to the constantly growing technological diversity of connected devices and the Internet's market penetration, these conflicts are settled by technological, economical, or judicial means that can hardly be foreseen during technology design time. As already pointed out by Clark et al. [1] in 2005, these colliding socio-economic interests make the Internet a rather unpredictable system, which is also transferable to symbIoTe including many stakeholders, devices, services, applications, and using the Internet for communication purposes. Clark et al. termed these conflicts as *tussles*, which in this Deliverable D1.3 is equally used to express problems between stakeholders. Accordingly, [1] postulated the "Design for Tussle" of Internet technology, to preclude these conflicts or at least mitigate their effects for the Internet ecosystem.

The rising relevance of socio-economic factors for the design of Future Network (FN) technology was also recognized by the ITU-T Recommendation Y.3001 [2] as a need for "social and economic awareness". In particular, Recommendation Y.3001 identifies the design goal of economic incentives for FNs, which postulates that FNs are to be designed to provide a sustainable competition environment for solving tussles among the range of participants in the Information and Communication Technology (ICT) and telecommunication ecosystem. In the light of this objective of social and economic awareness and the related design goal of economic incentives, the ITU-T Recommendation Y.3013 suggests that the technically driven FN design and standardization has to be complemented by a clear socio-economic assessment of FN technology [3]. In particular, Y.3013 proposes tussle analysis as a meta-method to assess, if a technology or a standard for FNs is designed in a socio-economic aware and incentive-compatible manner and can also be applied to solutions like symbIoTe. Especially, in the future it will become essential to apply the Tussle Analysis to investigate socio-economic factors in the design of FN technology to identify stakeholders and their tussles already in architecture design process to be prepared for upcoming business model analysis to bring a successful solution on the market.

The Tussle Analysis was developed to contribute to the design of the Future Internet [4] and is considered to be a meta-method, i.e., it describes three steps to be implemented by specific methods, so as to assess and improve a FN technology's or standard's compatibility with socio-economic interest conflicts, i.e., tussles. In other words, the Tussle Analysis defines a systematic socio-economic assessment to be performed during technology design and/or standardization phases in order to anticipate the extent to which this technology is "designed for tussle" [1]. The Tussle Analysis is illustrated briefly in Figure 2 and constitutes mainly by the following three steps, where recommended methods for the steps can be found in [3, 5]:

1. Identification of all stakeholders - Stakeholders can be actively or passively affected by the technology (e.g., protocols, symbIoTe).
2. Identification of all stakeholders' interests, conflicts between these interests (tussles), and all means available to them.
3. For each tussle:
    a. Assessment of the impact to each stakeholder (short-term, mid-term, or long-term depending on the context).
    b. Identification of ways for stakeholders to circumvent negative impacts (or gain unwarranted advantages), and consequences for the ecosystem, e.g., effects on other stakeholders. These may also include stakeholders, who have hitherto not been affected, i.e., who are not in the set of stakeholders compiled in step 1.
    c. Iterative application of tussle analysis for each such manipulation technique, identified in step 3b.

In the ideal scenario the tussle outcome (constellation anticipated in step 3) is an equilibrium point. This means the following two conditions hold [3, 5]:

C1. All stakeholders identified in step 1 derive a payoff that is considered fair and have no means to increase their payoff, wherefore they will not take means to change the outcome, i.e., step 3c does not need to be applied and, thus, the tussle will not evolve further, and

C2. No stakeholder of another technology, who was receiving a fair payoff before, gets an unfair payoff after this tussle equilibrium has been reached, i.e., step 3c does not need to be applied.

If both conditions C1 and C2 hold the analysis of this particular tussle is completed and the focus should be shifted to remaining tussles identified in step 2. In case, at least one of the conditions is not met, it has to be investigated, how technology specification, implementation, or standardization details can be changed, such that both conditions C1 and C2 are met. If no such changes are possible, a new iteration of the methodology must be performed (step 3c) by making assumptions on the most probable policies adopted by unhappy stakeholders, i.e., it has to be investigated, how the tussle will evolve. Since this subsequent iteration will again reach step 3, it will be investigated repeatedly, whether the evolved tussle can be stabilized by specification, implementation, or standardization changes. Theoretically, this allows for stabilizing a tussle after it evolved multiple times. However, due to imponderability and disturbance of the ecosystem it is always desirable to stabilize a tussle as early as possible. Thus ideally, a new technology should immediately lead to a stable outcome, i.e., both conditions are met without any tussle evolutions.

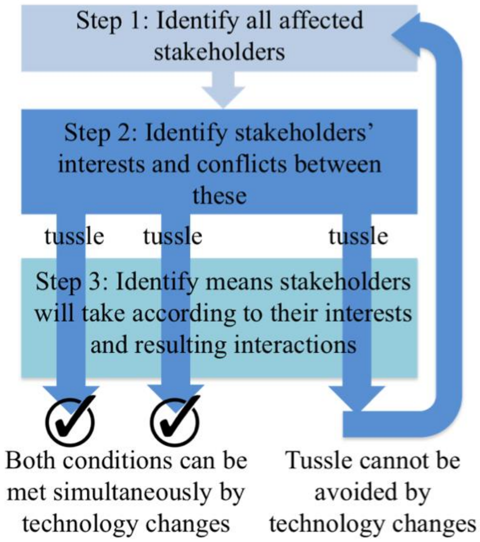

Figure 2 Workflow of Tussle Analysis

In the Appendix in Section 11.1 an example for performing Tussle Analysis is presented based on the introduction of TCP's (Transmission Control Protocol) bandwidth sharing algorithm and resulting spillovers die to this new technology. Further details can be found in [3, 5].

Similar to the aforementioned example, the Tussle Analysis can be applied to symbIoTe. Starting by identifying stakeholders and their tussles, following how those can be solved when symbIoTe comes on the market and might raise new tussles or even spillovers. The Tussle Analysis was applied to symbIoTe indirectly to identify relevant stakeholders and aspects what need to be taken care of bringing symbIoTe to the market. This method was used by the symbIoTe consortium in conjunction with the selected business model CANVAS [8] described in Section 3.3.3 to identify stakeholders, their needs, and requests concerning symbIoTe. During the next period, a complete application of the Tussle Analysis approach to the IoT market and the symbIoTe goals will be performed and the outcomes will be documented in D1.5

3.2 Value Network Analysis

The aforementioned Tussle Analysis allows assessing, if a new item (technology, product (e.g., symbIoTe) or standard) is designed in a socio-economic aware and incentive compatible manner. In contrast, the value network analysis allows investigating and visualizing how this new item will change the economic landscape after the introduction of it [20]. Business model analysis focuses on a single actor and allows investigating how the different blocks of the business model CANVAS will react on the introduction of this new item.

A value network indicates how a value is exchanged between involved business actors. First, the main roles (responsibilities) taken up in the market are indicated. These roles are then mapped to actors (market players) that really take up the indicated responsibility (by grouping one of more roles in a single actor). Furthermore, value streams between roles or actors are identified. These streams can take different forms like monetary or nonmonetary, tangible or intangible assets. Therefore, a value network gathers a broader multi-actor view on the market, expanding the already identified stakeholders and building blocks by CANVAS and Tussle Analysis. A sample model of value network is shown in Figure 3. Those value networks can be developed for each of the use cases and offered services by symbIoTe and will include different streams (e.g., legal implications, tussles, and incentives) of each role (e.g., symbIoTe, user, service provider, hardware manufacturer).

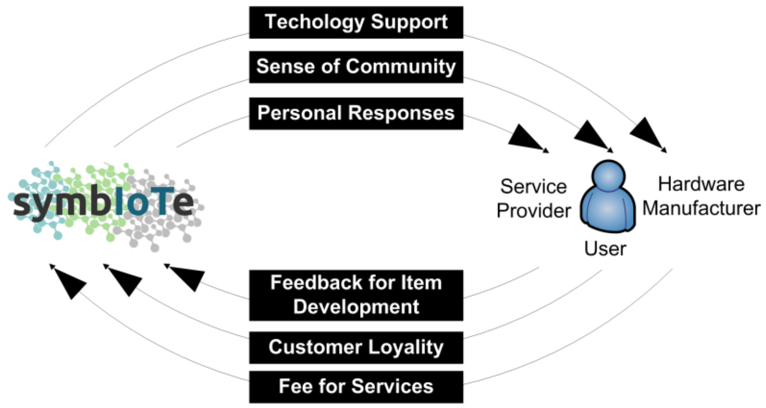

Figure 3: Simplified Value Network

Based on the complexity of roles the resulting value network becomes enormous complex, especially when thinking about

- the envisioned functionalities supported by symbIoTe as stated in the use case description (see D1.1 [23]) and architecture definition (see D1.2 [24]), as well as
- the identified stakeholders, their requirements, services, and requests as received by CANVAS (see Section 6).

Figure 4 shows an example of partial network value map for mobile content (e.g., positioning data, event information) [19]. Similar mappings and complexity is envisioned for symbIoTe offering IoT services, different functionalities, and possibilities to exchange data in different manners.

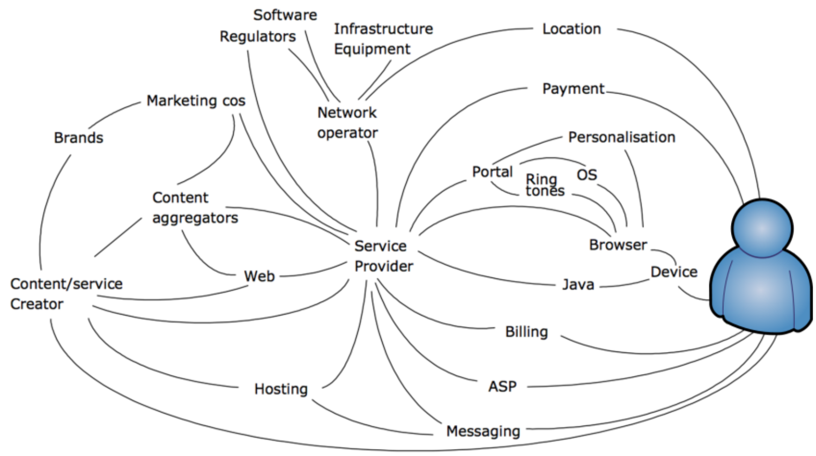

Figure 4: Partial Network Value Map for Mobile Content (based on [19])

Based on the resulting complex graphs the value network analysis gives the opportunity to receive an indication of quality and expectance of the new item by addressing the following three basic questions [19]:

1. Exchange Analysis: What is the overall pattern of exchanges in the system?
2. Impact Analysis: What impact does each value input have on the stakeholder?
3. Value Creation Analysis: What is the best way to create, extend, and leverage value, either through adding value, extending value to other stakeholders, or converting one type of value to another?

It is foreseen for the next deliverable D1.5 that such a value network analysis will be performed for the envisioned use cases in symbIoTe and, thus, is only mentioned here in theory to complete the applied methodology.

3.3 Fundamental Business Models

Besides the aforementioned methods that will be applied by symbIoTe to identify involved stakeholders, their needs, and their tussles, it is highly relevant for defining a business recommendation for symbIoTe to understand the current IoT market in general. Therefore, this section gives a brief overview about fundamental related work in the area of two-sided markets and IoT business models so as to be able to provide a recommendation of business aspects for symbIoTe in the next period. Furthermore, as a main outcome of this comparative analysis a general business model is selected – called CANVAS – to be applied by all use case owners to specify the initial business opportunities for symbIoTe based on so-called building blocks (see Section 6).

3.3.1 The Two-sided Markets

Two-sided markets, sometimes also called multi-sided markets, are markets with two-sided (multi-sided) externalities. Rochet and Tirole published first a description in [21]: "*Multi-sided markets are characterized by (at least) two distinct sides interacting through a common platform. The presence of each side generates positive externalities to the other side, i.e. the utility for each group increases in the number of members of the other group. This allows platform operators to cross-subsidize between different sides of the markets.*"

A good and well-reported example can be found in the gaming community where manufacturers of gaming consoles interconnect to parties building the two-sided market:

- Side 1 is represented by the gamers.
- Side 2 is represented by the gaming developing companies.

On the one hand, gamers benefit from developers' work (large number of new video games) and on the other hand, developers find a large customer base. The console manufacturer sets the conditions, under which each group can "participate", i.e. by charging per-unit shares on game developers' sales and/or by providing technical support like development kits. Further, console prices could be reduced, even below production costs, to attract more gamers. Controlling these conditions allows implementing mechanisms that maximize the platform operator's overall profits.

In most cases of two-sided markets, one side of the market is subsidized (e.g., gamers) by the platform operator in order to increase profits with the subsidizing side (e.g., developing companies). Other well-known product examples that have created multi-sided markets are credit cards, computer operating systems, Internet portals, and shopping malls. More examples can be found in [21]. In contrast to “traditional” multiproduct markets, one side of the market does not internalize complementarities. For example, gamers only buy video games and consoles but there is no direct feedback on the complementary product game development.[1]

In general, all markets with network externalities, where platforms can effectively cross-subsidize between different categories of end users, can be considered as two- (or multi-) sided markets. Therefore, the volume and transactions depends not only on the price level charged to the parties but also on the pricing structure as stated in [21]: “*… under multi-sidedness, platforms must choose a pricing structure and not only a price level for their service.”* Cross-subsidization, however, cannot be achieved if both sides of the market coordinate their activities, i.e. the activity of one side directly affects the other side. However, even if there is no direct interaction, monetary transfers between them could circumvent any cross subsidization. Hence, the design of a platform-based service creating a multisided market would involve deeper investigation of the underlying economic drivers in the sector of the involved participants.

The platform to be created in the symbIoTe project exhibits the aforementioned features of multi-sided markets. As symbIoTe interconnects providers of IoT platforms and clients interested in measurement data and supports clients in identifying and accessing data and services available in the network, all parties benefit from a growing network on either side. In the symbIoTe setting it is beneficial to attract as many sensor network providers as fast as possible, in order to create a sufficient market size. This implies that this side of the market qualifies to be the subsidized one, whereas revenues are to be generated by the data products and/or services exchanged on symbIoTe. In order to design an adequate pricing scheme for symbIoTe, the involved economic sectors need to be studied in detail. It should be focused on the question, whether multi-sidedness holds for all use cases, or whether there are opportunities for collusive behaviour, potentially breaking multi-sidedness.

3.3.2 IoT Business Models

Before bringing a product (e.g., platform, protocol, framework) on the market it is important to identify stakeholders and business opportunities in general. However, how can a business model be predicted or applied to the envisioned market release? In order to answer this specific question it is important to get an overview of existing business models, in case of symbIoTe especially for IoT. Therefore, Task T1.2 compared different IoT business models from literature with each other. The results are presented in this section.

As pointed out by Jue et al. [11] the business model concept raised in its importance, characteristics and perspectives changed over time, due to the Internet.

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[1] Externalities in markets with “traditional” ccomplementary products (e.g. razors and razorblades) are fully internalized by the customers, as they are *both* bought by the latter, which autonomously decides which combination or system to buy.

Table 1 presents an overview of IoT business models. Jue et al. [11] identified as highly relevant in 2016, which also inspired the selection of tools for business analysis performed in Task T1.2. When looking on the result of the comparison it is obvious that it is common to develop specific business models for specific business categories. Only two business models on the market are independent of business category, concretely the MOP Model [12] and CANVAS [8]. Those two have in common that they break the business model down to building blocks as shown in Table 2.

This analysis of business model maps also the items identified by [16, 17, 18]. Existing IoT business models follow the proposed structure from Gassmann et al. [18] consisting of three dimensions illustrated in Figure 5:

- “Who” describes collaborating partners, which builds the “Value Network”,
- “Where” describes sources of value co-creation rooted in the layer model of digitized objects,
- “Why” describes how partners benefit from collaborating within the value network, and
- With the intention of addressing “How”, the proposed framework has integrated the IoT strategy category, tactics, and value chain elements.

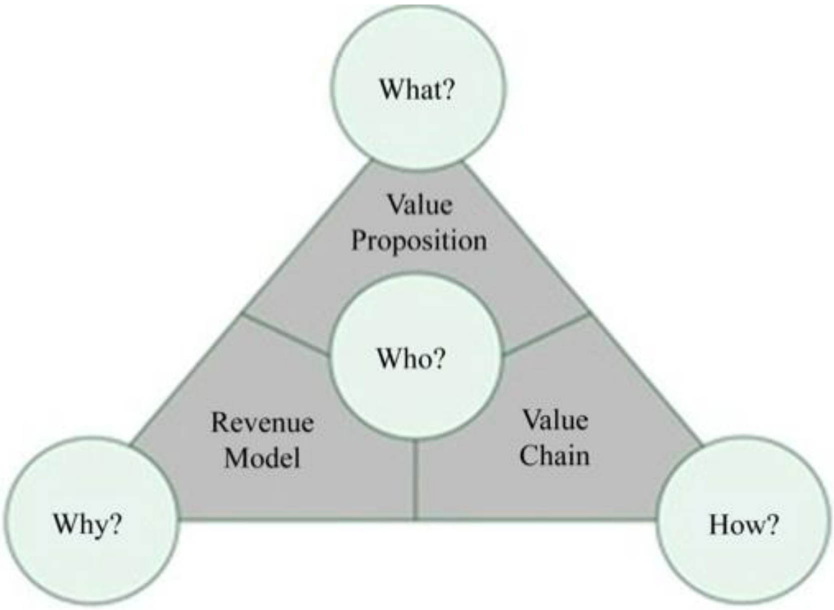

Figure 5: The Archetypal Business Modell by Gassmann [16, 18]

Over the years, the CANVAS business model got more accepted in the community of Economics and, thus, it was decided to use CANVAS for the business model analysis in symbIoTe to identify on the one hand stakeholders and on the other hand items for the building blocks. A brief description of CANVAS is presented in Section 3.3.3, before symbIoTe’s use case owner perform CANVAS throughout Section 6.

Table 1: Comparing IoT Business Models [11]

Business Model	Year	Business Category	Findings
MOP Model [12]	2013	None	The multidimensional structure composed of technology dimension, industry dimension, policy dimension, and strategy dimension.
DNA Model [13]	2012	Smart Logistic	The basic visual structure and relationships between the DNA blocks are design, needs, and aspirations are the same at any level of the business model.
Value Net Model [14]	2015	Telecommunication	The strategy of customer is centers, information sharing and resource integration is relevant.
2x2 Matric Dimension [15]	2012	Automobile	Business to Consumer (B2C) solutions through IoT technology rises in automotive industry.
Business Model CANVAS [8]	2004-2005	None	Building blocks are identified that are relevant in general and not specific to IoT. Major source of the model is the importance of information for value creation and the value proposition.

Table 2: Identified Building Blocks for IoT Business Models [11]

Main Perspective	Components (Building Blocks)	Key Elements
Infrastructure	Key partners	Software Developer, Data Analyst, Device Manufacturer
	Key resources	Software, Information, Customer Resource
	Key activities	Product and Platform Development, Partner Management, Platform and Resource Integration Ability
Value Proposition	Value Proposition	Convenience, Performance, Customization, Share
Customer	Relationship	Co-creation, Self-service Communication, Fast Feedback
	Customer Segments	Mobile Users, Companies
	Channel	Direct and indirect distribution and communication
Financials	Cost Structure	IT Cost, Infrastructure
	Revenue Structure	Subscription Fees, Usage Fee

3.3.3 Business Model CANVAS

In order to develop a business model recommendation for symbIoTe the considered five use cases will undergo a business analysis supported by involved project partners. One option to analyse the business opportunities symbIoTe, especially for assumed symbIoTe use cases, is to perform a CANVAS analysis for each use case out of the perspectives of responsible project partners (cf. Section 6). Therefore, this section presents a description of the Business model CANVAS following reference [8] as an introduction and giving advices how to fill the building blocks leading to a recommendation for all work packages of symbIoTe to develop successful solution for each envisioned use case.

Business models in general give the opportunity to present an overview in which way a company or a project does its business. As stated in [8] a business model "*is a description of the value a company offers to one or several segments of customers and of the architecture of the firm and its network of partners for creating, marketing, and delivering this value and relationship capital, to generate profitable and sustainable revenue streams.*"

Osterwald et al. proposed a single reference model known under the name CANVAS [8, 9]. It includes the most widely used components in the business model literature, namely customer segments, value propositions, channels, customer relationships, revenue streams, key resources, key activities, key partnerships, and cost structure (cf. Figure 6 [7]). Each of these components tries to answer specific questions to build a business model for a special purpose (e.g., company, project) [9,7]:

- **Key partners**: Who are our key partners? Who are our key suppliers? Which key resources are we acquiring from partner? Which key activities do partners perform?
- **Key activities**: What key activities do our value propositions, our distribution channels, customer relationships, and revenue streams require?
- **Value propositions**: What value do we deliver to the customer? Which one of our customer's problems are we helping to solve? What bundles of products and services are we offering to each customer segment? Which customer needs are we satisfying?
- **Customer relationships**: What type of relationship does each of our customer segments expect us to establish and maintain with them? Which ones have we established? How are they integrated with the rest of our business model? How costly are they?
- **Customer segments**: For whom are we creating value? Who are our most important customers?
- **Key resources**: What key resources do our value propositions, our distribution channels, customer relationships, and revenue streams require?
- **Channels**: Through which channels do our customer segments want to be reached? How are we reaching them now? How are our channels integrated? Which ones work best? Which ones are most cost-efficient? How are we integrating them with customer routines?
- **Cost structure**: What are the most important costs inherent in our business model? Which key resources are most expensive? Which key activities are most expensive?
- **Revenue streams**: For what value are our customers really willing to pay? For what do they currently pay? How are they currently paying? How would they prefer to pay? How much does each revenue stream contribute to overall revenues?

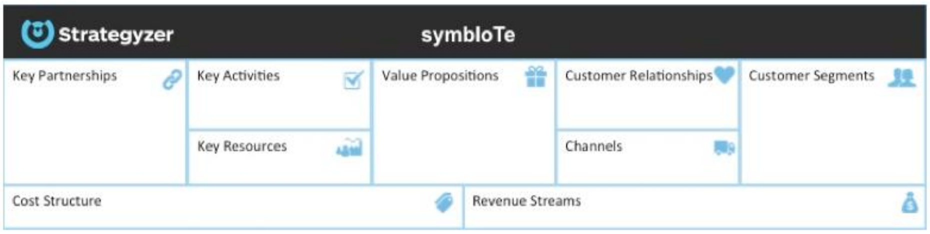

Figure 6: The Business Model CANVAS [7]

All those questions can be addressed by stakeholders in a project and will reflect a spot of a moment that might be updated and/or adjusted during business development. In order to answer those questions to find the best business model for symbIoTe all involved key industrial partners will perform CANVAS for symbIoTe's use cases during Task 1.2. symbIoTe has defined the following use cases as initially characterized in D1.1 [23] and now finally specified in this deliverable: Smart Residence (cf. Section 6.1), EduCampus (cf. Section 6.2), Smart Stadium (cf. Section 6.3), Smart Mobility and Ecological Routing (cf. Section 6.4), and Smart Yachting (cf. Section 6.5).

The CANVAS analysis was lead by the key industrial partners and use case leaders, namely ICOM (telecom vendor, Cloud provider), NWX (residential platform provider), UNIDATA (IoT gateway manufacturer), S&C (smart home platform provider), UW (smart city solution provider), and VIP (mobile operator). This deliverable includes CANVAS analysis performed by the aforementioned partners in order to receive a first glimpse on the business opportunities envisioned for symbIoTe. If nothing else is stated per use case the following marking in figures presenting CANVAS hold: Purple are issues related to citizens, green are issues related to developers, and yellow indicate general issues.

The final recommendation will be defined in D1.5 and will include the updated CANVAS analyses and the outcomes of performed interviews and workshops.

4 Current State of the IoT Business Ecosystem

To identify and eventually monetize the symbIoTe solution it is necessary to discover the IoT opportunities and a strategy (referring to business options) to define the way the project solution can join the ecosystem and provide value to the IoT stakeholders. IoT represents a constantly growing environment of sensors and devices that create a considerable amount of granular data about our surroundings. These creates complexities and at the same time opportunities. In order to define the business options, there is a need to understand better this environment.

4.1 The Digital and Physical Value-creation Layers in an IoT Application

In the Internet of Things, digital business model patterns necessarily intermingle with those from the non-digital world to create a hybrid construct, which becomes particularly clear in the value-creation layers involved in an abstract Internet of Things application [30]. The value-creation layers (see Figure 7) are the result of an analysis of numerous applications that today are classified as the Internet of Things in academia and in practice. Keep in mind that IoT-EPI defines in total eight layers, because they are using another categorization of the layers compared to [30]. Details can be found in [34, 35].

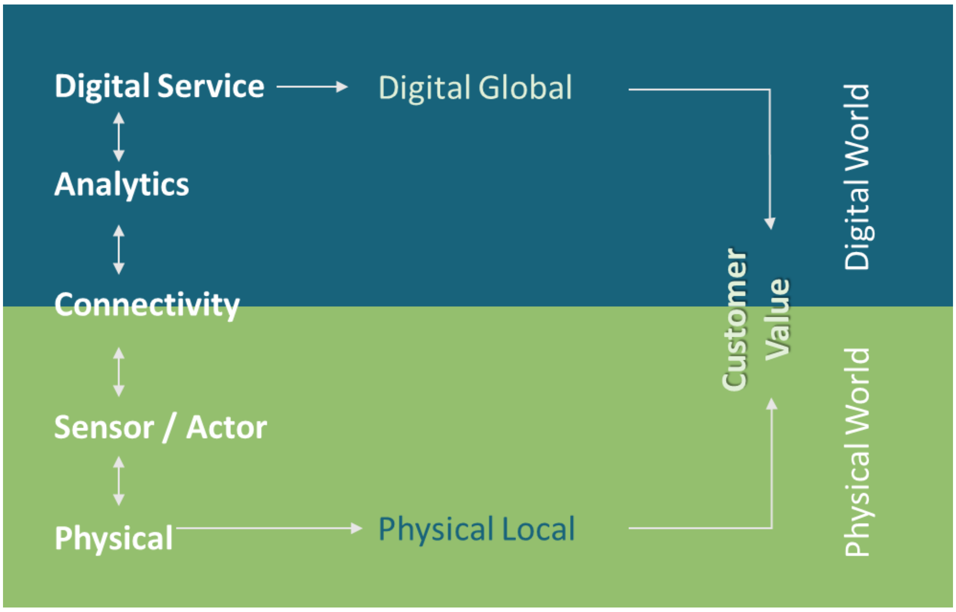

Figure 7: Value-creation Layers in an IoT Application as used by symbIoTe [30]

Layer 1 is the physical layer referring to the hardware technologies (e.g., datacentres, servers, etc.). The physical layer is the first option to design IoT systems "from the ground", for example by integrating relevant functions already on chip level, thereby building entire systems, also known under the term "system on chip" (SOC).

Layer 2 is named sensor/actuator layer. Here, the physical thing is equipped with a minicomputer with sensor technology and actuating elements. The sensor technology measures local data, while the actuating elements deliver local services and thus generate local benefits.

Layer 3 deals with the connectivity, meaning how the sensor technology and actuator elements from the aforementioned layer are connected to the Internet so they become globally accessible.

Connectivity per se does not deliver any added value and, thus, a layer dealing with analytics is integrated as layer 4. Here, sensor data is collected, stored, checked for plausibility, and classified. Then the findings of other Web services are integrated with them to arrive at consequences for the actuator elements – typically in a Cloud-based backend system.

At the final layer, called Digital service, the options provided by the previous layers are structured in digital services, packaged in a suitable form – for instance, as a Web service or mobile application – and made available globally. The characteristics of digital business model patterns apply to these digital services, which are inseparable from the smart things that generate the data.

One important insight is the fact that layers 1 through 5 cannot be created independently of each other. That is why the arrows connecting them are bi-directional. An IoT solution with value is usually not the mere addition of layers but rather a process of integration extending into the physical level. How the hardware is built, for instance, is increasingly influenced by the subsequent digital levels. Viewing the levels or steps in isolation will make many attractive digital services impossible. It seems more and more essential that hardware be developed in close interconnection with Internet solutions.

4.2 Internet-driven Business Model Patterns

When investigating the current developments in IoT Business Models it can be stated that most of the accessible descriptions follow three trends. Whether the IoT will also generate new business model patterns and, if so, which ones. Many of the IT-influenced business model patterns – regardless of the technology wave from which they emerged – follow three overarching trends [30]:

- **Integration of users and customers**. IT enables companies to increasingly integrate their customers in their value-creation chain. In other words, IT allows companies to delegate some tasks to their customers.
- **Service orientation.** Run time services and/or after-sales digital contact with customers is on the rise. Using IT-based services, IT allows companies to maintain and make use of customer relationships even after the sale.
- **Core competence analytics**. Precise collection and analysis of transaction and use data are increasingly valuable and represent a key skill for product design, pricing, and sales structuring.

4.2.1 Common challenges in the IoT business ecosystem

The key challenge and goal for IoT stakeholders and the IoT ecosystem is to create value for individuals, organizations and businesses. Under technical point of view in the IoT sector there is still a heterogeneous landscape of vertical solutions and services, there is an inefficient usage of resources (sensors) across domains / platforms. There is slow growth of IoT of limited openness, accessibility, availability to all and affordability. Search for resources, state of the art solutions can be a complicated issue that involves several ecosystems, products, vendors, locations, and markets. If access to data and platforms happens in a secure but open ecosystem, through a common interface then the possibilities to create new services, to make cities, homes and businesses smarter, to access new market segments increase drastically. In addition, for IoT companies, it's attractive yet economically risky to try to combine a number of standards, devices, semantics within a single platform or system. Professional IoT platform owners are hermetic and wish not external developers and manufacturers to co-develop parts of their systems. As summarized by Eclipse foundation at the IoT developer survey 2016 [32, 33], the three main concerns are security, interoperability, and connectivity as shown in Figure 8.

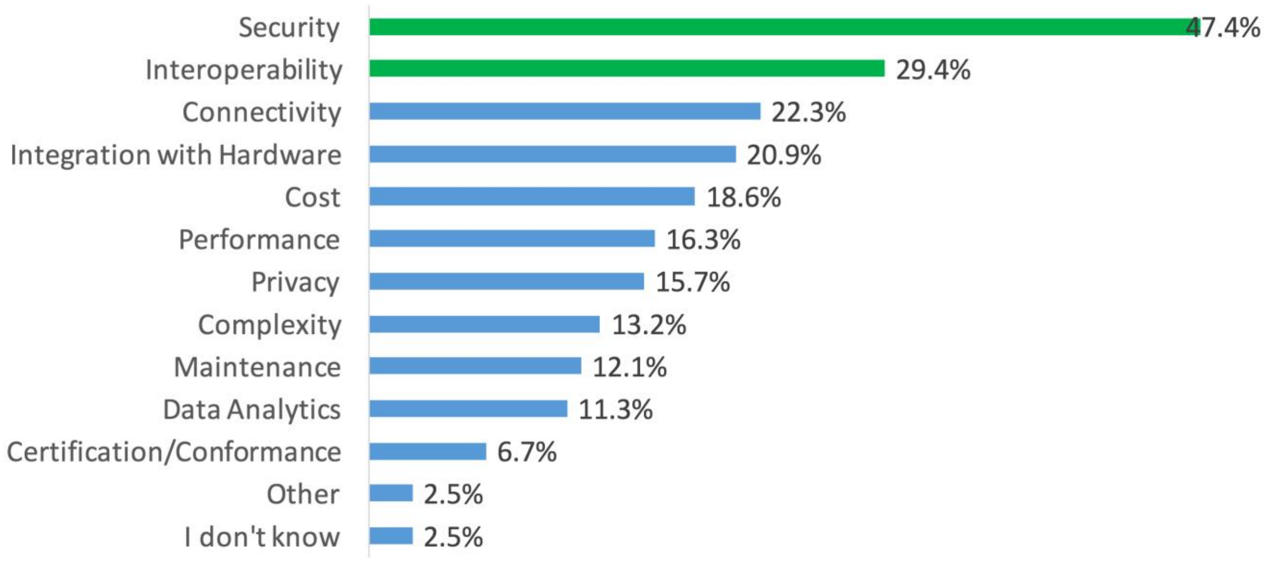

Figure 8: Top IoT concerns [32]

4.2.2 Key stakeholders

In order to receive a feeling of the variety of stakeholders (Phase 2) each key industrial partner from the consortium performed CANVAS and at Vienna during the 3rd Plenary Meeting on July 7, 2016 a workshop entitled "Innovation Workshop" was led by partners from ATOS. One part of the workshop was to identify stakeholders and create a kind of mapping in groups concerning their relation to symbIoTe's solution and ecosystem. Using both tools – CANVAS and workshop - together the following findings were identified for Phase 2 in Task T1.2:

- Depending on the use cases the stakeholders are different, due to the specific area the use cases are linked to.
- Stakeholders come from different areas with different knowledge and requests.
- Stakeholders will be final users, collaborators, early adopters, clients, influencers or competitors.

When mapping identified stakeholders into different groups it is obvious that the mapping depends on the viewing angle. Table 3 and Table 4 show two angles identified in the Innovation Workshop that can be completed by the items in the specific CANVAS sheets per use case. Here identified stakeholders were mapped into six groups (stakeholder groups) where each group was split into a general and a specific stakeholder category.

Another approach to map stakeholders can be performed from the angle of IoT in general resulting in

Table 5.

Table 3: General Stakeholder types mapping identified stakeholder groups

Stakeholder group	**General Categories**
Final Users	Management Companies, Freight Companies/ Logistics (AZKAR- Barcelona), Restaurant staff, School/University Staff, Hotel Staff, Home Automation and Cable TV (STB – Set-Top Box), IoT platform owners (one or more), Hotel Guests, Scientists, Sport Coaches, Cyclists/Runners, Tourists, Citizens, Boat owners, Stadium visitors, Restaurant clients, Children, Students, Smart Home owners, Rental Services clients
Collaborators	Open IoT Communities, Telecom Operator, Hardware companies, Researchers, Application developers, Environmental groups, Service provider in a stadium
Early Adopters	Start-ups developing services on top of symbIoTe services, Innovation Hubs, Entrepreneurs, Car Rental Companies, Marketing Companies, Developers, Travelers, Luxury apartment owners, Yacht owners, Students, Port authorities
Clients	Food Suppliers (Supermarket), Hotels, Telecoms, Real estate companies, Managing Infrastructures and, Facility companies, Local Authorities and decision makers, , Bike rental companies, Hardware companies, Vulnerable groups (diabetics), Tourism services providers, Event Organizers , Health Centers, Managers ad Smart stadiums, Urban planners/architects, Insurance companies
Influencers	Politicians, Tech bloggers, Car manufacturers, Local Authorities, Users/clients, Environmental groups, Hotel chain owners, Architects, IoT Communities, Smart City Stakeholders, CEOs, Fun Clubs, ITS operators, Lawyers, Technology innovators / drivers, Local Authorities, Standardization Organizations, Freight companies, Personal behavior, Social Networks
Competitors	Telecom operators, Bureaucracy, Cloud service platforms, IoT platforms, H2020 Project Consortiums

Table 4: Specific stakeholders mapping identified stakeholder groups

Stakeholder group	**Specific Categories**
Final Users	Depends on use case
Collaborators	ThingSpeak (The open data platform for the Internet of Things), EXOSITE (IOT platform owners), Philips HUE (Toolkit, smart devices, Platform)
Early Adopters	Android IOS, Project partners
Clients	City of Dubai (Open Data law)
Influencers	Google
Competitors	OPEN HAB Project, IoT Cloud providers (Philips, Bosch), Google, CISCO (IOT Platform), INDRA (IOT Platform), IBM (IOT Platform), Ericsson, Siemens, E-Estonia X-roads, Xively (Internet of Things product relationship management solution), SecureWSN (Secure and Efficient Wireless Sensor Network)

Table 5: Stakeholder mapping from IoT perspective

Stakeholder group	**Activity**	**Specific Examples**
IoT device Manufacturers	Interacting with symbIoTe	Intel, Samsung, Huawaii, RPI, UDOO
IoT Platform Providers	Interacting with symbIoTe	Municipalities, public admin, stadiums
IoT Platform Operators	Interacting with symbIoTe	TELCOs, Carriers, Ericsson
IoT Service Developers & System Integrators	Using symbIoTe to build their IoT Apps/Services	IoT developer Companies, Atos
IoT Service Providers	Providing contact links to service developers and system integrators	Start-ups developing services on top of symbIoTe services, TELCOs & Carriers, Application developers
Final Users	Coming from Business two Business (B2B) or Business to Consumer (B2C) area	All types of symbIoTe use cases' final users

5 Initial Business Options for symbIoTe

Based on the Section 4, this section investigates the envisioned and initial business opportunities for symbIoTe. When analyzing the current status of symbIoTe, the following items can be identified that will characterize symbIoTe's solution:

- Programming IoT framework and environment for cross-platform IoT application development and deployment.
- APIs and "standardized" interfaces along with a methodology on how to make an existing platform interoperable.
- Search engine for identifying IoT platforms and corresponding resources in a unified way.
- Domain-specific enablers and value-added services for niche markets (e.g., environmental monitoring and mobility, green routing).
- IoT ecosystem that allows search and use of resources in a transparent way, which benefits both the users and providers.
- Unique environment for interconnecting platforms and devices, which allows the engineering of potentially infinite services (services for people/end users, services for administration, services for companies, exploiting a very large amount of data and information (without managing them).
- A framework that connects platforms that integrates IoT data into existing mission-critical applications and processes and, more significantly, leverages connected products and assets to create new innovative applications that transforms the world.
- A standardization framework.

The mission of symbIoTe is well pinned down with the above item list, but how will symbIoTe address the challenges in the IoT business ecosystem having the content of Section 4 in mind? As pointed out before the IoT ecosystem is quite complex and, thus, symbIoTe wants to solve three main challenges: First, symbIoTe will support IoT platform federation and mediation covering technical, syntactic and semantic interoperability. This will be covered byworking with an abstraction of the total underlying system. Second, symbIoTe will support IoT device roaming between platforms, connecting heterogeneous devices under a common access API. The goal is sharing and exchanging heterogeneous resources and services throughout all linked applications. Third, symbIoTe will go for a cross platform application development involving all identified stakeholders and envisioned services in IoT to make symbIoTe an all round solution. Furthermore, symbIoTe contributes to standards and protocols for IoT federation of platforms. Reduces the entrance barriers for new companies in the IoT market, for innovators and startups.

5.1 Value creation for key symbIoTe stakeholders

The value creation can be observed from two perspectives, namely from the one from system integrators and platform owners, as well as from application developers. Both views are equally important, because they influence each other.

Concerning the view of system integrators and platform owners the following things were already identified:

- symbIoTe offers a standardized API and methodology to create interoperable platforms from existing solutions. A number of compiling solutions is emerging, each adopts a specific standard (Web of Things, oneM2M, OGS SensorThings API), but it is unclear which is the winning standard at this point and who will gain a major market adoption.
- A symbIoTe-enabled platform can be reached by a larger amount of end users and devices. Services provided can be integrated with new features and take benefit from the extension of communication to new devices.
- The symbIoTe system integration is a service can bring added value in different contexts like management of industrial process, smart city. Unlike a stiff IoT solution, our product gives businesses maximum flexibility for customization of its smart environment who needs a unique solution with a high integration, interoperability and security, that can merge different smart platforms that works with different protocol
- For IoT providers, who look for a way to spread their platform, increasing the number of the customers, the symbIoTe platform federation provides a way to allow an IoT platform to interoperate with others, keeping its own identity and features.
- For mature IoT companies who need to innovate and compete globally the Pan-European network of IoT experts is a strategic alliance that provides access to state-of-the art IoT technologies, manpower, foreign markets and early adopters.

Looking on the perspective of the application developers it can be stated that they are represented by innovative and creative companies that provide applications based on IoT solutions can access to symbIoTe by registering to specific set of data, platforms and devices. Therefore, symbIoTe will give the following opportunities:

- For application developers developing cross-platform IoT applications, symbIoTe programming framework and environment enables identification of adequate IoT devices across IoT platforms and standardized access and usage of those devices across platforms. Applications can be built by exploiting such information with a common language allowing costs saving and reducing time to market. SymbIoTe provides a unique environment for creating infinite applications and new services.
- symbIoTe facilitates IoT application developers, who need a framework to operate with smart devices, but do not like to develop a different application for every different platform, the symbIoTe project offers a way to communicate with a unified language with all compliant platforms and devices.

5.2 Business Model Options for symbIoTe Solution

There are numerous services that can be created with the symbIoTe solution. IoT stakeholders can use the core services to build enablers, to reach yet unknown IoT platforms, to mine data to create applications using the symbIoTe unified solution. The business opportunities for the complete solution will be further analysed in the next two years. In this section examined some basic business models that symbIoTe can use to reach the market.

Gassmann et al. defined 55 successful business model patterns [31]. Four of them seem to be the most suitable ones for the symbIoTe solution. Those are two-sided market (see

Section 3.3.1), subscription, open source, and pay per use. Especially, the last three were already identified by the performed CANVAS by the use-case owners (cf. Section 6). This CANVAS analysis identified further business patterns listed in the corresponding sheets in the use-cases. CANVAS itself discovers further opportunities for the symbIoTe middleware solution and offers a unique value proposition possibility for symbIoTe. The main principle of all envisioned business model for symbIoTe is that final users do not have to pay for a product or related services and apply a Business-to-Business-to-Consumer (B2B2C) approach.

For a better understanding on the envisioned business model for symbIoTe the four highly relevant ones are characterized briefly below and describe the symbIoTe approach on each one of them by answering the following questions: How can each business model create value for the main symbIoTe users/customers. In which symbIoTe domain can it apply for?

The first identified pattern is the one of **two-sided markets** such as Amazon Store (1995), eBay (1995), Google (1998), Facebook (2004), and Groupon (2008). A brief description with a concrete example was already presented in Section 3.3.1. Looking on the pattern description it can be stated, that a two-sided market facilitates interactions between multiple interdependent groups of customers. The value of the platform increases as more groups or as more individual members of each group are using it. The two sides usually come from disparate groups. Looking on this pattern out of the persepective of symbIoTe the following two collaborations can be identified:

- Application developers collaborate with enabler developers to acquire specific services and with IoT platform owners under the same uniformed environment creating a synergetic environment. Users can create services on data analysis, storage, selling etc.
- Hardware producers to collaborate with IoT platform owners and municipalities / big enterprises /utilities to create new services upon the symbIoTe environment.

With the two-sided market IoT stakeholders can become active participants of the value network creation, which can lead to successful and innovative ideas. It is envisioned that the Application domain, Cloud domain, Smart Space domain, and Device domain of symbIoTe will be involved in this business model pattern.

The second identified pattern is the one of **subscription** as known from Netflix (1999) and Spotify (2006) for example. Here, the customer pays a regular fee, typically on a monthly or an annual basis, in order to gain access to a product or service. While customers mostly benefit from lower usage costs and general service availability, the company generates a more steady income stream. Looking on this pattern out of the persepective of symbIoTe the following two collaborations can be identified:

- IoT platform owners can construct the symbIoTe interworking API layer to be symbIoTe compatible to extend their services and clients. They can use to support IoT device roaming to enable visiting devices from other platforms to use their local infrastructure in a controlled manner.
- Application developer can develop an application over some resource made available by the ecosystem, avoiding deploying their own sensors.

Form the existing domains in symbIoTe it is envisioned that the Application domain and the Cloud domain will be involved in this business model pattern.

The third business model pattern is the one of open source strategy as known from IBM (1955), Mozilla (1992), mondoBIOTECH (2000), and Wikipedia (2001). In software engineering, the source code of a software product is not kept proprietary, but is freely accessible for anyone. Generally, this could be applied to any technology details of any product. Others can contribute to the product, but also use it free as a sole user. Money is typically earned with services that are complimentary to the product, such as consulting and support. From the view of symbIoTe it is envisioned that IoT platform owners / Application developers / Service providers can use the platform freely and develop their services on top of the symbIoTe middleware. Partners can use the symbIoTe solutions at a consulting level for the users. Similar to the second pattern the Application domain and Cloud domain will be involved here.

The last identified important business model pattern is the one called **pay per use** as known for Google (1998) and Car2Go (2008). In this model, the actual usage of a service or product is metered. The customer pays on the basis of what he or she effectively consumes. The company is able to attract customers who wish to benefit from the additional flexibility, which might be priced higher. Looking from the symbIoTe's perspective the following two collaborations can be identified:

- Application developers / Service providers can use specific developed enablers to collect data and develop their symbIoTe independent products.
- IoT Platform owners can buy under specific licenses for federation and integration to access clients, data or other platforms.

Same as before it is envisioned that the Application domain and the Cloud domain of symbIoTe are involved.

6 Final Use Cases with Initial Business Analysis

This section includes the final use case specification delivered from Task T1.1 and an initial business analysis delivered from Task T1.2 covering Phase 1 and Phase 2 as described in Section 2.3.1.

Addressing Task T1.1 all involved industrial partners and use case owners were requested to specify the investigated use cases by symbIoTe. Therefore, each use case description follows the shown schema in Figure 9. At the top is the *use case*, while the next component is the *showcase*, which presents a more detailed view of one concrete application within the use case. The showcase identifies and describes (IoT) platforms, sensors and actors, while the last component, the *workflow*, as a part of a showcase, describes one specific situation or activity. There can be more workflows completing a showcase, and more showcases for one use case[2].

Addressing the objectives of Task T1.2 the key industrial partners and use case owners identified the involved stakeholders and applied the business model CANVAS method to identify building blocks for their use cases that also indicate requirements for successful solution design. Requirements are fed to the architectural design task(s) that then feed the core platform implementation tasks. Further CANVAS and discussions together with workshops and interviews made the stakeholder list more complete. This becomes obvious when looking on the findings presented in Section 7.2.1 for Phase 1 and in Section 7.2.2 for Phase 2. Received results will highly influence the next steps (Phase 3) as outlined in Section 7.2.3.

In the following, for each use case, a brief description is presented based on D1.1 [23] leading to the CANVAS analysis. Finally, the identified showcase specification is presented. Depending on the specific use case, one or more showcases are envisioned and specified.

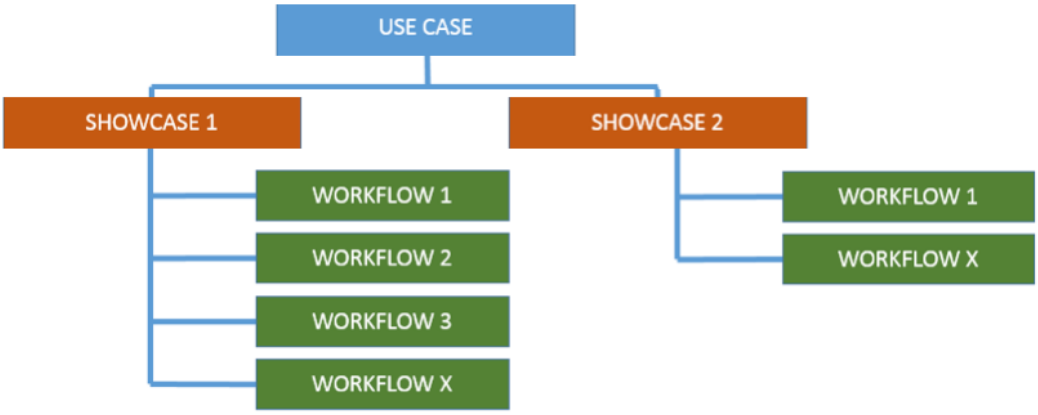

Figure 9: The structure for describing a use case

[2] Slightly different, but more precise and clear structure and nomenclature is applied in this deliverable compared to the deliverable D1.1 [23], where a use case was simply further subdivided in sub-use cases.

6.1 Use Case 1: Smart Residence

Home services are getting increasingly connected both within the houses, but also to the outside world. Currently, there are many niches, providing isolated solutions and developing specific standards [19, 20].

The market for smart residence solutions is expected to grow rapidly in future. Thus, many different players are targeting this market (e.g., Google, Amazon, Bosch, Siemens, etc.). They try, however, to push their solutions and standards into the market and thus, to exclude others by creating controlled environments. To be attractive for the users and for developers of applications, the need is seen to achieve interoperability and federation across platforms and domains. A movement sensor, for example, can be used for alarming services (e.g., fall detection). It can, however, also be used for health monitoring (fall detection, dementia support, etc.), or for adjusting and controlling ambient light and heating system in a house/residence. These use cases are usually spread over multiple platforms. Enabling this multi-functionality of such devices will enable the design of flexible applications being not reliant on a single type of hardware. Moreover, it will enable the creation of integrated home automation platforms.

The Smart Residence use case aims to demonstrate interoperability across different smart home IoT solutions through a generalized abstract model to describe inter-connected objects, providing a dynamic configuration of available services and a natural and homogeneous user experience.

A health monitoring system, in addition to the smart living platform, has the ability to create a comfortable, safe and helpful living/residence environment, supporting a scenario where residents are provided with context-aware and personalized health and comfort services at home.

6.1.1 CANVAS

Symphony [27] is the NXW platform for the integration of home/building control functions, devices and heterogeneous subsystems. It can monitor, supervise and control many different building systems, devices, controllers and networks available from third-party suppliers. As hardware/software compound, Symphony encompasses media archival and distribution, voice/video communications, home/building automation and management, and energy management. Energy management collects information from measurement sensors and performs actions based on behavioural policies aimed at energy saving. The resulting CANVAS is shown in Figure 10.

The selected **key partnerships** aim at creating the basis of the structure to support the creation, development and implementation of the symbIoTe solution.

- Platform operators can utilize symbIoTe to provide interoperable infrastructure, being used by other applications later on.
- Application provider can provide solutions utilizing symbIoTe federation framework, thus generating a critical mass of services being of interest for partners.
- The open-source community can support platform development on different levels (core development, application development).

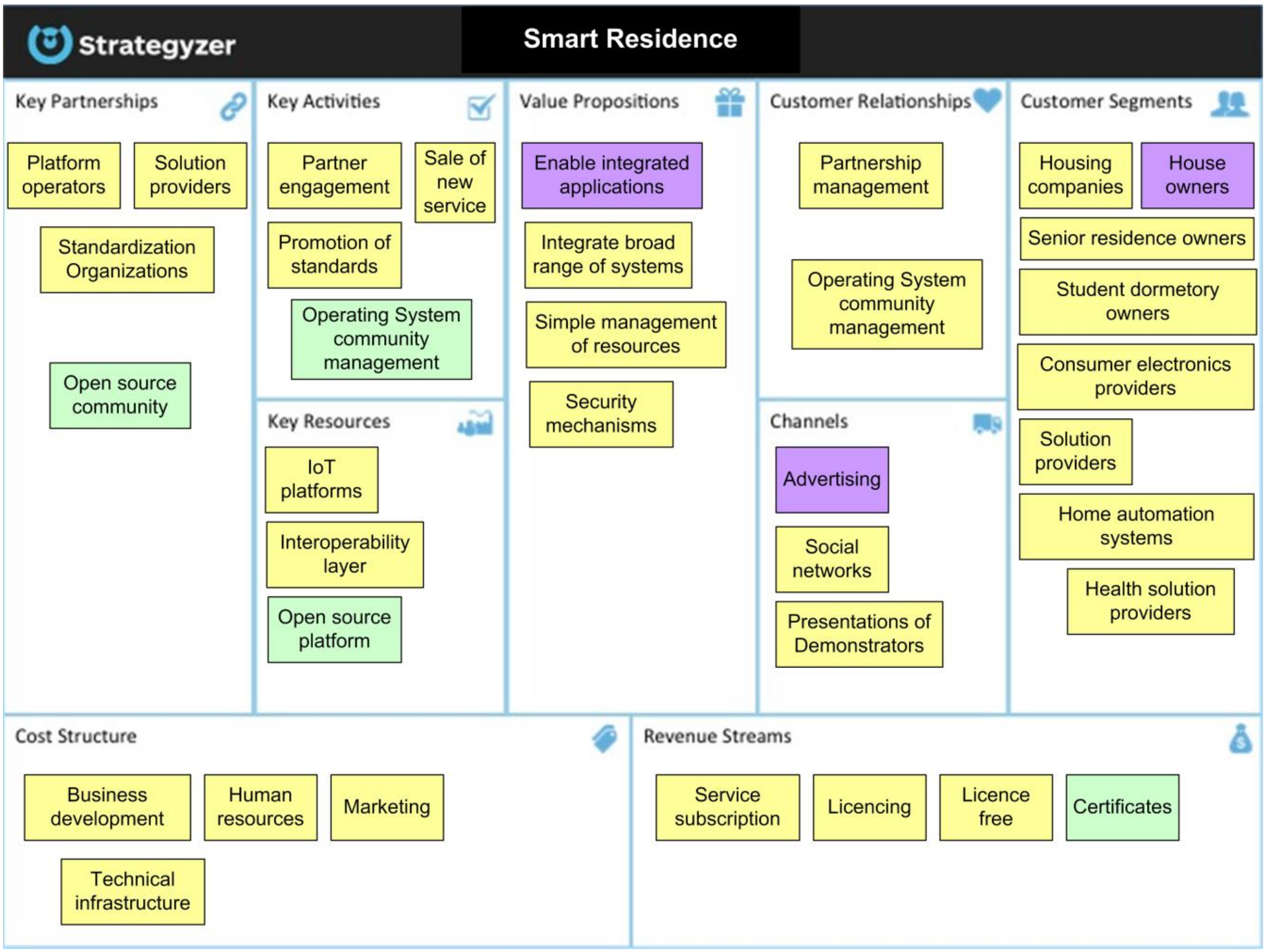

Figure 10: CANVAS for use case “Smart Residence”

Concerning **value proposition** symbIoTe builds its orchestration middleware on top of existing standards for protocols and interfaces, plus a number IoT platforms both proprietary (i.e. developed by its industrial partners) and from open source (e.g., OpenIoT [6]). The key value for all customer segments will be that symbIoTe enables platform interoperability and provides a federation platform to (1) enable integrated applications, (2) to integrate a broad range of systems (now and in the future), (3) to enable simple (centralized and remote) management of the available resources, and (4) to provide security mechanisms to ensure trust in federated environments.

Three main **user segments** were identified for this use case, namely house owners, housing companies, and solution providers. Each of them has different requirements and needs to face individual problems. Therefore, symbIoTe offers individual functionalities to overcome those challenges.

For house owners, the main benefit of using symbIoTe is enabling simpler operation by supporting integrated operation across platforms, by enabling one interface for all applications & platforms, and by simplification of complex tasks across platforms. Further benefits are securing remote management of resources in the environment, the ability to integrate new services with less overhead, and simple service provisioning for guests in the house. Today house owners to face different problems, like the need to upgrade system regularly, handling complex user interfaces, handling interoperability problems between platforms, and personal security concerns. symbIoTe can help to overcome these problems by offering the following functionalities:

- Cross-platform applications allowing complex interaction concepts
- Support to integrate new services easily
- Provide guest access to shared resources for visitors
- Secure management and sharing of resources across platforms
- Standardized cross platform communication interfaces
- Reuse of resources in different applications

For housing companies, the main benefits of using symbIoTe are higher quality service and owner maintenance costs. Compared to house owners the problems to be faced are different: Locked-in on certain providers due to incompatibility of different platforms, complex and unreliable technology must be supported, and diverse needs of clients in one solution need to be addressed together with customer's security concerns. For all problems it has to keep in mind that the initial costs and running cost are envisioned to be high. symbIoTe will support the following functionalities in order to overcome these mentioned challenges: (1) Cross-platform applications, (2) remote management of resources, (3) standardized cross platform communication interfaces, (4) support to integrate new services easily, (5) secure management and sharing of resources across platforms, and (6) reuse of resources in different applications.

For solution providers, the main benefits of using symbIoTe are mainly three, namely symbIoTe enables solution providers to create higher quality solutions, to create more capable solutions by integrating existing components, and to concentrate on own competences and eliminate the need to develop generic or rarely used components by themselves. The main problems solution providers face today are complex environment and high competition in the specific application area. symbIoTe offers the following functionalities to face these challenges:

- Stable, well documented, easy to approach framework for developers
- High number of supported platforms and resources
- Broad range of use cases covered
- Basic functionality resolves typical problems (authentication, security, etc.)

Concerning **customer relationships** several platforms and online support are made available for the customers nowadays. Some focus on the developers such as Open source Development community and specific online platforms and others aim at addressing the general customers (e.g., municipalities, citizens and others).

Concerning **customer segments** the following observations were made**.** House Owners have to deal with private users, who use different platforms in their household (e.g., heating system, home entertainment, alarming system, health monitoring). For the private users it is important to have a single point of access and a future proof platform, so that they will be able to integrate new solutions and applications now and in the future. For housing companies the same issues apply as for house owners, but at a larger scale. Additionally, they have a strong need of managing their facilities remotely. Solution providers are developing solutions (e.g., platforms or services) for house owners or housing companies. For solution providers, the technological platform is of high importance as they have high demands on development support and simple management of different resources. Solutions can be from any domain, including home automation, health & care, safety, etc.

Finally, the following **revenue streams** could be identified for this use case:

- Concerning service subscription revenue can be created by charging stakeholders for the centrally managed services.
- Concerning licensing revenue is created by providing licenses for using the system / part of the system.
- Concerning certificates revenue is created by providing certificates, e.g. on standard conformity.
- Concerning license fee different revenues are possible: By providing (parts of) the system for free, revenue has to be created indirectly. This might be by offering specific services only for paying customers or by generating revenue by other customers (e.g., free for open source, charged for commercial applications). Alternatively, usage might be free, but fees are charged for getting certification of the customer's product.

6.1.2 Showcase Specification

In the following, the showcases and their related workflows for the use case of Smart Residence are described. The corresponding sequence diagrams can be found in the appendix. An overview is given in Figure 11.

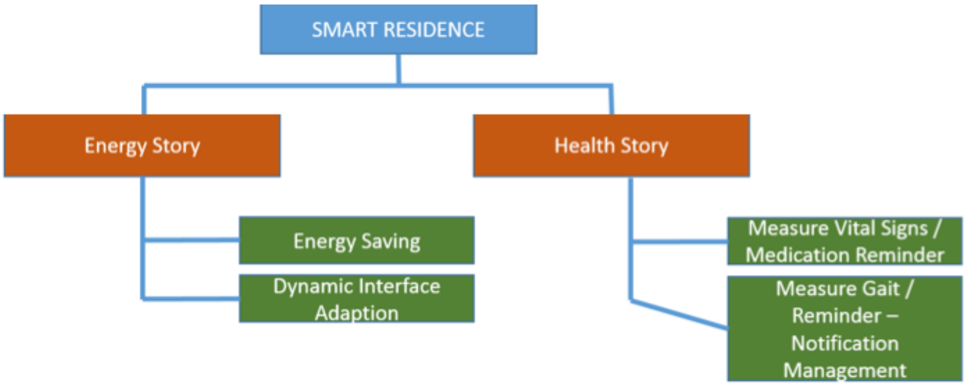

Figure 11: Smart Residence showcases and workflows

6.1.2.1 Setting of Showcase 1: Energy Story

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 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; Luke and Alice move then to the next room, waking up their children, and start to prepare breakfast in the kitchen. When they enter the 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 and at the time they all leave the house, the smart system recognises the departure and modifies levels to new "empty home" schema. This is translated into switching off lights and fan coil, while 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 as an interface by Emily, which will automatically reconfigure the controllable cyber-physical systems (CPS) in range (e.g., TV remote command, adaptive light switch). 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 meantime, the home has automatically come back to the “user-at-home” situation, again regulating dimmer lights and temperature at the comfort values.

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

In the following the envisioned platform, sensors and actors (actor "specifies a role played by a user or any other system that interacts with the subject" as defined in UML [25]) used are listed and briefly characterized:

- Platforms (defined as features in Symphony [27]):
  - 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.
  - 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.
- Sensors:
  - Light: A light device able to read lux level and to control light dimmers and (eventually) colors. Different commercial devices can be used, according to the protocols handled by the IoT platform, which manages the devices.
  - Fan coil: A heating or cooling device, which is part of an HVAC (Heating, Ventilating and Air Conditioning) system.
  - Curtain: Automated remote controlled system for curtains, equipped with a motor, capable of opening and closing window coverings.
  - Anti-intrusion sensor: A device, which detects intrusions or in a wider meaning i.e., detecting people for different purpose than intrusion.. Sensors can perform such detections by a variety of methods, such as monitoring doors and windows for opening, or by monitoring unoccupied interiors for motions, sound, vibration, or other disturbances.
  - symbIoTe compliant app: A symbIoTe compliant application, running on a smart device (e.g. tablet), which is capable of control a cyber-physical system, reconfiguring itself dynamically, basing on the devices in range.

- Cyber physical system: Any smart device, which is controllable from a remote application.

- Actors
  - Residents: Follows daily routine; controls home environment; calls for help in case of emergency; takes medication
  - Non-Resident: A visitor in a symbIoTe enabled home interacting with the environment.
  - Lights: House lightning system
  - Curtains: house motorized curtain system
  - Fan Coils: House fan coils
  - Cyber Physical Systems (CPS): Mobile robotics and electronics transported by humans (e.g., smartphones)

There are two workflows associated with the Showcase 1 on “Energy Story”. The first workflow is named “Energy Saving”. Its workflow description is summarized in Table 6 and the corresponding sequence diagram is shown in Figure 28 in the Appendix. The second workflow named “Dynamic Interface Adaption” is summarized in Table 7 and the resulting sequence diagram in Figure 29 in the Appendix.

Table 8 provides the most relevant requirements needed for the implementation of the workflows described above. The full set of requirements is defined in Deliverable D1.2 [24].

Table 6: Workflow for 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 is equipped with the necessary devices (the anti-intrusion system, the lighting system, lux sensors, curtain motors, fan coils. **Pre-condition 2** - Room has a predefined comfort scenario registered into the system (set of light dimmer values, curtains opening and temperature)
Involved Actors	Resident, lights, curtains, fan coils
Sensors Involved	Lights, fan coils, curtains, anti-intrusion sensors
Platforms Involved	Symphony [27], Smart Lights (symbIoTe enabled)
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. Curtain motors are activated 5. Light actuators are set *6.* The fan coils are set to the predefined scenario value
Alternative Scenarios	Scenario registered fan coil failure that makes the temperature impossible to reach the comfort value. The application can use symbIoTe system to identify fan coils in the next empty room in order to drive the temperature to the desired value.
Assumptions	None.
Domain Level / Compliance Level	Smart Space Domain / L3

Table 7: Workflow for Dynamic Interface Adaption

Description	The user's control interface, represented by an application 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
Sensors Involved	symbIoTe compliant app, cyber-physical systems
Platforms Involved	Symphony
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	One of the controllable devices usually detected in a room is unplugged or broken, so the user's 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.
Assumptions	None.
Domain Level / Compliance Level	Smart Space Domain / L3

Table 8: Requirements List for showcases of use case 1 based on D1.2 [24]

Req. #	Req. Description	Why is this requirement important and relevant for the use case (short description)	Workflow
1	IoT platform providers MUST be enabled to register the available (composite) IoT services to the symbIoTe system. The system MUST allow IoT platform operators to update and revoke (unregister) their registrations.	To permit to a sensor/actuator of the Smart Space to be available, Symphony platform needs to register devices within symbIoTe. If a device is no longer present in the Smart Space, it needs to be unregistered	Energy saving / Dynamic interface adaption
12	The common information model MUST support geo-reference information.	The symbIoTe compliant app on the smart device needs geo-references to dynamic adapt its configuration	Dynamic interface adaption
14	The system SHOULD enable the control of access to the advertised IoT services for reasons related to local legislation, current overload, security issues, etc., if the underlying IoT platforms support it.	The app connected to the smart residence may not be allowed to use all the smart devices in the Smart Space	Dynamic interface adaption
18	The system MUST provide unique identifiers of the (registered) IoT services	Both the devices and the symbIoTe compliant	Energy saving / Dynamic interface

	within the system. Uniqueness MUST be enforced within and across IoT platform boundaries, including the case of mobile IoT devices.	applications must be correctly identified and accessed	adaption
19	symbIoTe MUST distinguish IoT devices which are fixed (geo-location does not change over time) and mobile (their location changes).	The symbIoTe compliant application is seen as a mobile device, to permit configuration update	Energy saving / Dynamic interface adaption
59	symbIoTe smart spaces SHOULD be able to operate without a permanent Internet connection.	The devices have to be driven locally	Energy saving / Dynamic interface adaption
62	A device running a symbIoTe app or a Smart Device SHOULD be able to access a Smart Space even if Internet connectivity is not available	A device running a symbIoTe app must be able to drive devices locally	Dynamic interface adaption
66	There SHOULD be a way for a local symbIoTe app to directly interface with the hosting Smart Space, that is by accessing it through the LAN rather than the Internet.	A symbIoTe app can locally interface with the Smart Space	Dynamic interface adaption

6.1.2.2 Setting of Showcase 2: Health Story

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 for a period of 3 weeks, 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. A notification is delivered to the tablet to remind John to perform his daily gait measurement. When he enters the bathroom, a smart gait measurement device (e.g. a 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 a context aware device, which is using the information from the symbIoTe enabled home to identify the best suitable time and location to do that. 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. After having a long and activity-packed day, Claire and John go to sleep.

This showcase assumes the involvement of two platforms that are described briefly in the following: Telehealth Service Platform and Home Automation Service Platform.

The Telehealth Service Platform, called KIOLA [29], is 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. KIOLA as a mobile health data collection and online therapy management system, featuring KIOLA Mobile Client (KMC) Android application, is currently deployed in various national and international projects. It has been successfully tested and validated with end-users in international AAL-related projects (iStoppFalls; FP7; 160 users, DOREMI, FP7, 30 users) in England, Germany, Australia, Spain and Italy. Since February 2016, KIOLA is used in an Austrian diabetes management program currently including 794 patients. Moreover, it is currently used in chronic heart failure management programs (Herzmobil, 49 users and Cardiomemory 18 users). In 2016, parts of KIOLA components (decision support system components) have been certified according to the Austrian medical product law.

The second platform, called Home Automation Service, is 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.). The concrete platform has not been decided yet. Further evaluations are in progress.

The following sensors and actors (assuming same definition as before) will be involved in this showcase and are briefly described in the following listing:

- Sensors
  - Gait Measuring Device: A device to record a person's gait speed and gait variability. Different devices, including smart floors (e.g., SensFloor) or optical/ultrasonic sensor based solutions, can be used. Data is handled at local processing units (e.g., Raspberry Pi) and forwarded other platforms using TCP/IP connections.
  - Blood Pressure Meter: A medical measurement device to record a person's blood pressure and heart rate. Data can be read out from the device using Bluetooth or Nearfield Communication (NFC) connections.
  - Body Weight Scale: A medical measurement device to record a person's body weight. Data can be read out from the device using Bluetooth or NFC connections.
  - Smart Pill Boxes: Devices to store and retrieve medications. Medication intakes can be scheduled through the health platform. If a medication has to be taken, the device notifies the patient. When the patient takes the medication out of the box, a notification is send to the health platform.
  - Bluetooth Low Energy (BLE) Beacons: Devices, which are able to broadcast information like UIDs, URLs, or alike over a BLE link in a very energy conserving way. There are various de-facto standards for the content as well as the protocol containing the information. Eddystone[3] is a well-supported protocol specification for BLE beacons supported by several manufacturers. To meet privacy requirements when identifying people with BLE beacons, the latest specification covers ephemeral identifier. These identifiers appear to be random to the public but resolve to individuals only for registered services.

[3] https://github.com/google/eddystone (last access December 20, 2016)

- Actors
  - Residents: Follows daily routine; controls home environment; calls for help in case of emergency; takes medication
  - 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.
  - Lights: House lightning system

There are two workflows associated with this showcase. The first workflow, "Measure Vital Signs/Medication Reminder", is characterized in Table 9 and its sequence diagram is illustrated in Figure 30. The second is called "Measure Gait / Reminder – Notification Management". This workflow (cf.

Table 10) demonstrates the interplay between symbIoTe, a device capable of measuring a person's gait and another device capable of alerting a user to do certain actions. The respective sequence diagram is illustrated in Figure 31.

Table 11 provides the most relevant requirements needed for implementation of the workflows described above. The full set of requirements is defined in D1.2 [24].

Table 9: Workflow description for Measure Vital Signs / Medication Reminder

Description	This workflow demonstrates how personal data like vital signs, exemplified by a body weight measurement, is recorded in an environment not linked to a specific person. symbIoTe mediates between the different actors of this workflow allowing the vital signs to be linked to the personal medical record of a specific person. The workflow is demonstrated by taking a weight measurement in an environment, where other people are allowed to perform such measurements as well, but only relevant ones are recorded in the personal medical record.
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.
Involved Actors	Resident
Sensors Involved	Medical devices (body weight scale, blood pressure meter, etc.), wearable BLE Beacon, tablet (linked to the Home Health platform)
Platforms Involved	symbIoTe, medical data management platform (KIOLA), home automation platform (opt.)
Process Flow	*1.* The resident (Claire) is about to perform the measurement of her vital signs (e.g., body weight, blood pressure and heart rate) and enters the bathroom where her weight scale is located. *2.* Claire steps on her body weight scale and performs a measurement. *3.* The body weight scale sends the data to the non-personal tablet, which acts as a user interface to the Home Health platform. *4.* The tablet transmits the data to the Home Health platform. *5.* The Home Health platform queries symbIoTe for a place (or an actuator in a platform in the SymbIoTe nomenclature) to store the body weight measurement related to the beacon ID (virtual location). *6.* symbIoTe provides the resource access proxy (RAP) URL to access the target (KIOLA telehealth) platform. *7.* Since the Home Health platform received a RAP URL suitable for storing weight observations, it transmits the measurement to Claire's personal medical record.

	8. KIOLA acknowledges the weight measurement. *9.* Since the Home Health platform has just talked to Claire's medical record, it tries to retrieve a list of open (medication) reminders. *10.* KIOLA provides the Home Health platform with a list of reminders, which it displays on one of its interfaces (e.g., tablet) and notifies the user.
Alternative Scenarios	Another person performs a weight measurement, whereas no BLE beacon is close to the tablet in step 2.1 or there is no resource access proxy URLs for the beacon in step 2.6. The weight measurements are kept within the Home Health platform. Publish/Subscribe Scenario: Instead of registering a sensor for weight measurements in step 1.3, KIOLA could subscribe to weight measurement sensors for specific beacon IDs to retrieve measurements later on automatically through symbIoTe (step 2.10). The Home Health platform is publishing the weight measurement through symbIoTe in that case in step 2.9.
Assumptions	None.
Domain Level / Compliance Level	symbIoTe Compliance Level 1 (platform integration)

Table 10: Workflow description for Measure Gait

Description	John - as he has recently experienced a fall - can use a gait-measurement device to regularly perform exercises and daily measurements concerning his balance as requested by his physician.
Trigger	There are two triggers for this workflow. (1) The KIOLA telehealth platform sends a notification (depending on the time of day) to Johns Phone in order to let him know to proceed with the gait measurement. (2) John enters the bathroom with the Beacon-enabled gait measurement device. When John walks over the carpet, recordings are automatically assigned to his health record.
Pre-Conditions	John needs to have his phone in his pocket or at least nearby. John is registered at the KIOLA telemedical platform (step 1.1)
Involved Actors	Resident
Sensors Involved	Medical devices (gait measurement device), wearable BLE Beacon, personal mobile phone linked to the telemedical platform
Platforms Involved	Telemedical platform (KIOLA), home automation platform
Process Flow	1. The resident (John) walks on the floor, which automatically measures the gait. *2.* The current gait measurement is stored in the home automation platform. *3.* John's personal phone is recognizing the BLE beacon attached close to the gait measure device (floor). *4.* The personal phone queries symbIoTe to retrieve a sensor for the beacon ID (registered in step 1.2). 5. symbIoTe provides a resource access proxy URL for the gait measure sensor. *6.* Optional/Alternative flow: The personal queries the smart space domain for a sensor for the given beacon ID. *7.* Optional/Alternative flow: The local symbIoTe core provides a resource access proxy URL for the gait measure sensor. *8.* The home automation platform send the current gait measurement. 9. The gait measurement is recorded on the personal phone. 10. The gait measurement is stored on the personal device. *11.* Optional: John confirms on his phone to transfer the gait measurement to his personal health record. *12.* Optional: The phone transfers the data to the KIOLA telemedical platform.
Alternative Scenarios	Alternative Scenario 1: *1.* Another resident (Claire) enters the room; she is not carrying a phone.

	2. She uses the gait measurement device and then leaves the room. *3.* The readings from the device (as no context is available) are now discarded. <u>Alternative Scenario 2:</u> To keep all data local to the smart space domain, the home automation IoT platform could register the gait measure device to a local symbIoTe core (steps 1.4, 1.5). Then the query for appropriate sensors would be kept local within the smart space (steps 2.6, 2.7).
Assumptions	None.
Domain Level / Compliance Level	symbIoTe Compliance L1 (platform integration) extensible to L2 (sensor integration)

Table 11: Requirements List for second showcases of use case 2

Req. #	Req. Description	Why is this requirement important and relevant for the use case (short description)	Workflow
1	IoT platform providers MUST be enabled to register the available (composite) IoT services to the symbIoTe system. The system MUST allow IoT platform operators to update and revoke (unregister) their registrations.	To find a medical record for a specific type of vital sign, the KIOLA platform needs to register virtual sensors for each type of vital sign for each user within symbIoTe. If users are no longer eligible to handle their medical records in the platform, these virtual sensors need to be revoked or updated.	Measure Vital Signs
11	The information from IoT services and IoT devices MUST have the units in which the data is described associated to standard unit of the common information model (meters, kg, etc.). The encoding of units should adhere to a standard (e.g. UCUM).	When a vital sign is recorded within a smart space, the measurement may not be in the same unit of measurement as handled in the medical record.	Measure Vital Signs
14	The system SHOULD enable the control of access to the advertised IoT services for reasons related to local legislation, current overload, security issues, etc., if the underlying IoT platforms support it.	The device in the smart residence may not be allowed to store the data within the medical record. This may be a temporarily or a permanent issue.	Measure Vital Signs
44	The system MUST allow the registration of IoT platforms with the purpose of subsequently enabling them to register their IoT services (Req.1). The system MUST allow to unregister an IoT Platform.	The platform hosting the medical record for the workflow, must be registered as an IoT platform. Subsequent sensor registration will be performed for each user and type of vital sign. When the medical record is no longer available, symbIoTe must be aware of this situation to no longer provide this information to other IoT platforms.	Measure Vital Signs
Security_1	The system MUST offer mechanisms for the authentication of symbIoTe entities/actors i.e.,	The measured vital sign may not be stored for a certain user on a target platform. It must be ensured, that only authorized platforms can store data on the target	Measure Vital Signs

	users/application developers, IoT platforms, developed applications and clients.	platform for a specific user.	
Security_2	The system MUST offer mechanisms for the authorization of symbIoTe entities/actors i.e., users/application developers, IoT platforms, developed applications and clients.	The measured vital sign may not be stored for a certain user on a target platform. It must be ensured, that only authorized platforms can store data on the target platform for a specific user.	Measure Vital Signs
Security_8	The system MUST preserve end-user privacy. (E.g. locations of end users / sent sensor data and their identity, e.g. via data anonymization)	Vital signs may give a strong link to an users identity, hence the system must take adequate measures to protect this users privacy.	Measure Vital Signs
Security_10	The system MUST ensure privacy protection on each layer, do not publicly expose e.g., devices information or application used by applications.	A sensor measuring vital signs used locally within a smart space must not be exposed publicly.	Measure Vital Signs

6.2 Use Case 2: EduCampus

The EduCampus use case is inspired by the eduroam (EDUcation ROAMing) initiative. The key idea behind both concepts is to agree on a common framework to harmonize infrastructure services, in order to provide researchers, teachers and students easy and secure access to campus services when visiting campuses other than their own. While eduroam focuses on network access, the EduCampus use case aims for IoT middleware services.

The vision behind the EduCampus is following. When looking at the rapidly growing market for sensors included in smart devices, used in or attached to smart buildings, establishing smart campus infrastructures, there will be rich offering of services based on IoT middleware installations on a campus. Examples are climate control systems in workplaces, electronic access control systems, indoor location and navigation support, guidance systems for handicapped people, location based collaboration support, or room information and reservations systems as discussed in the EduCampus showcase below.

Sometimes these services will be unique to certain campus, but in many cases there will be very similar services on different campus, but realized in deployment specific ways. This will result in services, which are functionally identical for different campus solutions, but technical incompatible for visiting campus users. In any case there will be multi-platform deployment, consisting of different IoT-domains and also of different IoT-middleware products. By facilitating the symbIoTe interoperability framework for campus deployments, EduCampus aims to be the incubator for interoperable IoT-platform federations.

6.2.1 CANVAS

The underlying idea behind the business model is to improve the attractiveness of the own campus, by adding associated campuses and achieving a harmonized federated campus infrastructure. As supporting measures, the business model can be opened to third party services, if campus owner chooses to enable such offerings.

The following business CANVAS analysis (cf. Figure 12) shows the key elements of federated campus services.

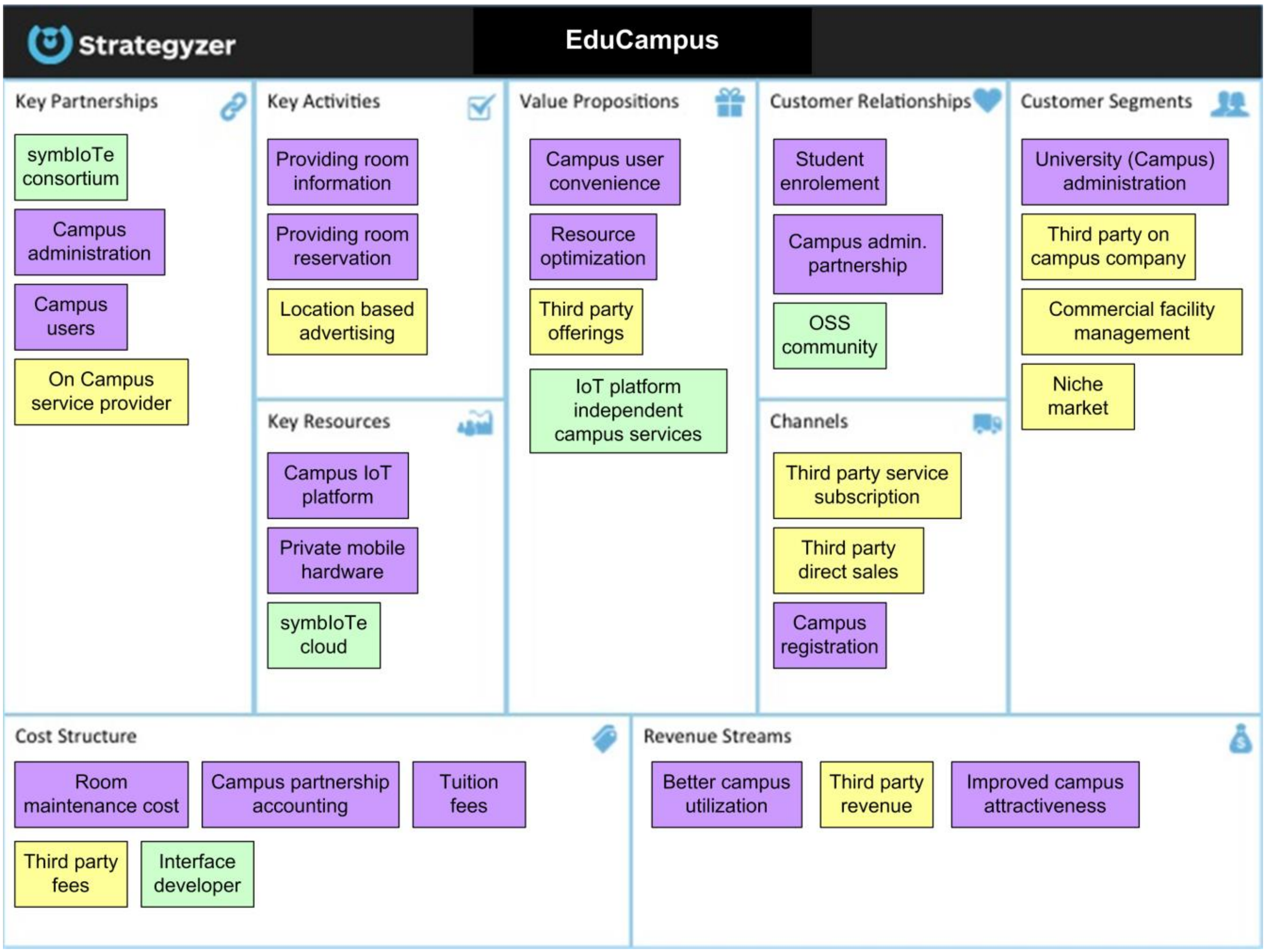

Figure 12: CANVAS for use case “EduCampus”

The **key partnerships** containing the stakeholders to establish a connected campus services and to maintain it are the symbIoTe consortium, the campus administration, the campus users, and the campus service providers. Those stakeholders have different tasks to fulfil. The symbIoTe consortium will organize and support the framework development community providing the common software components and development guidelines. The campus administration as the campus service and infrastructure owner will be responsible for any kind of service level agreement between campuses. The business interest of the campus administration is to lower the administration costs and to improve the user experience for individual campus users. The campus users will be the main clients for the federated campus services. For the tuition fees the campus users are authorized to use certain campus services. Campus service providers (e.g., library, printer centres, room occupation facility) are third parties, who are providing value added services for the campus users or the campus administration. An example could be a coffee shop providing bookable meeting space with a catering service.

Concerning **value proposition,** EduCampus aims to enhance the campus user convenience and at the same time optimize the resource allocation. Third party offerings are included to extend the basic campus service. The symbIoTe framework will enable IoT platform independent campus services making different campuses interoperable and therefore provide the same user experience when visiting a remote campus.

The **customer relationships** are mainly the following three: (1) Student enrolment with a certain home campus administration, (2) campus administration partnerships between two associated campus organizations, and (3) the Open Source Software (OSS) community to provide common software framework to different campus facilities.

Concerning **customer segments** the following observations were made: (1) A University (campus) administration is the main target customer segment for this use case. (2) A Third party on-campus company can be considered as a secondary customer segment. Such companies will benefit from an easy accessibility for the campus users. Their offerings will enrich the campus service attractiveness. It is assumed that these services are accompanied with service level agreements, like rental costs for rooms. And (3) a commercial facility management company, which may be responsible for several associated campuses, is also a typical customer segment. However, this segment will not be in the focus of the first use case development phase.

As **revenue streams** the three were identified for this use case and are briefly described in the following:

- Better campus utilization will lead to a more efficient usage of costly campus infrastructure. This will save maintenance costs for the campus administration.
- Third party revenue will increase because of better visibility of their services to campus users.
- An improved campus attractiveness will lead to an improved user experience and the working quality on the campus. This will increase the value of the campus.

6.2.2 Showcase Specification

In the following, the showcase and related workflows for the use case of EduCampus are described. An overview is given in Figure 13.

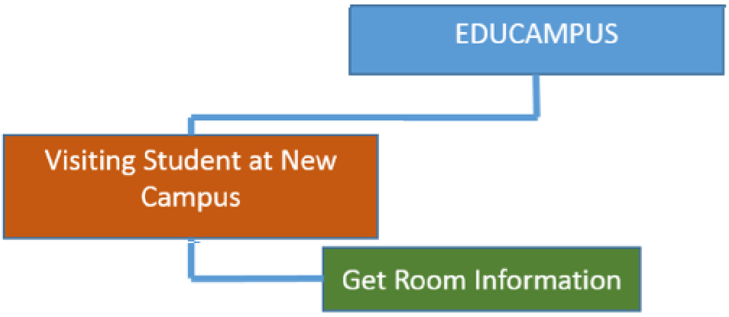

Figure 13: EduCampus showcases and workflows

6.2.2.1 *Setting of Showcase:* Visiting Student at New Campus

Legacy campus applications, like facility management systems or course and education management systems, are in most cases long-lasting and well-adapted frameworks for a given campus. Experimentation with such systems is only possible under well-controlled conditions and it requires a high initial effort to setup the development and test environments.

To create a showcase for the EduCampus vision, a connection is made to already existing experimentation environments of different campus applications. These platforms are created in order to enable experimentation, and to extend and change the platforms was it would not be possible with an operational system.

However, the experimental platforms are containing the limitations of the real operational systems. An important limitation is that each campus application is using its own representation of the managed assets. That implies a platform specific modelling of assets, a specific view on these assets and a specific way to control assets. A consequence for the federation of campus applications within the EduCampus use case is the capability to deal with assets from a remote campus as they would be modelled like the own assets. That is an essential requirement for the symbIoTe framework.

In this showcase three platforms are involved: The KIT SmartCampus system, the IOSB Building Management solution, and the experimental platform EDITA.

The KIT SmartCampus system is an experimentation campus information management system to provide building and room information. There is a dedicated emphasis on handicapped people, which are requiring specific information about potential access barriers to buildings and rooms.

In 2016, the Fraunhofer ISOB developed an advanced building management systems for its building in Karlsruhe, Germany. The management solution is called IOSB Building Management and its indentation of this system is to enable experimentation with building automation within an operational environment.

The Fraunhofer IOSB has a cooperation with the Laboratory of Computer Sciences, Paris 6 (Labortoire d'informatique de Paris 6; LIP6), which is a part of the 4TUUniversité Pierre et Marie CurieU4T (UPMC). In the framework of this cooperation, an experimental version of the existing facility management system of the UPMC administration is available. This experimentation platform, called EDITA, has read access to live data of the operational system. In cooperation with the partners at LIP6 it is possible and even expected to setup new kinds of applications.

Concerning involved sensor in the assumed showcase the following can be stated: Each campus deployment will have an individual selection of sensors associated to certain campus buildings or rooms. The association will be depending in the campus deployment strategy, as a smoke detection sensor may be associated to a floor containing several rooms, or to a temperature sensor may be located inside a conference room, or a weather sensor may be attached to a building. Because of these deployment variations, the selection of sensor information for a given room will be resolved based on the actual data model for the campus and the availability of sensor data. A specification of sensors is listed in Table 12 and the following actors are assumed:

- Campus User: A person that is using campus services. The campus user will be carrying mobile devices and will use services provided by a campus. A campus user is registered to one campus.
- Home Campus User: A “Home Campus User” is a “Campus User” which is currently located on its registered campus.
- Visiting Campus User: A “Visiting Campus User” is a “Campus User” which is currently located on a remote campus, associated to its registered campus.

The visualisation of the resulting sensors will depend on the actual platform user interface. A simple example is presented in Figure 14 illustrating the available sensor data for a given room in various display forms. Some data are shown in simple text, some as gauges or time services. In the case of this platform, the display form will be chosen based on the type of the sensor data. Additional sensors will be integrated for the proximity measurements based on the Bluetooth Low Energy standard. Further, the sensors to be used on campus UPMC and KIT are to be defined in the year 2017 in cooperation with the Consortium partners in Paris and Karlsruhe.

Figure 14: Sensor stream visualisation for the IOSB building management

For the showcase, only one workflow is associated, which deals with the question to get room information. The respective workflow is characterized in Table 13 and demonstrates the capability to use campus services by using a federated campus application. The resulting sequence diagram is shown in Figure 32 in the Appendix. Table 14 provides the most relevant requirements needed for implementation of the workflows described above. The full set of requirements is defined in D1.2 [24].

Table 12: Sensors within IOSB Building Management Platform in Karlsruhe

	Datastream Description	**Name**	**Symbol**
Central Energy Consumption Unit	Electricity Consumption of 1 – 6	Energy	kWh
	Total heat consumption of building	Energy	kWh
	Thermometer3 - Freigelände vor RZ	Degree Celsius	°C
Single Rooms			
Room S011	Humidity Room S011	Percent	%
	Temperature Room S011	Degree Celsius	°C
Room S021	temperature setpoint Room S021	Degrees Celcius	°C
	comfort economy weight Room S021	t.b.d.	t.b.d.
	air quality Room S021	t.b.d.	%
	ventilation setpoint S021	m3/h	m3/h
	presence Room S021	Persons	P
	thermostat setpoint Room S021	points scale 1-10	Points
	Temperature Room S021	Degree Celsius	°C
	Humidity Room S021	Percent	%
	CO2 Concentration Room S021	Parts Per Million	Ppm
Room W535	Humidity Room W535	Percent	%
	CO2 Concentration Room W535	Parts Per Million	Ppm
	comfort economy weight Room W535	t.b.d.	t.b.d.
	air quality Room W535	t.b.d.	%
	Temperature Room W535	Degree Celsius	°C
	thermostat setpoint Room W535	points scale 1-10	Points
	ventilation setpoint W535	m3/h	m3/h
	presence Room W535	Persons	P
	thermostat setpoint Room W535	points scale 1-10	Points
	Temperature Klimasensor 1 W535	Degree Celsius	°C
	Humidity Klimasensor 1 W535	Percent	%
	CO2 Klimasensor 1 W535	Parts Per Million	Ppm
	Anwesenheit in Raum W535	Binary	
	Türkontakt 1 W535	Binary	
	Binär-Sollwert Fenster W535	Binary	

Table 13: Workflow for getting room information

Description	A Campus User is registered to a campus A and is visiting a campus B and uses its own campus A application to get room information from the campus B application.
Trigger	Campus User request
Pre-Conditions	**Pre-condition 1** - Campus user is registered on campus A **Pre-condition 2** - Campus A and campus B are associated by a service level agreement that allows the service invocation by remote registered users.

	Pre-condition 3 - Visiting campus user is located close to a room on campus B
Involved Actors	Visiting Campus User
Sensors Involved	Single room sensors
Platforms Involved	IOSB Building Management and KIT SmartCampus
Process Flow	*1.* Visiting campus user request information from campus A service *2.* Campus A service detects current location on campus B *3.* Campus A service forwards information request to campus B service *4.* Campus B service provides requested information to campus A service *5.* Campus A service answers request from visiting campus user
Alternative Scenarios	None.
Assumptions	Information request exchanges between campus A and B involves model transformation performed by the symbIoTe framework.
Domain Level / Compliance Level	Level 2

Table 14: Requirements for ISOB showcase based on Deliverable D1.2 [24]

Req. #	**Req. Description**	**Why is this requirement important and relevant for the use case (short description)**	**Relevant for UCs**	**Workflow**
43	The system MUST support an 'attribute mapping functionality' through which it is possible to map attributes generated/released in one IoT domain to the same/similar attributes valid in different IoT domains.	The actual data must be mapped from a remote attribute representation to a local one. This also includes user credentials associated to attributes.	EduCampus	Get Room Information
67	symbIoTe MUST accept visiting devices to be merged in the visited Smart Space.	Campus user need to use personal devices in a visiting campus.	EduCampus	Get Room Information
69	The system MUST support arbitrary extensions of the common information model for the description of available IoT services across different IoT platforms.	The connection of services from two different campus management systems with different IoT deployments and different semantics must be possible.	EduCampus	Get Room Information

6.3 Use Case 3: 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.

Another common usage of Stadium venues is hosting large concerts or other musical events (such as musical festivals) where concerts do have similar patterns to sporting events (short duration of up to few hours), but music festivals often last for longer periods of time – both within the day, but can also span multiple days. For most showcases and workflows there are no significant differences in services provided between the two (music and sport events) but where differences exist they are noted. However, the provision of those services require the use of several technologies based on different IoT infrastructures, either permanently installed in the stadium or deployed or made available for a specific event, in any case 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.
- Specific care is needed in case of emergency services which are also offered either by stadium manager or organization – primarily locating and notifying emergency services provided on site (emergency medical teams and security personnel) – this kind of services are specially needed in (electronic) music festivals due to higher incidence of both security or medical emergencies.
- 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 become 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.

All these services, and many more that can be defined in the scope of Smart Stadium solutions, require the interaction with different IoT independent platforms that would require very complex programming and adaptation to the characteristics of the specific platforms deployed in each stadium. For example, any location-based service will require interacting with a geolocation/indoor location service, which implementation may dramatically change from one stadium to another (open air stadiums where at least some areas are covered with GPS positioning or closed halls/arenas which fully require indoor location service), while this will happen seamlessly with symbIoTe-enabled platforms.

6.3.1 CANVAS

symbIoTe's partner Atos has already a running e-payment solution for the Smart Stadium use case in place, called Worldline [26]. This solution positioned Atos as a main actor in the sports and events market in the home country. However, this is a very specialized market with high competition. It requires being able to comply with the challenge of continuously providing always-innovative solutions such as the envisioned one in symbIoTe. Therefore, in contrast to the other use case owners Atos performed CANVAS from their specific view having Worldline in mind. Even if there are not too many providers of smart stadium solutions, at the same time the number of stadiums with the potential to implement such a solution is not very high, resulting in high competition among solution providers. symbIoTe can provide to Worldline a competitive advantage, allowing Atos to develop more valuable solutions at a lower cost.

The value of symbIoTe for Atos is on the possibility to use symbIoTe technologies to enhance Atos Connected Solutions Worldline, as a Hub, to make possible selling services more flexible and extensible. This includes among others adding new services (enables rapid and flexible service co-creation) from various IoT platforms (e.g., on-demand media vs. catering) and broaden data collection and interaction from a bigger number of IoT devices/platforms/solutions extracted from various abstracted underlying platforms with symbIoTe (e.g., localization information provided by multiple infrastructures for low & high resolution).

To validate the aforementioned value, the technical innovations provided by Atos's use case are the following, the last two are mentioned for completeness sake even when not symbIoTe-enabled, because they strengthen the envisioned application: (1) Provision of a symbIoTe-enabled stadium app, which seamlessly integrates services from four underlying IoT platforms (Beacons/indoor location network; Network of Information devices; Network of Retailers devices, and Monitoring Network), (2) symbIoTe-enabled privacy and security services, (3) provision of indoor location services in a high-density environment, and (4) Multi-tenant services on top of several independent infrastructure.

The value for Atos is enormous. For example, the Worldline Smart Stadium solution will open the stadium to new added value services that can be offered not only by the stadium manager, but also by third parties, or will also be able to provide new personalized services that enhance the visitor experience in the stadium. Thus, Atos envisions expanding their confidential business model around for Worldline. Influenced by symbIoTe technologies Atos envisions becoming a broker in service offering and can introduce a multi-level IoT value chain (platform operator/ owner of stadium and/or localization infrastructure; IoT service provider; on-demand media/parking/catering/etc.; services; system integrator or full experience IT provider).

The CANVAS shown in Figure 15 fully describes Atos intention for advancing the use case into the innovation pipeline, due to a clear value proposition to some of Atos' customer segments within the framework of current solutions for Smart Stadiums, and therefore advancing these solutions to provide better business value. Therefore, the CANVAS describes Atos' business model when adopting symbIoTe technologies and the results of the use case into Atos' own commercial line-up. However, as a business model CANVAS, this represents, at this point in time, the initial vision, and therefore will be pivoted as necessary. Some parts of the business model are confidential and, thus, not mentioned at all in CANVAS or only named very abstract.

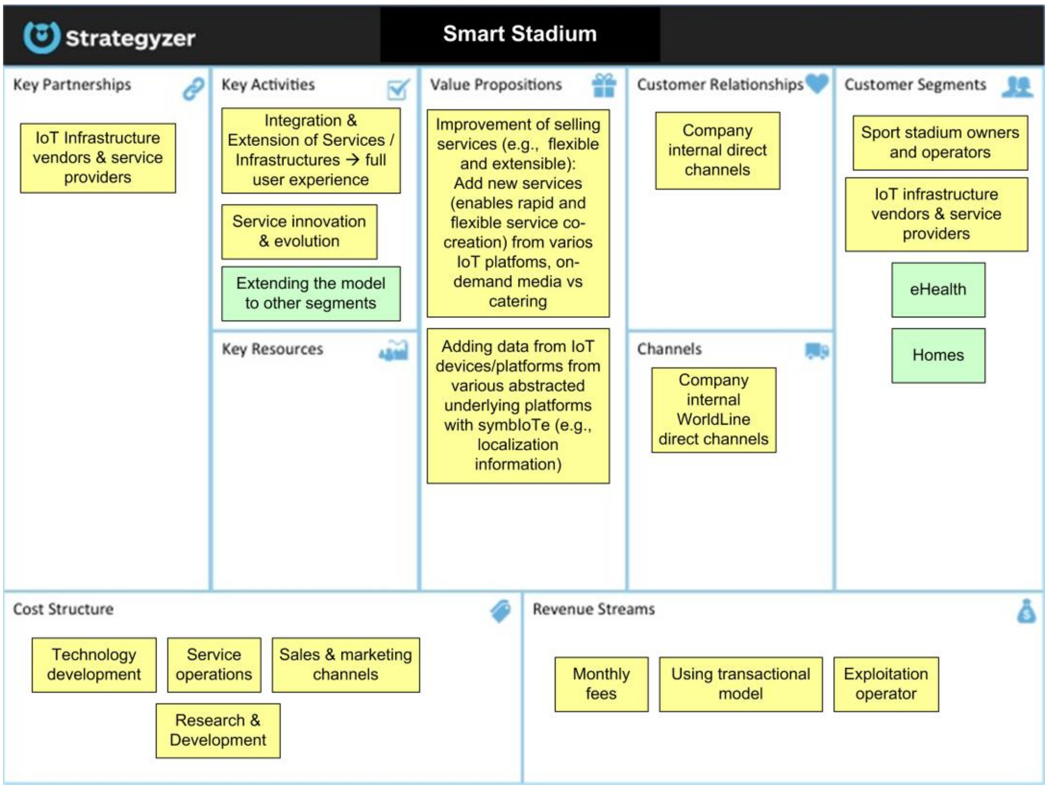

Figure 15: CANVAS for use case “Smart Stadium”

Concerning **customer segments,** the Smart Stadium solutions are directly targeted to Sport Stadiums owners and also, to operators and IoT Infrastructure Vendors & Service Providers providing services that we can partner with. Other segments are envisioned to be events that are specific designed for end-users, such as music events.

Concerning **customer relationships** and **channels** it can be observed that both are managed by Atos direct channels as a world leading IT Providers and handled confidential. Thus, it is not allowed to go into details here.

Concerning **key partnership** in this model two are the expected most important partners: First IoT Infrastructure Vendors & Service Providers and second, IoT Service & Solution Providers as part of the full value chain of solutions involved in Smart Stadiums. More can appear depending on specific showcases.

Concerning **key activities** in this model, Atos envisions that the main activities will be around (a) integration and extension of services and/or infrastructures providing for end-user an amazing full user experience (e.g., live data of the event and further information taken part behind the scenes) and (b) service innovation and evolution. In which the use of symbIoTe technologies in conjunction with other Atos developed technologies will be essential. Also important is to learn from the process of extending the model to other segments.

Concerning **key resources** Atos gained extremely valuable experience in several experiments carried out and technologies used in the Olympic games, and Smart Stadium Solutions is very important. Also important, Atos’ previous experience in managing the full value chain, especially in conjunction with Atos’ capacity as a leading IT system integrator.

Concerning **value proposition** the USP is clear. symbIoTe will help Atos to improve selling services in a more flexible and extensible way. As a result Worldline will be able to (a) add new services to enable rapid and flexible service co-creation from various IoT platforms (e.g., on-demand media vs catering) and (b) to include data from IoT devices/platforms from various abstracted underlying platforms with symbIoTe (e.g., localization).

Concerning **cost structure** and **revenue streams** anticipating at this point the cost structure and revenue stream is a very challenging task. However, the use case is expected to be merged into current solutions for Smart Stadiums offerings, therefore major costs on technology development, service operations, sales and marketing channels, and of course, on R&D are expected. In terms of revenue streams, the use case in conjunction with Worldline involved sales' unit are experimenting with the following options: (a) Monthly fee, (b) transactional model (by evaluation of number of users and/or transactions), and (c) exploitation operator (by evaluation of percentage on revenue).

As pointed out by the consortium partners, such symbIoTe-enabled event or stadium smartphone application as described by CANVAS before can also be provided by (music) event organizers. Here the application typically includes line-up and schedule information of the event, basic venue map and additional premium audio/video content. It is envisioned that by connecting such application to other symbIoTe-enabled platforms and systems would either provide some data or act as an enabler for the environment. One typical use case could be indoor geolocation or information to opera events. Due to the fact that this scenario is just an initial idea for further developments of the use case it is ignored in the upcoming showcase description for the moment.

6.3.2 Showcase Specification

In the following, the showcases and their related workflows for the use case of Smart Residence is described. An overview is illustrated in Figure 16, where three showcases are assumed.

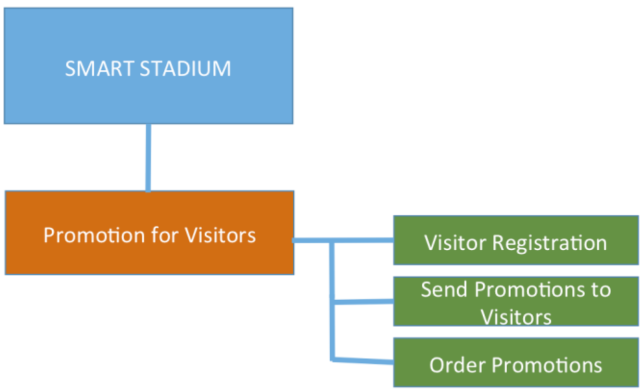

Figure 16: Smart Stadium showcases and workflows

6.3.2.1 Setting of Showcase: Promotions for Visitors

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, and advertising panels. Most of these services are provided by third parties, and it is essential for them to reach as many customers as possible while optimizing 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 optimization 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), Alice (42) and their son John (10), 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. On their way to their seats, they find several interactive panels with information about the stadium and many interesting offers. Alice discovers that there is 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 favorite 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 easily go to the kiosk to just pick-up the T-shirt with no queues.

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.

Since there are complex interactions among the different platforms involved in this use case, Figure 1 illustrates those relationships and the way in which the Smart Stadium use case takes advantage of symbIoTe.

As before, most workflows equally apply to music festival environment, both in open-air stadium or closed arenas/halls. Primary differences are in number of visitors within the Stadium (in example, stadium with sporting capacity of 35.000 seats can have double this number of visitors in concert/festival environment). Also, while concerts do have similar duration to sport events (of several hours), music festivals can last for several days and last much longer opening hours (over 12 hours in a day). Especially electronic music festivals are known for having some specific requirements on emergency medical services and security services – example of three-day Ultra 2016 music festival in Split, Croatia (150.000 visitors over two day program) included over 200 emergency medical interventions (with some hospitalization) and almost 200 people detained by security service and police (2/3 due to drug-related incidents and remaining due to disorderly conduct). So some additional workflows would be needed, and Smart Stadium apps would need to include solutions such as panic button to summon either security staff or police (in case of physical assault) or emergency medical staff (in case of medical emergency).

Geolocation of the panic button activation would enable emergency services staff to converge on the affected person(s). Other workflows - access & registration, promotions and coupons, locating and purchasing from vendor food and drink stands are same as in typical sport events, just with differences on longer working hours, possibly with smaller peaks in service distribution over time (no typical half-time effect).

For this showcase four platforms are involved, and a fifth optional platform could also be included namely: The user platform, the beacon platform, the promotion and information platform, the remote ordering platform, and the optional mobile/wireless access network platform.

This Users Platform comprises all the visitors' devices (smartphones, tablets) that have been registered through the Smart Stadium app. The platform manages these devices as IoT devices that a third party can locate and access. It is important to mention that the platform does not link any device information with any personal data.

The Beacons Platform takes care of the underlying beacons distributed throughout the stadium. It is a static inventory of beacons containing the following information from each one: Identifier, characteristics, the location based on tags (e.g., floor-1, corridor-2, door-3), and a static image with the beacon located in the stadium.

The Promotion and Information Platform manages all devices that display promotions and that can be used to consume those promotions. It 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.

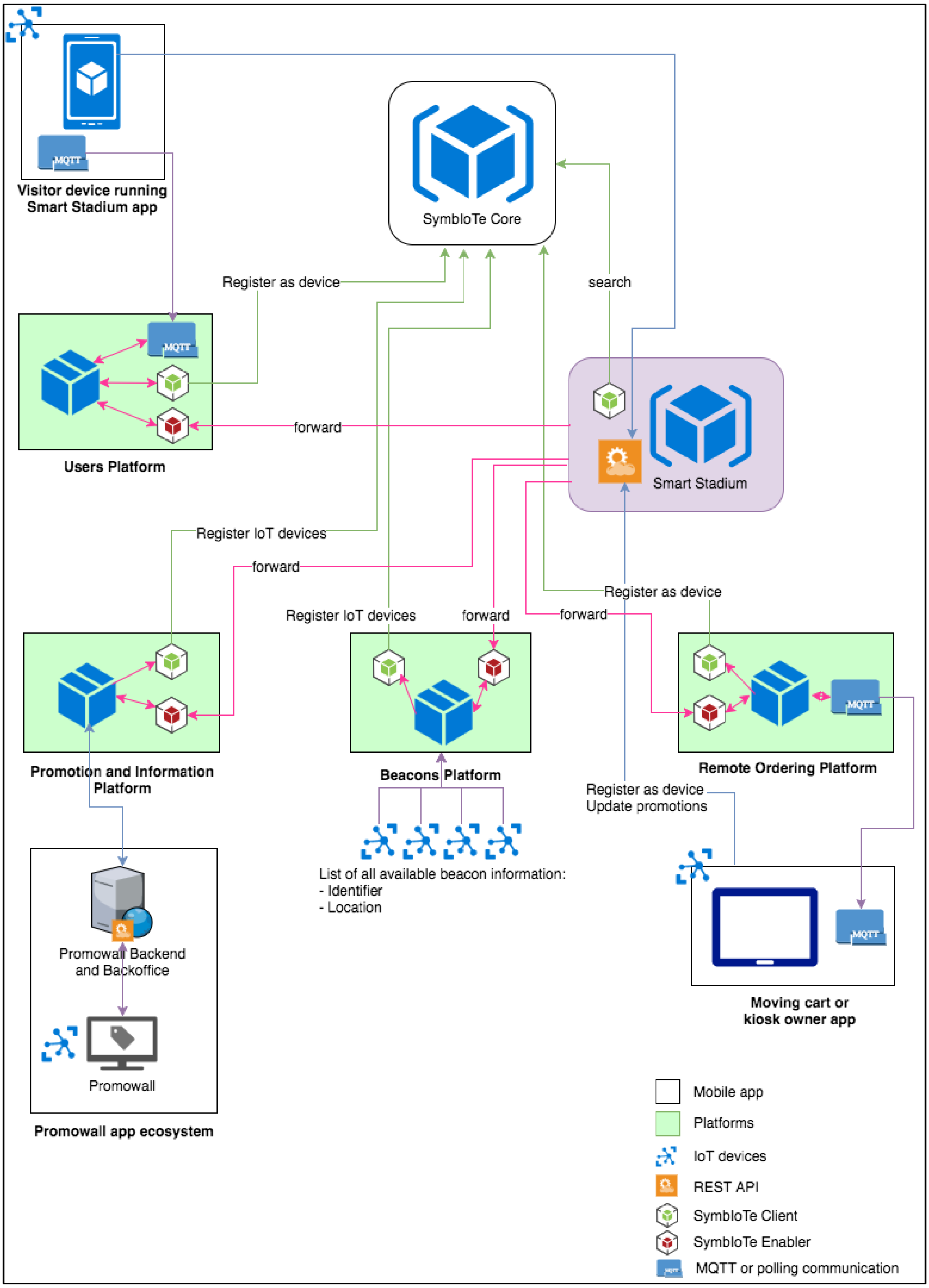

Figure 17: Platforms involved in the Smart Stadium use case

The Remote Ordering Platform manages retailer devices (kiosk and moving carts), and published promotions and coupons. It 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.

The optional involved platform is the Mobile/Wireless Access Network Platform. Apart from beacon-based indoor geolocation, mobile and wireless LAN networks can also be utilized as a method for indoor geolocation, or can supplement the beacon-based system. Mobile access networks utilize complex small-cell systems (Distributed Antenna Systems, micro-cells and pico-cells), which can provide geolocation (cell identifiers can be used by Smart Stadium app to provide geolocation even without any integration with mobile network Operation Support Systems). Future development of 3GPP-based mobile networks (future Release 14) includes activities in providing indoor location services. With wireless LAN networks that can be provided by stadium operators, same principle applies – even without tracking individual users and their data, Smart Stadium app can be instructed to identify access points and map them to geolocation.

In this showcase four types of sensors are involved – the visitors' mobile devices, beacons, promowalls and the retailer devices. The visitors devices such as smartphone (or tablets or any other device running Android), which are registered through our Smart Stadium app, which provides an identifier (this is the only identifier in terms of this show case, so no personal data is used), location and availability to receive notifications from third parties. Figure 19 shows some app screenshots on a mobile device. Beacons are a class of Bluetooth low energy (BLE) devices that broadcast their identifier to nearby portable electronic devices. Examples for such beacons are illustrated in Figure 18. The technology enables smartphones, tablets and other devices to perform actions when in close proximity to a Beacon. It is typically used to enable location or proximity based functions.

Promowalls (cf. Figure 21) are large touch screens that display promotions from service providers whom have been granted access to them. Visitors use them to check and access promotions and coupons. The Promotional Wall solution by Worldline consists of three parts: a Digital Signage screen for displaying the coupons, a campaign manager that enables merchants to create coupon programs, and the consumer app to capture coupons and redeem them at the store. In the case of the Smart Stadium use case, the Promowall app will be an integral part of the Smart Stadium app.

Retailer devices are the devices used to receive, display and manage promotions and coupons by retailers (kiosk managers, moving cart owners). These are very simple devices just provided with communication capabilities and a display. Several implementations are possible; it can be for example an Android tablet with a specific app designed for this purpose, or even a specifically designed device, usually based in very affordable platforms such as Raspberry Pi (cf. Figure 20). Retailer device in some jurisdictions needs to be permanently on-line as it needs to provide "fiscalization" service (real-time bill confirmation by tax authority), thus permanent and high-quality connectivity service is required for such devices (either by providing specialized network infrastructure or prioritization in existing communication network infrastructure).

Figure 18: Beacons from different brands

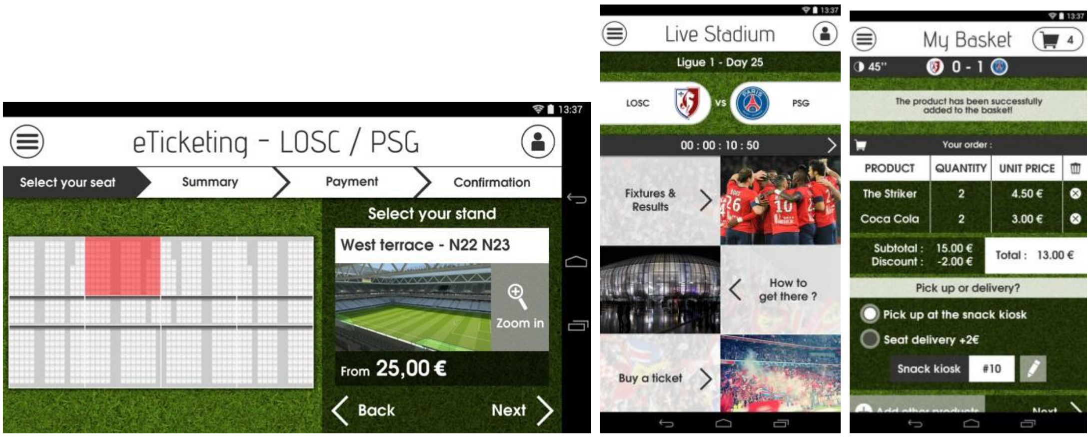

Figure 19: Smart Stadium enabled visitors' mobile devices

Figure 20: Hardware platforms suitable for the implementation of the Retailer Device

Figure 21: Promowalls for the Promotion and Information Platform

Based on the above-described settings different actors are also involved in this showcase and briefly described in the following:

- 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 Promowalls.
- Service Providers: Services providers provide complementary added value services to stadium visitors, such as food, 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, two different service providers are in the direct focus: (1) Food and Beverage moving carts, (2) Kiosks (souvenirs, magazines, newspapers, etc.), and (3) information content distribution.
- Stadium Managers: The stadium manager has the responsibility of managing all stadium services, from the most basic ones (ticketing, access, emergency medical services, security staff…), to the added value services. They setup the stadium infrastructure for service providers.
- Network Infrastructure Providers (optional): Stadiums and arenas are very complex communication environments, due to extremely high density of users, which require very specialized network solutions – both wireless LAN networks (that can be also provided by Stadium Manager), but also mobile access networks for providing connectivity to visitors. In addition, network infrastructure needs to provide connectivity for third-party vendors and service providers present on the location.

For this showcase of the use case Smart Stadium three workflows are associated, namely Visitor Registration, Send Promotions, and Order a Promotion. The respective workflow descriptions are given in Table 15 to Table 17 and the resulting sequence diagrams in Figure 33 to Figure 35 in the Appendix.

Table 15: Workflow 1 for Visitor Registration

Description	Visitors' phone is registered as IoT device.
Trigger	The visitor initiates the process by entering the stadium.
Pre-Conditions	**Pre-condition 1** - Visitor app is in visitors' devices. **Pre-condition 2** - Visitor arrives at the stadium. **Pre-condition 3** - All the required hardware devices are already in place: Beacons are distributed throughout the stadium **Pre-condition 4** - Beacon Platform is configured (inventory) with the location of all beacons in the stadium
Involved Actors	Actors involved in this showcase are the visitors
Sensors Involved	Beacons distributed across the stadium and visitors' smartphone.
Platforms Involved	User platform and Beacons platform
Process Flow	*1.* The visitor launches the Smart Stadium App *2.* The visitor app asks Smart Stadium for the list of beacons with their locations *3.* Smart Stadium asks Beacon Platform for the beacon list and maps and returns it to the Smart Stadium App

	4. The visitor app identifies beacons around to calculate visitor's position *5.* The visitor app calculates its location based on distance of closest beacons and registers itself in Smart Stadium using this information *6.* Visitor app registers itself into the User Platform, which implies registering the visitor's phone in symbIoTe as an IoT device of the User platform *7.* The visitor app requests Smart Stadium the list of available services *8.* The visitor app shows the visitor all services
Alternative Scenarios	None.
Assumptions	None.
Domain Level / Compliance Level	L1, L2

Table 16: Workflow 2 for Send Promotions

Description	Service providers send promotions to visitors and to promowalls
Trigger	Service providers initiate this workflow searching for near visitors and promowalls in the stadium.
Pre-Conditions	**Pre-condition 1** - Service provider is properly authorised to publish promotions. **Pre-condition 2** - User platform has registered all visitor devices into symbIoTe Discover service. **Pre-condition 3** - Smart Stadium App is installed and running in visitors' devices. **Pre-condition 4** - Promowalls are properly registered, configured and network reachable
Involved Actors	Actors involved in this showcase are visitors and service providers.
Sensors Involved	Visitors' smartphones, retailer devices and promowalls.
Platforms Involved	User platform and Promotion and information platform
Process Flow	*1.* Service provider (either kiosk manager or F&B manager) wants to send promotions to visitors in a specific area (close to him) and promowalls *2.* Service provider asks Smart Stadium for visitors and promowalls in that area *3.* Smart Stadium performs the request to symbIoTe *4.* Service provider app iterates through visitor list and sends promotions to them, via Smart Stadium 5. Smart Stadium forwards this information to User Platform 6. For each Promowall, retailer app sends promotions and coupons to it via Smart Stadium *7.* Smart Stadium forwards the information to Promotion and information platform
Alternative Scenarios	None.
Assumptions	symbIoTe Core allows searching IoT devices by meta attributes: - Location. E.g.: hall, corridor 4, etc. - Feature. E.g.: visitor-device, WC-device, moving-cart-device, shop-device, promowall-device, etc. Received device info contains: - Unique identifier - Endpoint to send messages to it
Domain Level / Compliance Level	L1, L2

Table 17: Workflow 3 for Order a Promotion

Description	Visitors place an order to the closest moving cart.
Trigger	The visitor initiates the process by looking for available moving carts around.
Pre-Conditions	**Pre-condition 1** - Smart Stadium App is installed and running in visitors' devices. **Pre-condition 2** - Visitor devices are properly registered to the system and located in the stadium. **Pre-condition 3** - Moving carts are properly registered and located in the stadium. **Pre-condition 4** - Promotions and offers are configured for each moving cart.
Involved Actors	Actors involved in this workflow are visitors and service providers (in this example moving cart owners).
Sensors Involved	Moving cart tablet (retailer device) and Visitors' phone (indirect, located).
Platforms Involved	User platform and Remote Ordering Platform
Process Flow	1. The visitor wants to order some food and launches Smart Stadium App to list all moving carts around. 2. Smart Stadium App requests Smart Stadium for moving carts around. 3. Smart Stadium forwards the request to symbIoTe. 4. Visitor selects a moving cart, the closest one. 5. Smart Stadium App requests Smart Stadium for the cart offering. 6. Visitor selects the products he wants. 7. Smart Stadium App sends the order to Smart Stadium. 8. Smart Stadium forwards the request to Remote Ordering Platform. 9. Remote Ordering Platform sends the request to the appropriate moving cart. 10. The Retailer App displays the order to the cart owner. 11. The cart owner accepts the order. 12. The Retailer App sends an acknowledge message to Smart Stadium. 13. Smart Stadium forwards the ACK to User Platform. 14. The User Platform sends the ACK to the appropriate visitor device. 15. Smart Stadium App displays the notification and the visitor waits for his order to arrive. 16. The cart owner uses Retailer App to look for the visitor who placed the order. 17. Retailer App requests Smart Stadium for the visitor location. 18. Smart Stadium forwards the request to symbIoTe. 19. Retailer App displays the visitor location. 20. Cart owner walks to the visitor and finishes the purchase.
Alternative Scenarios	This workflow is provided as an example of the many other "ordering" workflows that can be defined in this showcase, for example involving also promowalls. However, all these workflows are very similar and main differences will remain at application level, so the workflow that described in this table can be considered as representative of all these possible workflows.
Assumptions	symbIoTe Core allows searching IoT devices by meta attributes: Location (e.g., hall, corridor 4), Feature (e.g., visitor-device, WC-device, moving-cart-device, shop-device, promowall-device) Received device info contains unique identifier Endpoint to send messages to it
Domain Level / Compliance Level	L1, L2

Table 18 provides the most relevant requirements, only relevant for Smart Stadium use case, needed for implementation of the workflows described above. The full set of requirements is defined in Deliverable D1.2 [24].

Table 18: Requirements for Showcase Promotions for Visitors

Req. #	Req. Description	Why is this requirement important and relevant for the use case (short description)	Work-flow
2	The system MUST expose the available (composite) IoT services to application developers and other IoT platforms. Directory listings and text search are examples of potential interfaces to application developers and platform providers.	Search for visitor IoT devices, get beacon map, remote ordering services, user services, promotions	1, 2, 3
12	The common information model MUST support geo-reference information.	Location of IoT devices: phones, beacons, shops, etc.	1, 2
18	The system MUST provide unique identifiers of the (registered) IoT services within the system. Uniqueness MUST be enforced within and across IoT platform boundaries, including the case of mobile IoT devices.	Refer to a specific service: location, remote ordering, users, etc.	1, 2, 3
38	The system MUST allow applications to subscribe to IoT services to continuously receive the generated data/information, in addition to active requests for information from a used IoT service (when supported by the underlying IoT platform). In this mode of operation the application receives the data whenever this is pushed (published) by the corresponding IoT device.	News service, messaging (incoming promotions, etc.) service can broadcast updates, promowalls need to be updated constantly as well as retailer smart devices and visitor phones, cart owner and visitor needs messages to place and accept orders.	1, 2, 3
39	The system SHOULD support registration updates i.e., IoT platform operators/enablers should be able to update their registered IoT services with SymbIoTe. For example, updating provided information upon sensor/actuator upgrades.	Register or deregister visitors as soon as they enter or leave the stadium.	1, 2
Security_1	The system MUST offer mechanisms for the authentication of symbIoTe entities/actors i.e., users/application developers, IoT platforms, developed applications and clients.	Login and access control.	1, 2, 3
Security_2	The system MUST offer mechanisms for the authorization of symbIoTe entities/actors i.e., users/application developers, IoT platforms, developed applications and clients.	Enable access to authorized platforms and apps as they contain information about visitor locations, even if anonymized.	1, 2, 3
Security_5	The system MUST support the revocation of access rights to users/application developers, IoT platforms.	Logout.	1, 2, 3

6.4 Use Case 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 CO_2 emissions and made inroads into tackling congestion and environmental pollution" [21].

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.

This use case will try to show how, with symbIoTe, developers can use different data from different platforms from different domains easily. This is a big advantage for developers who intend to create complex systems using various sources of data. In the context of smart cities, it will also show how advantageous it is for platform owners and cities to provide their data through the symbIoTe ecosystem, allowing developers/organizations to easily create valuable services to its citizens.

6.4.1 CANVAS

Ubiwhere (UW) the key industrial partner for use case 4, entitled Smart Mobility and Ecological Routing, performed a CANVAS analysis from their perspective. UW provides and adapts their smart cities platform for symbIoTe to provide data on parking occupancy, traffic metering, and air quality monitoring. Additionally, their router will be used for the ecological routing purpose. With these settings they performed CANVAS where the results are shown in Figure 22. The not self-explaining issues, like key partnerships, value proposition, customer relationships, customer segments, and revenue streams, are described in more detail in the following.

The selected **key partnerships** aim at creating the basis of the structure to support the creation, development and implementation of the symbIoTe solution. The hardware providers, a group of partners, support the development and implementation of the solution providing hardware for the testing and operation of symbIoTe. A partnership with device manufacturers allows an easier piloting and dissemination strategy. The Municipalities are the relevant partners for piloting and implementing the developed solution. The mobility services include collective transportation companies, sharing systems such as bike sharing, Mobility management systems. The partnership with these services allows a better integration in the mobility system as well as a brother dissemination of the solution, being accessible in different areas of the city.

Concerning **value proposition** symbIoTe builds its orchestration middleware on top of existing standards for protocols and interfaces, plus a number IoT platforms both proprietary (i.e. developed by its industrial partners) and from open source (e.g., OpenIoT [6]). There are several value propositions related to the technology used for this solution, which are mainly important for developers. The following support is essential to ensure an open and adaptable solution: (1) Interoperability with IoT platforms and with 3rd party services, (2) involvement of enablers (e.g., APIs routes), (3) integration of Cloud-based solution, and (4) support of an open source framework. For the citizens, the main value proposition resides in the Convenience for the routes planning supporting decision making and reinforcing mobility integration, supported by a rewarding system which will be put in place for a more effective user´s engagement, the General interest and support on CO_2 reduction, an important social issue. In addition to all of these added values, it can also support users to improve their health and wellbeing.

Concerning **customer relationships** several platforms and online support are made available for the customers. Some will focus on the developers such as open source development community and specific online platforms and others aim at addressing the general customers e.g. municipalities, citizens and others.

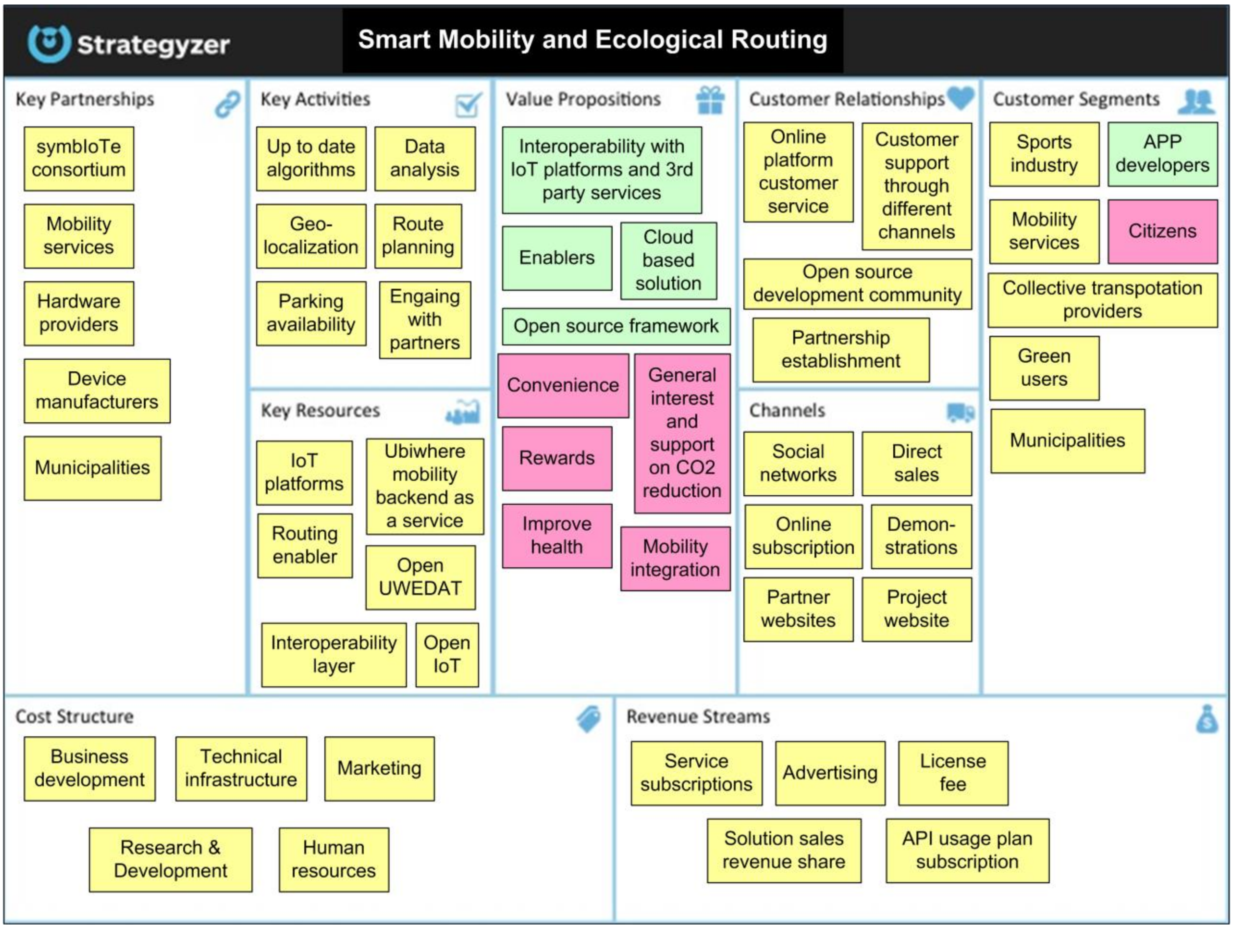

Figure 22: CANVAS for use case “Smart Mobility and Ecological Routing”

Concerning **customer segments** different observations were made: (1) In sports industry there are several target groups, which are potential customers including sportswear, cycling, local business, sports wearable and manufacturers. (2) Application (APP) developers constitute a main target for the development of new apps and solutions for the data provided. (3) Municipalities are potentially interested in improving the quality of lives of their citizens through symbIoTe and promoting sustainable and environmental friendly mobility solutions. (4) Mobility services, such as collective mobility and bike sharing, can acquire this solution as a complementary service provision, improving mobility interoperability. And (5) citizens will be the general users of the symbIoTe solution that can opt for a free or premium access for a daily use.

Two main **revenue streams** have been identified for this use case. First, symbIoTe target audience includes two types of customers: paying and non-paying. Non-paying customers are citizens who join the platform/app interested in exploring the available opportunities in the city. They are the 'critical mass' that creates the solution´s uptake. And second, customers belonging to the fee paying category are essentially municipalities (who pay to have the mobility and ecological routing service in their area), mobility services and local businesses (who pay for the service to be integrated in theirs), premium users (who pay to have certain benefits, such as access to more resources/services) and developers (who pay to use the available APIs). Together they form an ecosystem, which is essential for keeping the platform economically sustainable.

6.4.2 Showcase Specification

In the following, the showcase and its related workflows for the use case of Smart Mobility and Ecological Routing are described. An overview is given in Figure 23.

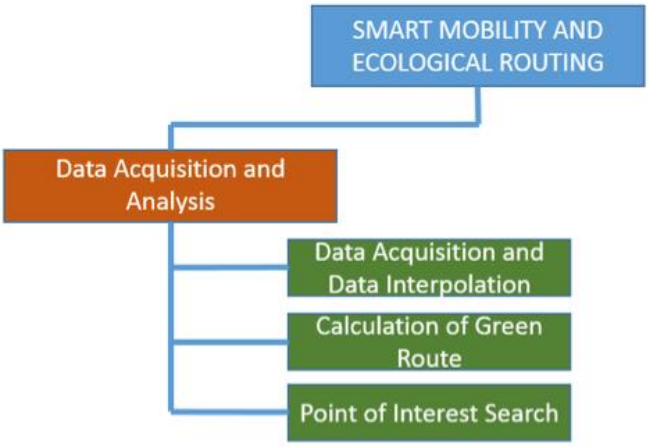

Figure 23: Smart Mobility and Ecological Routing showcases and workflows

6.4.2.1 Setting of Showcase: Data Acquisition and Analysis

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 neighborhood. Mary will organize the event in the old neighborhood, but it has changed a lot in the last years and she does not know which coffee shop to choose. She uses a 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. Since he is late, he requests from the symbIoTe routing application the fastest route for him.

For this showcase are four platforms involved: The Mobile Crowdsensing Air Quality Platform (OpenIoT), the Stationary Air Quality Platform (UWEDAT), the Smart Cities Mobility Backend as a Service Platform (Ubiwhere MBaaS), and the Third-Party System (OpenStreetMap).

The Mobile Crowdsensing Air Quality Platform (OpenIoT[4]) is an open-source Cloud platform for the Internet of Things, developed in the scope of the FP7 OpenIoT project [19]. 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.

[4] http://www.openiot.eu

The cities of Zagreb and Vienna operate Air Quality Measurement Networks, whose data is typically collected from fixed stations. This platform is called “Stationary Air Quality Platform” (UWEDAT [5]). 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.

Currently, Ubiwhere’s middleware platform Smart Cities Mobility Backend as a Service Platform (Ubiwhere[6] MBaaS) 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.

The last platform called Third-Party System (OpenStreetMap[7]) is 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.

Two sensor types are required for the assumed showcase and different actors listed in Table 19 are assumed. The used sensor types are Fixed Sensor Stations and the so called FER Mobile sensors briefly described below.

The Fixed Sensor Stations belong to already existing air quality networks. They are neither operated especially for the symbIoTe project nor has the Uwedat-Platform any influence on the operations. Uwedat just gathers publically available data from the network and makes it available via an interface compatible with symbIoTe. Fixed Air Quality Monitoring stations usually come in form of small buildings or containers. Sometimes there are integrated in existing buildings. The measurement equipment inside such containers works in a very controlled environment, which allows to measure with very high accuracy. Also the measurement equipment is often calibrated and checked against existing standards. Measurement values have to go through different plausibility checks and individual values are sorted out before publication if they are doubtful. This makes the measurements of

[5] http://www.ait.ac.at/en/research-fields/crisis-disaster-management/uwedat/ (last access December 20, 2016)
[6] http://www.ubiwhere.com/ (last access December 20, 2016)
[7] www.openstreetmap.org/ (last access December 20, 2016)

fixed stations very reliable. Fixed stations typically measure a multitude of pollutions - which one depends on which pollutants are relevant at the specific location. The data of fixed stations is usually not available in raw form. Only a processed and aggregated form of the data (hourly mean values) is available for Vienna and Zagreb.

The FER Mobile Sensors are a wearable sensor that measure air quality data on the fly as shown on Figure 24. They are designed and built during the FP7 OpenIoT project by the University of Zagreb team from off-the shelf components which integrate electrochemical gas sensors for measuring atmospheric sub-ppm level concentrations of carbon monoxide (CO), and either nitrogen dioxide (NO2) or sulphur dioxide (SO2) along with other environmental parameters such as temperature, atmospheric pressure and humidity. They are designed to be carried by regular citizens while they are on the move, so that the measured data is annotated with geographical location and sent to a server in the cloud. In such way, citizens collect environmental data during their routine movements enabling large coverage area as opposed to a fixed station that only provide measurements at a location where the station is installed. The shortcoming of mobile sensors is a lower data quality that they offer compared to fixed stations, which include lower precision and accuracy, and high cross sensitivity to other components of the atmosphere.

Figure 24: FER Mobile Sensor and corresponding Android application

Table 19: Actors for showcase “Data Acquisition and Analysis”

Actor	Description
Measurement station	Measures high quality data. The project has no control over this actor.
Uwedat	Uwedat makes the cached data from the data harvester available to the symbIoTe environment. It acts as a “sensor platform”.
Mobile sensors	These sensors measure air quality data and convey it to the OpenIoT platform.
OpenIoT	This platform gathers data from the mobile sensors and makes them available to the symbIoTe environment. It acts as “sensor platform”.
MoBaaS	This middleware platform can gather data from hardware sensors (parking, traffic, air quality), process it and provide it through RESTful interfaces. It also provides a Route planner using different means of transportation.
Interpolator	The interpolator is a “domain specific enabler” component with respect to the symbIoTe platform. It takes available data from the Uwedat and the OpenIoT platform. It also takes the network of roads from the routing system. All this data is combined to calculate pollution concentration for individual road segments. This data is made available to the routing platform through another “sensor platform” interface with the road segments acting as virtual sensors.
Routing system	The routing system acts as a client to the symbIoTe system. It reads out the concentration of individual road segments and caches them locally. When a routing request is issued, the routing system will calculate an “optimal” route taking into account the common parameters: travel time, travel distance, and slope. Additionally, it takes the pollution along the potential routes into account. All this is used to find an “optimal” route.

User app	This application interacts with the user and routing system. It queries the user input and displays the calculated route.
User	Application user.

There are four workflows associated with this showcase: (1) Data Acquisition, (2) Data Interpolation, (3) Calculation of Green Route, and (4) Point of Interest Search. The workflows are described in Table 20.

Table 20: Workflows for Data Acquisition and Data Interpolation.

Description	The workflow focuses on urban environments where users with smartphones and wearable sensors collect data about the air quality around them. The complexity of the workflow 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. After the acquisition of the ecological measurements from sensors, the data is processed (and interpolated when needed) so it can be associated to street segments. This allows the routing service to know the environment conditions from each street and plan its route accordingly. Representatives of data acquisition actors in the physical world are pedestrians, cyclists, car drivers, public transport vehicles or fixed environmental stations. These actors can be grouped by their mobility into two groups: a sensor with a fixed location or a mobile sensor.
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, three different subtypes of contributions are identified: 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). The interpolation process is typically synchronized with the data acquisition process and it is planned to be triggered in regular time intervals.
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. The equipment should be (pre-) calibrated so that the devices provide data of better quality. . **Pre-condition 2** User willingness to contribute sensor data A user needs to be willing to contribute his data for the workflow to be successful. Privacy concerns and devices' energy efficiency can deter users, so these concerns should be addressed. Additionally, monetary rewards could be granted for users who cover less populated areas.
Involved Actors	Air Quality Station, Data Harvester, Mobile Sensors, Uwedat system, OpenIoT system and the Interpolator.
Sensors Involved	Fixed Stations, FER Mobile Sensors
Platforms Involved	In this workflow case, the following subsystems are identified: 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 workflows provided by symbIoTe compliant platforms. OpenStreetMap is used for the interpolation.
Process Flow	*1.* Data Acquisition

	a. User connects to a platform and, if necessary, turns on sensing device *b.* Platform requests data *c.* Device checks if it meets requirements for data acquisition, if so, it starts the process of data acquisition *d.* Platform updates data request (e.g. , the sensing frequency, request for new data) *e.* User devices periodically send data *f.* User spots an event of interest and uploads manually the information about the event *g.* User has reached its end destination and stops the process of data acquisition *2.* Data Interpolation *a.* Gather all data from sensors (for given area, time interval, etc.) *b.* Prepare the interpolation (calculate coefficients) *c.* Get the street segment network from the routing engine *d.* Interpolate for each street segment *3.* Make data available to the routing engine
Alternative Scenarios	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. The Data Interpolation service requires minimal set of sensor readings to be able to interpolate values for other close by street segments.
Assumptions	This process never fails for a longer time so that new data is always available in time.
Domain Level / Compliance Level	L1, L2

Table 21: Workflow for 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, taking into account the air quality measurements retrieved from multiple IoT platforms. The user can be presented various alternative routes and, additionally, during travel, can be rerouted according to new data coming from the sensors.
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 • Routing APIs must be integrated with the service • Routing service must integrate air-quality data obtained from symbIoTe-compliant platforms • User must be able to choose the destination and define several preferences (e.g. mode of transportation) and route-types (e.g. normal, avoid pollution, avoid traffic) • User location must be obtained through geo-location service **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 tasks should be done by the Data Interpolator described in the last workflow.
Involved Actors	Routing System, User App, User

Sensors Involved	None Directly
Platforms Involved	The subsystems required for the workflow is the Smart Cities Mobility Backend as a Service, provided by Ubiwhere, which allows the ecological routing through a symbIoTe-compliant service, which takes into account the air quality measurements collected by symbIoTe–compliant IoT platforms mentioned in the Data Acquisition workflow. It can provide alternative routes and is able to reroute the user according to new data coming in from the sensors. It will also be possible to use the routing service Ariadne developed by AIT. This service is also able to calculate a set of alternative routes including ecological routes based on the air quality rating. In addition, it is possible to calculate intermodal routes, i.e. the best routes using the modes of transport walking, cycling with a private bicycle & cycling with a bicycle rented at the local bike-sharing system.
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 algorithm finds a couple of appropriate routes using the new tags as routing cost *6.* The computed route (along with any alternatives, if available) is presented to the user, along with its corresponding information (e.g. travel time estimation, air quality of the route) *7.* User selects route *8.* Navigation instructions are presented for the selected route *9.* During travel, the user's route can be updated according to new air quality information that arrives from the sensors
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
Assumptions	None.
Domain Level / Compliance Level	L1

Table 22: Workflow for Point of Interest Search

Description	Public places often have different characteristics, e.g., parks or cafés have different Point of Interest Searching workflow 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.
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. **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 workflow) are value-adding parameters for this service.
Involved Actors	The workflow 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.
Sensors Involved	None Directly
Platforms Involved	The Point of Interest Searching workflow 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 workflow 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
Assumptions	None.
Domain Level / Compliance Level	L1

Analysing the four workflows a number of signature requirements can be identified and grouped into the following four major categories: (1) Generic requirement on an information model used in the system (Req.: 3 and 4), (2) detailed description of properties of an information model (Req.: 11, 12, 18 and 19), (3) description and scope of an enabler used in the use case (Req.: 20 and 21), and (4) requirement that describes the functionality of making a long-term requests for data (Req. 38). All those requirements are analysed in detail from the use case point of view. The result is listed in Table 23.

Table 23: Requirements for showcase Data Acquisition and Analysis

Req. #	Req. Description	Why is this requirement important and relevant for the use case (short description)	Relevant for UCs	Work-flow
3	The system MUST support a common information model for the description of available IoT services across IoT platforms.	Since the use case is driven by data from different IoT platforms it is important to use a common information model to describe all available resources, so that application and enabler developers can fetch a resource description using a single information	1,2,3,4,5	1,2

		model no matter on underlying platform.		
4	IoT services SHOULD appear to application developers in a homo-geneous manner i.e., the interface for application developers should not differentiate across IoT platforms. Data source/identity shall be exposed to application developers.	Offering of a homogeneous interface facilitates development of novel services because gathering data from different platforms is done in the same way.	1,2,3,4,5	2
11	The information from IoT services and IoT devices MUST have the units in which the data is described associated to standard unit of the common information model (meters, kg, etc.). The encoding of units should adhere to a standard (e.g., UCUM).	Providing a unit of measurement is crucial in the ecological domain since measurements can be published using various units of measurements (e.g., pollutant gases can be presented in particles-per-million (ppm) or milligrams-per-cubic meter (mg.m-3)). A standard for units of measurements facilitates storing, processing & presentation of data.	1,2,3,4,5	1,2
12	The common information model MUST support geo-reference information.	The use case is heavily dependent on geo-reference data because the use case is focused on users that are mobile across urban areas. Mobile users in the role of data consumer require data based on their current location (e.g. navigation from a current location) and during the role of data producer, a user device annotates sensed data with appropriate GPS location.	1,2,3,4,5	1,2,3,4
18	The system MUST provide unique identifiers of the (registered) IoT services within the system. Uniqueness MUST be enforced within and across IoT platform boundaries, including the case of mobile IoT devices.	Uniqueness of identifiers is important to be able to trace the origin of data at various levels: from the platform level to the sensor level.	1,2,3,4,5	1,2,3,4
19	symbIoTe MUST distinguish IoT devices which are fixed (geo-location does not change over time) and mobile (their location changes).	The use case comprises data from the two different data sources that differ on their characteristics: a fixed station, which provides verified data in a single location, and mobile sensors, which can provide measurements of a lower quality over large areas.	1,3,4,5	1,2
20	The system MUST offer domain-specific enablers that hide from application developers the existence of multiple IoT platforms and resources targeted to a specific domain. The system must manage all	Enablers will offer functionalities to application developers so that they do not have to re-implement the same logic for their applications, rather they can use it as-a-service offered by an enabler. The use case implementation relies on enablers that will encapsulate partial functionality, such as: an	1,2,3,4,5	2,3,4

	the underlying resources, include the required logic, ensure the required quality, performance, etc (see Requirements 2, 5-12) The system SHOULD allow application developers to create their own enablers (focusing on a single domain or be cross-domain), defining their own logic, etc. These "user-owned enablers" should be available at least to their creators.	interpolation of sensor data for areas that do not have enough measurements or routing service from the starting point to destination.		
21	The system SHOULD allow application developers to create their own enablers (focusing on a single domain or be cross-domain), defining their own logic, etc. These "user-owned enablers" should be available at least to their creators.	The use case envisions use of domain-specific enablers during service execution. E.g., an interpolation enabler, which collects data from various platforms and interpolate missing values, will offer interpolated values to routing service (which is also an enabler) but also to any other interested symbIoTe user.	1,2,3,4,5	2,3,4
38	The system MUST allow applications to subscribe to IoT services to continuously receive the generated data/information, in addition to active requests for information from a used IoT service (when supported by the underlying IoT platform). In this mode of operation the application receives the data whenever this is pushed (published) by the corresponding IoT device.	The use case relies on data that is created on-the-fly by citizens. The subscription option would reduce the overhead caused by the successive data requests in the case of polling for new data.	1,2,3,4,5	2,3,4

6.5 Use Case 5: Smart Yachting

Motor yachts all over the European part of the Mediterranean are about 5000 units in the class over 24 meters length, and approximately 3 million around below 24 meters length [10]. According to the *Study on the competitiveness of the recreational boating sector*, published in 2015 by the European Consortium for Sustainable Industrial Policy (ECSIP) [22], Marinas in Europe realise a yearly turnover of almost €4 billion and employ approximately between 40,000 to 70,000 people. Even after the economic crisis of 2008, Marinas continued to invest since it is paramount for them to keep their standards high, in order to continue to attract customers.

The report also noted that in this regard little has been done so far to fully exploit the advantages of Information & Communication Technologies in touristic ports, leaving therefore a significant space that can be filled with innovative proposals. The port is an organization/authority and public space for which it is crucial to implement smart systems that can automate business workflows, to simplify and reduce the costs of their manual execution.

The Smart Yachting use case focuses on facilitating, through automation and by exploiting data from sensors, the processes between the personnel on-board of a boat and the various actors of the Port; these processes are based on the communication and data exchange between yachts, port authorities, port operatives plus the supply companies in the yachting cluster.

The vision behind the use case is to see the whole port as a unique “platform”. In other words, an infrastructure that exposes data and common services to visiting yachts (but in perspective also to tourists coming from inland). Thanks to symbIoTe, it will be possible to automate a significant set of processes by exploiting the interoperability between the IoT platforms of the ports and those of the yachts.

The use case includes two showcases, the Smart Mooring and the Automated Supply Chain. The former aims to automate the mooring procedure of the port, simplifying a quite bureaucratic process (it is important to point out in fact that Marinas operate in strongly regulated contexts). Also in its workflow, a significant number of machine data can be acquired and exchanged: some of them are actually needed by the authorization procedure (e.g. the latest route of the Yacht); others (e.g., fuel consumption, pollutant emissions) are extremely valuable for the Port Authority, in order to produce more accurate analytics about the situation of the port.

The Automated Supply Chain on the other hand is based on the idea of identifying, through IoT sensors, the needs for goods and services on board, so that automated requests for offers can be issued on the marketplace platform in the Port, provided by the Navigo Digitale platform, that can manage any kind of resupply, from maintenance services to consumables. For a Yachtsman in fact the resupply, possibly in an unknown territory, can be quite problematic. The service proposed can provide a much-needed help, since:

- A significant list of “needs” on-board (products, services) can be automatically detected by sensors. This spans from the general need of technical maintenance (for an unexpected fault or for a warning condition detected on a system on-board) to the lack of certain goods, identified by high-end, sensor-based, appliances (e.g., a smart refrigerator).
- The corresponding requests for offers can be transmitted to the providers nearby the port, even without directly knowing them,
- Offers can be received, evaluated and accepted/rejected by the yachtsman, without even leaving the boat!

In general, the smart yachting use case is useful for all kinds of boats with established Internet communication in different ways (e.g., communication, navigation, data exchange). The envisioned goal is to attract first and foremost a great technological value and great excellence demand in services (especially for mega and superyachting over 24 meters length), using it as a leading role for the expansion of other nautical sectors.

Navigo, the key industrial partner for use case 5 performed a CANVAS analysis from their perspective taking customers feedback into account. Navigo provides advanced services to port authorities and other actors of yachting territory cluster through the Navigo Digitale Platform (ND) [28].

6.5.1 CANVAS

The CANVAS analysis (cf. Figure 25) that has been performed by Navigo regards a set of services aimed to automate the information processes between the boat and the mainland, finalized to allow the user on a boat to identify automatically the territorial cluster companies to address specific supplying needs, and – on the other hand – to allow the port authority to automatically exchange information with the boat e.g., during the mooring phase.

In the performed CANVAS it have been distinguished among issues related to yachtsmen (marked purple), to developers (marked green), and general issues related to the port ecosystem and yachting clusters (marked yellow). The developers may be boat/port Automation Solution Providers or Application (APP) developers.

The not self-explaining issues, like key partnerships, value proposition, customer relationships, customer segments, and revenue streams, are described in more detail in the following.

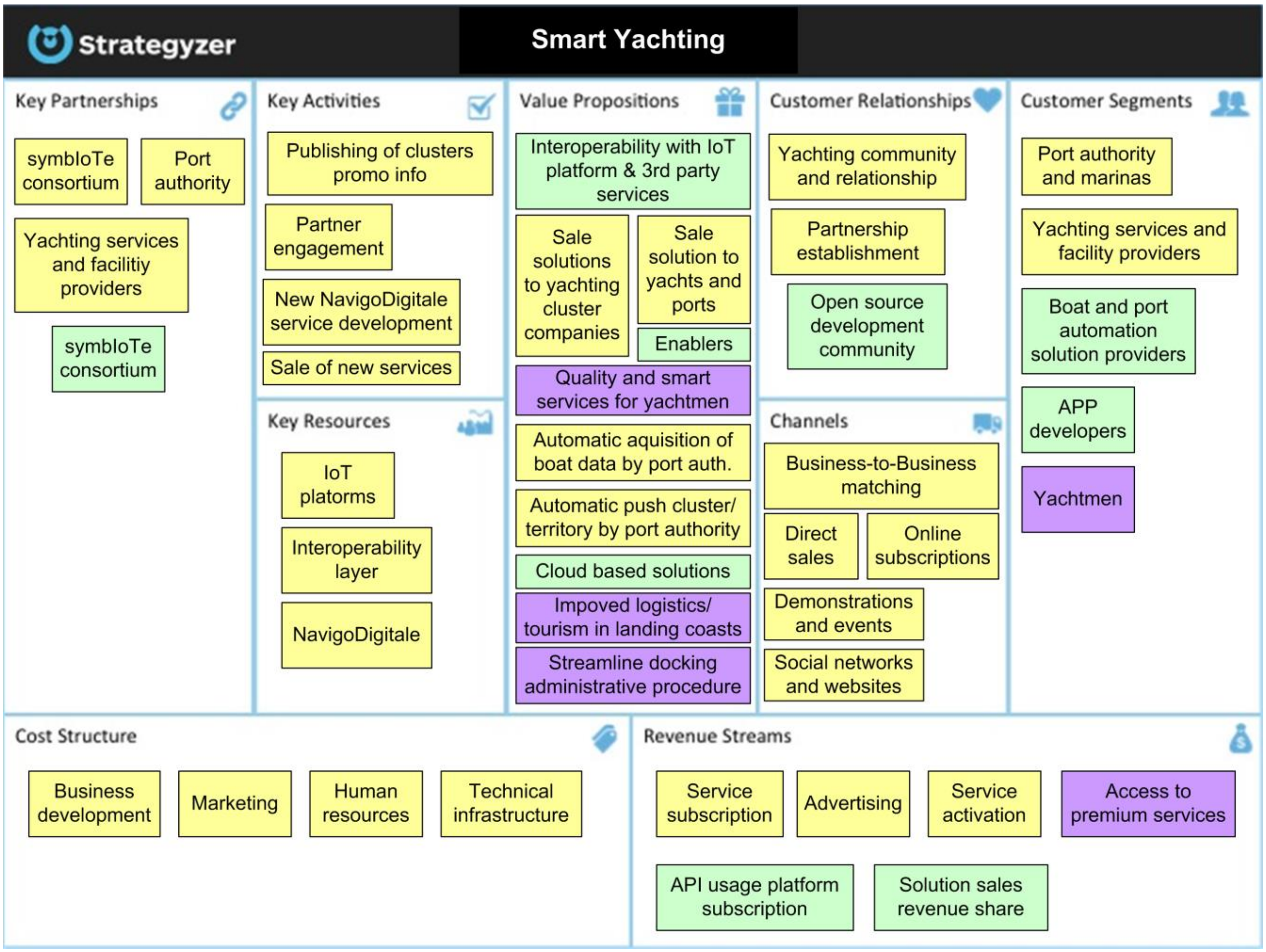

Figure 25: CANVAS for use case “Smart Yachting”

The selected **key partnerships** aim at creating the basis of the structure to support the creation, development and implementation of the symbIoTe solution. The symbIoTe consortium constitutes the main partnership group to develop, implement and disseminate the solution. The boat/port automation solution providers are a partner or a group of partners supporting the development and implementation of the solution providing the local instrumentation for the testing and operation of symbIoTe. The port authorities are the relevant partners for piloting and implementing the developed solution. The yachting facilities and services providers include charter companies, shipyards, and other supply chain companies. The partnership with these services allows a better integration in the yachting clusters as well as a broader dissemination of the solution, being accessible in different areas of the port as well in different marinas or in the surrounding territory.

Concerning **value proposition** symbIoTe builds its orchestration middleware on top of existing standards for protocols and interfaces, plus a number IoT platforms both proprietary (i.e. developed by its industrial partners) and from open source (e.g., OpenIoT [6]). There are several value propositions related to the technology used for this solution, which are mainly important for developers. The following four items are essential to ensure an open and adaptable solution: (1) Interoperability with IoT Platforms (e.g., instrumentation system different than Symphony but symbIoTe compliant that could be able to interoperate with Navigo Digital), (2) interoperability with third party services (e.g., Navigo Digitale), (3) support of enablers (e.g., allowing external application interoperations), and (4) integration of Cloud-based solution (e.g., Cloud-adjusted building blocks of specific platforms as specified in symbIoTe's project objectives). For the users perspective, the main value proposition resides to allow Yachtsmen to identify automatically the territorial cluster actors (Yachting Facilities/Services and other providers) to address the boat's needs of e.g., on-board detecting, and – on the other hand – allow the Port Authorities or Marinas to automatically acquire boat's information and send various territory information to the boat e.g., during the mooring phase. Furthermore through symbIoTe it should be possible to extend to Smart Yachting users the fruition of some of the values provided by other use cases like Smart Mobility or Smart Home or another interesting platform.

Concerning **customer segments** the following observations were made:

- In Yachting Facilities/Services Providers there are several target groups, which are potential customers including charter companies, shipyards, yacht management, marinas, technology providers and other supply chain companies
- Application (APP) developers constitute a main target for the development of new apps and solutions for the data provided.
- Boat/port Automation Solution Providers/Developers constitute a further target for the development of new solutions for the yachting ecosystem.
- Port Authorities or Marinas are potentially interested in improving the experience of their users through symbIoTe and promoting sustainable and environmental friendly yachting solutions.
- Yachtsmen will be the general users of the symbIoTe solution that can opt for a free or premium access for a daily use.

Concerning **customer relationships** several platforms and online support services will be made available: some of them will focus on developers, especially those of the Open source community, in order to encourage them to develop new applications for the Smart

Yachting use case; others will address the general customers (e.g., yachtsmen, port authorities) and partners of the Marine business world, by providing community building and business networking functionalities.

The identified **revenue streams** for this use case are similar to use case 4, namely paying and non-paying stakeholders. Here non-paying customers are yachtsmen who join the platform/app interested in exploring the available opportunities in the port and surrounding territory. They are the 'critical mass' that creates the solution´s uptake. Customers belonging to the fee-paying category are essentially Port Authorities, Yachting Facilities/Services Providers, local businesses, premium users and developers. Together they form an ecosystem, which is essential for keeping the platform economically sustainable.

6.5.2 Showcases Specification

In the following, the showcases and their related workflows for the use case of Smart Yachting are described. An overview is given in Figure 26.

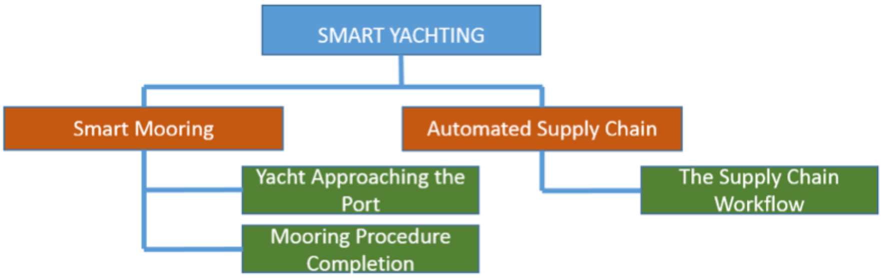

Figure 26: Smart Yachting showcases and workflows

6.5.2.1 Setting of Showcase: Smart Mooring

The owner of a 50mt luxury Yacht wants to spend some days in the Versilia coast of Tuscany, Italy, and chooses the Viareggio port to moor its boat. The boat has installed a symbIoTe compliant IoT platform (e.g., Nextworks' Symphony) to manage and automate a significant set of on-board services (from entertainment and comfort to communication).

The ordinary mooring procedure involves multiple manual steps. In a "normal" harbour the booking is requested via phone, where the yachtsman receives the confirmation for the mooring and defines all the necessary details (day and time of arrival, number of days of permanence, the wharf chosen for the mooring, etc.). Another phone call must be placed when the Yacht is approaching the Harbour, so that the Port Authority can send its personnel to the chosen wharf to support the actual mooring phase. After berthing taking place, the yachtsman has a limited time (e.g., 12 hours) to present to the Port Authority copies of documents regarding the ship, and additionally to fill out a set of forms with details about the yacht, the personnel on board, its latest routes, etc.

Viareggio Port is powered by the Navigo Digitale platform, which greatly simplifies and speeds up the workflow described above: moreover, ND integrates a symbIoTe compatible IoT platform (Port IoT Platform) and can automatically interact with a symbIoTe platform on-board of an approaching ship.

The booking request can be sent by the yachtsman via web through the ND web interface: the yachtsman immediately receives a confirmation and all the details for the mooring. The

ID of the boat is stored as a reference, together with the information about the IoT system on-board: at the same time, the platform sets an alarm for the chosen date and time, to control that the boat arrives in the specified timeframe (and to send an alert to the operators in case this does not happen).

As the boat approaches at the expected time the Viareggio Port, an antenna installed in the port (Ship Detection System) detects the Ship Identification sensor on board (e.g., a LoRa sensor) and sends the information to ND through the Port IoT Platform. The platform can unambiguously recognize the Yacht, ND starts a lookup using the ID of the boat, all as the part of the corresponding mooring request workflow. It recognizes that it comes from a symbIoTe compliant IoT platform; hence, it immediately and automatically waits for an incoming interconnection request from the IoT platform on board, that will be activated when the boat is near enough to the port to initiate an Internet connection.

At the same time, the alarm is turned off and a message to the mobile phone of the mooring team personnel is sent, to provide information about the boat, its expected time of arrival and the chosen wharf.

When the Yacht enters the port, its IoT system starts a connection through symbIoTe API with ND and sends all the information about the boat, needed by the Port Authority for the mooring procedure. The ND platform performs a first check of the information received, attaches them to the corresponding mooring request and assigns its workflow to the Port Authority, for the final approval.

The yacht arrives at the destination: a positioning sensor on the wharf allows ND to understand that the mooring procedure has been correctly finalised.

The Port Authority operator accesses the web interface of ND to verify that the information and documents received are correct: if everything is OK, she approves the mooring and closes the workflow. A notification is automatically sent to the yacht IoT system, so that the yachtsman can be informed.

In case of problems, the yacht' system is notified with a request for the yachtsman to appear at the Port Authority, to manually finalise the procedure.

For the above described showcase the platforms Navigo Digitale installed at the ports and the Symphony platform installed on yachts are required. Navigo Digital is a platform created to manage digital assets and services pertaining to harbours used for boating and yachting. Its scope embraces both physical (objects) and immaterial entities (documents and workflows). The Yacht IoT platform is based on Nextworks' Symphony line of products. It is capable of supervising a large amount of aspects of the life on board, from mechanics to navigation and comfort (brightness, temperature, supplies in smart appliances).

Four sensor types are required. First a Boat Identification sensor, where NAVIGO currently investigates the possibility of using a LoRa sensor to transmit the boat unique identifier (e.g. the MMSI – Maritime Mobile Service Identity – code or the IMO – International Maritime Organization – number) to the Ship Detection System installed in the port (see below). This transmitter will be controlled by the Symphony platform on board. Second, the ship detection system might be based on a LoRa Antenna, capturing the ID of the yacht sent from the Boat Identification Sensor. It will interact with the Port IoT Platform (Navigo Digitale). Third, Wheelhouse & Navigation systems sensors are needed. GPS and other navigation sensors will be used to track the latest routes of the ship, an information that must be provided in the Smart Mooring workflow. They will be controlled by the Symphony platform on board. Last, positioning sensors for the wharves are required that will detect when the berthing of the yacht has finally taken place. The details of the actual strategies to use (e.g., installing in the berths high-sensitivity infrared proximity/ultrasonic sensors or exploiting the positioning data of the yacht transmitted through LoRaWAN) is still to be defined. In any case, their information will be managed by the Port IoT Platform (Navigo Digitale).

For the envisioned showcase Smart Mooring the following actors are envisioned:

- Yacht: The vessel entering the Port.
- Yacht IoT Platform: The IoT platform that supervises and monitors the systems on-board.
- Yachtman: It is responsible for the mooring procedure. It might be the captain, the skipper, the ship-owner or any sailor in charge. She/he interacts with the Yacht IoT Platform.
- Port Authority: It is the Authority in charge of managing the berths and to supervise the whole life of the Port, including the approval of mooring requests from the ships.
- ND/Port IoT Platform: It is the Information System that manages the sensors installed in the port and that interacts with several applications in order to provide services to the Yachts.
- Port Authority Operator: She/he is a port employee delegated to supervise the berthing procedure, making sure that all the needed information and data are correct.
- Port Personnel: They are delegated to receive the Yachts at the dock and to help in the actual berthing of the boat.

There are two workflows associated with the showcase, namely *Yacht Approaching the Port and Mooring Procedure Completion*. The corresponding workflows are described in Table 24 and Table 25. The resulting sequence diagrams are shown in Figure 40 and Figure 41 in the Appendix.

Table 24: Workflow for Yacht Approaching the Port

Description	When the boat approaches the Port, the Ship Detection System identifies it; searches by the boat ID the corresponding mooring request. Messages are automatically sent to inform the Port personnel of the incoming yacht.
Trigger	When the Ship Detection System detects a vessel approaching the port within a defined distance range.
Pre-Conditions	**Pre-condition 1** The yachtsman has successfully requested a mooring authorization for a specific harbour (e.g., Viareggio, Italy) and at certain date and time through the Navigo Digitale system web interface.
Involved Actors	Yacht, Yacht IoT platform, ND/Port IoT Platform, Port Personnel, Port Authority operators
Sensors Involved	Ship Detection System Boat Identification sensor
Platforms Involved	Navigo Digitale (Port/Port Authority) Yacht IoT platform, symbIoTe compliant (e.g., Nextworks' Symphony)

Process Flow	1. The Ship Detection System in the port, connected to the Port IoT Platform, detects a boat approaching the Harbour and gets its identifier through the Boat Identification sensor, connected to the Yacht IoT Platform. 2. The Port IoT Platform (Navigo Digitale) receives the boat identifier and finds a pending mooring request for it 3. An alert is sent to the Port Authority Operators, to inform them of the incoming boat 4. The Port IoT Platform sends a message to the Port Personnel, so that they can wait for the incoming boat at the wharf chosen for the berthing
Alternative Scenarios	The Port IoT Platform does not find a pending mooring request for the boat. It sends an alert to the Port Authority operators, so that they can start a communication with the boat.
Assumptions	The Yacht has installed on board a Boat Identification sensor compatible with the Ship Detection System used in the Port. The Yacht has installed on board a symbIoTe compliant IoT system (e.g., Nextworks' Symphony).
Domain Level / Compliance Level	L1, L2

Table 25: Workflow 2 for Mooring Procedure Completion

Description	When the Yacht enters the port, its IoT system starts a connection with the Port IoT Platform, sending all the information about the boat, needed by the Port Authority for the mooring procedure. The Port IoT Platform attaches these data to the pending mooring request and assigns it to the Port Authority, for the final approval. A positioning sensor on the wharf detects that the yacht has berthed. The Port IoT Platform receives the signal and verifies that the Yacht has arrived at its correct destination.
Trigger	**Trigger 1** The Ship Detection System has recognised that the Yacht has entered the port **Trigger 2** The Positioning Sensor on the wharf has recognised that the Yacht has completed the mooring.
Pre-Conditions	**Pre-condition 1** The yachtsman has successfully requested a mooring authorization for a specific harbour (e.g., Viareggio, Italy) and at certain date and time through the Navigo Digitale system web interface. **Pre-condition 2** The yacht is approaching the harbour at the appointed date and time.
Involved Actors	Yacht, Yacht IoT Platform, ND_Port IoT Platform, Port Authority Operator
Sensors Involved	Boat Identification sensor Ship Detection System Positioning sensor for the wharves
Platforms Involved	Navigo Digitale (Port/Port Authority) Yacht IoT platform, symbIoTe compliant (e.g., Nextworks' Symphony)
Process Flow	1. The Ship Detection System identifies that the yacht has entered the port; the Port IoT platform finds its mooring request workflow and waits for the incoming connection from the Yacht IoT platform 2. The Yacht IoT platform connects, through symbIoTe APIs, with the Port IoT

	platform 3. The Yacht IoT platform sends to the Port IoT platform all the information about the boat, needed by the Port Authority for the mooring procedure 4. The Port IoT platform performs a first check on the information received from the boat system and, if everything is ok, assigns the mooring workflow to the Port Authority operator, for the final approval 5. The positioning sensor on the wharf recognizes that the Yacht has finalised the berthing procedure and sends this information to the Port IoT platform 6. The Port Authority operator verifies the information and documents attached to the mooring workflow: if everything is OK, she approves the mooring and closes the workflow on the Navigo Digitale Platform. 7. Navigo Digitale sends a notification, via the Port IoT Platform, to the yacht IoT system to inform that the mooring procedure has been correctly finalised.
Alternative Scenarios	**Alternative Scenario 1** The Port IoT Platform sees that the ship has berthed at the wrong destination: it immediately sends an alarm to the Port personnel to go and manage the situation. **Alternative Scenario 2** The Port Authority operator verifies that the information received are not correct. She refuses the workflow. Navigo Digitale, through the Port IoT Platform, sends a notification to the Yacht IoT platform, to notify the yachtsman that the mooring automatic procedure failed and that it is necessary to appear at the Port Authority for finalizing it.
Assumptions	The Yacht has installed on board a symbIoTe compliant IoT system (e.g., Nextworks' Symphony)
Domain Level / Compliance Level	L1, L2

Table 26 provides the most relevant requirements needed for implementation of the workflows described above. The full set of requirements is defined in D1.2 [24].

Table 26: Requirements for showcase Smart Mooring

Req. #	Req. Description	Why is this requirement important and relevant for the use case (short description)	Relevant for UCs	Workflow
12	The common information model MUST support geo-reference information.	The geographical positioning of the Yacht is essential to implement the workflows.	5	1, 2
19	symbIoTe MUST distinguish IoT devices which are fixed (geo-location does not change over time) and mobile (their location changes).	It is necessary to identify when the boat approaches the Port and the wharves	5	1, 2
5	The system MUST monitor the availability of the IoT services registered by IoT platform operators.	The services of the Port IoT Platform (ND) must be available to allow the Yacht IoT system to interconnect with them.	5	1, 2

Security_4	The authentication to a smart space SHOULD work even if the smart space is disconnected from the Internet.	The Ship Detection System and the Boat Identification sensor will not necessarily work on Internet based protocols (e.g. a LoRa connection is at present under study for implementing the identification of the ship)	5	1

6.5.2.2 Settings of Showcase : Automated Supply Chain

The 50mt luxury Yacht is approaching the Viareggio port and thanks to the mooring automation described in the previous showcase, the berthing process is smoothly in progress. At the same time, another service offered by the Navigo Digitale platform, can take place: the automated Supply Chain. The Yacht IoT system can acquire through sensors an indication of several services that might be needed, once the boat has moored in the port. For example, the need of fuel refill or to perform a technical maintenance due to a specific fault that has been detected, are two of the possible events that easily can be automatically captured by the Yacht IoT system. For very high-end yachts, as the one mentioned here, sensors can monitor a huge number of aspects of the life on board, including for example fine wine stocks level: it is expected therefore that the system might reveal when champagne supplies are running low!

For a Yachtsman, the management of all the supplies of goods and services, possibly in an unknown territory, is undoubtedly quite a hassle. Luckily, Viareggio Port has an automated supply chain service, powered by the Navigo Digitale platform that is exposed through its Port IoT Platform, obviously symbIoTe compliant!

As soon as the Yacht approaches the harbour, the Yacht IoT system interacts with the Navigo Digitale's Port IoT Platform to receive a list of services that it is possible to order in the Port through the marketplace. The Yacht IoT system matches them with the current needs on board and sends this information to the Port' system. The requests from the boat side automatically generate a set of Request for Proposals, one for each possible category of service, into the marketplace platform of Navigo Digitale (Centrale Acquisti). Here, through a web interface, the various suppliers and service providers in the port area can access and bid for them. The Yachtsman can connect with a browser to the Navigo Digitale platform to review the offers and accept or reject them.

The envisioned platforms and sensors involved in this similar to the Smart Mooring showcase and will be implemented and/or used in WP5.

Concrete it is the Navigo Digital Platform used that is a platform created to manage digital assets and services pertaining to harbours used for boating and yachting. Its scope embraces both physical (objects) and immaterial entities (documents and workflows). And the Yacht IoT platform Symphony is based on Nextworks' Symphony line of products. It is capable of supervising a large amount of aspects of the life on board, from mechanics to navigation and comfort (brightness, temperature, supplies in smart appliances).

Here again four sensors are needed. The already introduced Boat Identification sensor. Navigo investigates the possibility of using a LoRa sensor to transmit the boat unique identifier (e.g. the MMSI – Maritime Mobile Service Identity – code or the IMO – International Maritime Organization – number) to the Ship Detection System installed in the port (see below). It will be controlled by the Symphony platform on board. The Ship

Detection System might be based on a LoRa Antenna, capturing the ID of the yacht sent from the Boat Identification Sensor. It will interact with the Port IoT Platform (Navigo Digitale). Sensors in the Engine Control Room (Engine RPM, Fuel level, Bilge pumps status) will be used to identify defective conditions and maintenance needs. These sensors will be controlled by the Symphony platform on board. And Sensors from Smart Appliances are planned to be used that can identify the need for resupplying goods on-board (e.g. a smart fridge detecting when wine stocks are getting low). They will be supervised by the Symphony platform on board.

The showcase Automated Supply Chain as described above is not ready yet for production, but the corresponding installations will take place during symbIoTe having the following actors in mind:

- Yacht: The vessel entering the Port.
- Yacht Iot Platform: The IoT platform that supervises and monitors the systems on-board.
- Yachtman: It is the responsible of the mooring procedure. It might be the captain, the skipper, the ship-owner or any sailor in charge. She/he interacts with the Yacht IoT Platform.
- ND/Port IoT Platform: It is the Information System that manages the sensors installed in the port and that interacts with several applications in order to provide services to the Yachts.
- Suppliers: They receive the requests for proposal and can send offers for them.

There is one workflow associated with the Automated Supply Chain showcase. The corresponding workflow is described in Table 27 and the sequence diagram is shown in Figure 42 in the Appendix. And Table 28 provides the most relevant requirements needed for implementation of the workflow described above. The full set of requirements is defined in Deliverable D1.2 [24].

Table 27: Workflow for the Supply Chain

Description	The Yacht IoT system identifies all the possible needs for services (maintenance, fixing, and refit) or goods (from fuel to consumables). It receives from the Port IoT Platform the list of services that it is possible to order in the Port through the web marketplace. The Yacht IoT system matches them with the current needs on board and sends this information to the Port' system. The request from the boat side are automatically turned into a set Request for Proposals, one for each possible category of service, into the web marketplace.
Trigger	When the Ship Detection System detects that the vessel is entering the port.
Pre-Conditions	**Pre-condition 1** The Yacht IoT system can automatically detect the needs for services and goods to order. **Pre-condition 2** A common ontology for classifying the services and goods, needed on board and offered through the Port's marketplace, must be defined.
Involved Actors	Yacht, Yacht IoT Platform, ND/Port IoT Platform
Sensors Involved	Ship Detection System Boat Identification sensor

Platforms Involved	Navigo Digitale (Port) Yacht IoT platform, symbIoTe compliant (eg Nextworks' Symphony)
Process Flow	*1.* The Yacht IoT platform detects the needs of services and goods on-board. It classifies them by using the common ontology. *2.* The Ship Detection System identifies that the yacht has entered the port *3.* The Yacht IoT platform connects, through symbIoTe APIs, with the Port IoT platform *4.* The Port IoT platform sends the list of all possible services available in the marketplace, all classified with the common ontology *5.* The Yacht IoT platform automatically selects the items in the list that correspond to the current needs on board and sends this information to the Port IoT platform. *6.* The latter receives the requests and creates for them one or more Request for Proposals in the Navigo Digitale marketplace (integrated with the Port IoT Platform).
Alternative Scenarios	None of the available services of the Port matches the needs on-board. In this case, the Yacht IoT Platform does not take any further action.
Assumptions	The Yacht has installed on board a Boat Identification sensor compatible with the Ship Detection System used in the Port. The Yacht has installed on board a symbIoTe compliant IoT system (eg. Nextworks' Symphony).
Domain Level / Compliance Level	L1, L2

Table 28: Requirements for the showcase Supply Chain (only relevant for use case 5)

Req. #	**Req. Description**	**Why is this requirement important and relevant for the use case (short description)**	**Workflow**
3	The system MUST support a common information model for the description of available IoT services across IoT platforms.	It is paramount to provide a standard description of the rich set of services that the Navigo Digitale platform offers through symbIoTe.	3
12	The common information model MUST support geo-reference information.	The geographical positioning of the Yacht is essential to implement the workflows.	3
19	symbIoTe MUST distinguish IoT devices which are fixed (geo-location does not change over time) and mobile (their location changes).	It is necessary to identify when the boat approaches the Port and the wharves	3
5	The system MUST monitor the availability of the IoT services registered by IoT platform operators.	The services of the Port IoT Platform (ND) must be available to allow the Yacht IoT system to interconnect with them.	3
Security_8	The system MUST preserve end-user privacy. (E.g. locations of end users / sent sensor data and their identity, e.g. via data anonymization)	Data sent to the suppliers in the Port must be cleaned of any unnecessary details that might endanger users' privacy.	3

7 Findings and Future Steps

This section summarizes the findings of this deliverable D1.3 for Task T1.1 and Task 1.2 separately. Task 1.1 activities end with the finalization of this document. Task 1.2 will continue in the next period and, thus, envisioned steps are mentioned.

7.1 Task T1.1

The primary objective of the task was to provide a detailed and final description of the use cases of symbIoTe, such that they set a stage and guidelines to steer the trials and deployments in WP5. In specific, the finalization of use cases includes a thorough description of general settings, showcases and workflows. A showcase identifies and describes (IoT) platforms, sensors and involved actors, while a workflow, as a part of a showcase, describes one specific situation and sequence of activities. Moreover, each use case comes with the set of (technical) requirements identified in D1.2 [24], thereby demonstrating the feasibility of the showcase/use case. Further, the defined use cases environments (i.e., envisioned scenario, actors, and actions) have provided the stage for identification of stakeholders, to name one aspect of the Task 1.2 analysis activities.

The activities performed jointly by the consortium partners capture different point of views, take into account, and exploit the consortium's expertise in different fields, thus demonstrating the innovation and potential of the symbIoTe project.

The findings from Task 1.1 will be used in the ongoing and forthcoming activities, e.g., deployment and trials in WP5 and IoT platform federation efforts in WP3.

The findings and goals for each use case can be summarized as follows:

Table 29 Findings and Goals for each Usecase

Use-Case	Topic	Findings
Smart-Residence	Challenges	Ease usability by connecting platforms to create integrated applications and integrated user interfaces
	Features	The Smart Residence use case aims to demonstrate interoperability across different smart home IoT solutions through a generalized abstract model to describe inter-connected objects, providing a dynamic configuration of available services and a natural and homogeneous user experience. A health monitoring system, in addition to the smart living platform, has the ability to create a comfortable, safe and helpful living/residence environment, supporting a scenario where residents are provided with context-aware and personalized health and comfort services at home.
	Value Proposition	Smart-Residence aims to enable platform interoperability and provides a federation platform to (1) enable integrated applications, (2) to integrate a broad range of systems (now and in the future), (3) to enable simple (centralized and remote) management of the available resources, and (4) to provide security mechanisms to ensure trust in federated environments.
	Validation Emphasis	Demonstrate platform integration and evaluate usability in

		laboratory environment for energy saving and smart health applications using smart sensors & controls in combination with indoor localization.
	Integration Level	L1 to L3
EduCampus	Challenges	To access infrastructures on different sites, specific applications and interfaces are needed. This requires from users to download and register in this new environment, before being able to use it.
	Features	The vision behind the EduCampus is following. When looking at the rapidly growing market for sensors included in smart devices, used in or attached to smart buildings, establishing smart campus infrastructures, there will be rich offering of services based on IoT middleware installations on a campus. Examples are climate control systems in workplaces, electronic access control systems, indoor location and navigation support, guidance systems for handicapped people, location based collaboration support, or room information and reservations systems as discussed in the EduCampus showcase below. Sometimes these services will be unique to certain campus, but in many cases there will be very similar services on different campus, but realized in deployment specific ways. This will result in services, which are functionally identical for different campus solutions, but technical incompatible for visiting campus users. In any case there will be multi-platform deployment, consisting of different IoT-domains and also of different IoT-middleware products. By facilitating the symbIoTe interoperability framework for campus deployments, EduCampus aims to be the incubator for interoperable IoT-platform federations.
	Value Proposition	EduCampus aims to enhance the campus user convenience and at the same time optimize the resource allocation. Third party offerings are included to extend the basic campus service. The symbIoTe framework will enable IoT platform independent campus services making different campuses interoperable and therefore provide the same user experience when visiting a remote campus.
	Validation Emphasis	For the EduCampus, already existing experimentation environments of different campus applications will be connected. Indoor location sensors will be used to determine the position of a user inside a campus building. The position data will be combined with information systems about work and meeting facilities and optional with other sensor information available for rooms, like air quality or temperature.
	Integration Level	L2
Smart-Stadium	Challenges	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.
	Features	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. • Specific care is needed in case of emergency services which are also offered either by stadium manager or organization – primarily locating and notifying emergency services provided on site (emergency medical teams and security personnel) – this kind of services are specially needed in (electronic) music festivals due to higher incidence of both security or medical emergencies. • 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.
	Value Proposition	symbIoTe will enable partners to (a) add new services to enable rapid and flexible service co-creation from various IoT platforms (e.g., on-demand media vs catering) and (b) to include data from IoT devices/platforms from various abstracted underlying platforms with symbIoTe (e.g., localization).
	Validation Emphasis	The trials will be using beacons (BLE) and wireless networks for indoor location of users and third party businesses such as kiosks and moving cart retailers, promowall panels and remote ordering devices that allow retailers to activate promotions and visitors to read them and interact with them.
	Integration Level	L1, L2, L4
Smart-Mobility	Challenges	Different air quality measurement systems exist in different cities or even within a single city making it hard for application developers to provide scalable solutions.
	Features	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).
	Value Proposition	symbIoTe aims to provide (1) interoperability with IoT platforms and with 3rd party services, (2) involvement of enablers (e.g., APIs routes), (3) integration of Cloud-based solution, and (4) support of an open source framework. For the citizens, the main

		value proposition resides in the convenience for the routes planning supporting decision making and reinforcing mobility integration, supported by a rewarding system which will be put in place for a more effective user´s engagement, the General interest and support on CO2 reduction, an important social issue. In addition to all of these added values, it can also support users to improve their health and wellbeing.
	Validation Emphasis	All trials are foreseen to be executed with more than 20 participants for period of 30 days with different types of end-users which will actively use the ecological urban routing application and in parallel will contribute with the air quality, parking and traffic data. Currently, a first trial for Vienna involving cyclists is under preparation.
	Integration Level	L1, L2
Smart-Yachting	Challenges	The port is an organization/authority and public space for which it is crucial to implement smart systems that can automate business workflows, to simplify and reduce the costs of their manual execution. The Smart Yachting use case focuses on facilitating, through automation and by exploiting data from sensors, the processes between the personnel on-board of a boat and the various actors of the Port; these processes are based on the communication and data exchange between yachts, port authorities, port operatives plus the supply companies in the yachting cluster. The vision behind the use case is to see the whole port as a unique “platform”, an infrastructure that exposes data and common services to visiting yachts (but in perspective also to tourists coming from inland): thanks to symbIoTe it will be possible to automate a significant set of processes by exploiting the interoperability between the IoT platforms of the ports and those of the yachts.
	Features	symbIote, allows the full interoperability of the IoT platforms, of the Yacht and of the Port. In particular: • the software applications of the Port (Port-Net for the Mooring Workflow Management and the Marketplace Centrale Acquisti) will integrate with symbIoTe on the Application Domain (level 1) • the full interoperability amongst the IoT platforms will happen in the Cloud Domain (level 2).
	Value Proposition	symbIoTe aims to enable (1) interoperability with IoT Platforms (e.g., instrumentation system different than Symphony but symbIoTe compliant that could be able to interoperate with Navigo Digital), (2) interoperability with third party services (e.g., Navigo Digitale), (3) support of enablers (e.g., allowing external application interoperations), and (4) integration of Cloud-based solution. For the users perspective, the main value proposition resides to allow Yachtsmen to identify automatically the territorial cluster actors (Yachting Facilities/Services and other providers) to address the boat's needs of e.g., on-board detecting, and – on the other hand – allow the Port Authorities or Marinas to automatically acquire boat's information and send various

		territory information to the boat e.g., during the mooring phase. Furthermore through symbIoTe it should be possible to extend to Smart Yachting users the fruition of some of the values provided by other use cases like Smart Mobility or Smart Home or another interesting platform.
	Validation Emphasis	The trial will be implemented in the Port of Viareggio, in the Tuscan coast of Italy, where Navigo's headquarters are located and where Navigo has already established a partnership with the local Port Authority. Nextworks on the other hand currently works with some important Italian Yacht manufacturers, so it will be possible to test the use case in a real-life context.
	Integration Level	L1, L2

7.2 Task T1.2

Phases 1 and 2 from Task T1.2 focused on market and stakeholder analysis for symbIoTe. The findings are summarized in Section 7.2.1 for the analysis of IoT market as part of Phase 1, in Section 7.2.2 for Phase 2 on stakeholder analysis. Both lead to the future steps mentioned in Section 7.2.3 to address Phase 3.

7.2.1 Findings for Phase 1

As described in Section 3, different IoT business models exist on the market where some are very specifically defined for an IoT area (e.g., telecommunication, automotive) and others are independently defined. The independent ones are relevant, because they indicate dedicated building blocks that have to be addressed by symbIoTe to give a business model recommendation. The most accepted and well-known in economics is CANVAS [8] that was described in detail in Section 3.3.3 and performed by all use case owners identifying relevant aspects in the building blocks for symbIoTe's business model recommendation. Based on performed IoT business market analysis the following findings are identified for Phase 1:

- Specialized business models are in place, but can be abstracted by CANVAS presenting a general overview of market analysis.
- CANVAS includes main building blocks that include special items depending on use cases.
- For symbIoTe, each use case owner performed CANVAS and overlaps in identified stakeholders are obvious, but many differences in the other building blocks exist.
- Main IoT concerns are security, interoperability, and connectivity that need to be prioritized by application development.
- For symbIoTe for business opportunities were identified based on the ecosystem analysis of today's available solutions: Two-sided markets, subscription, open source, and pay per use.

Based on the above findings Task T1.2 will not devise a new IoT Business Model for symbIoTe but rather it will offer recommendations on which business models can be adopted and how they can be adapted in order for symbIote-based solutions to be sustainable. Therefore, D1.3 includes in Section 5 an initial analysis of the business model opportunities for symbIoTe which will further be developed in the upcoming 18 months. The already identified recommendations and opportunities include facts about the stakeholders (involved ones and future ones), business opportunities, and points mentioned in the building blocks of CANVAS. All these information is handed over to the work packages responsible for implementation (e.g., subscription solution) and dissemination for rising awareness in the IoT marked for symbIoTe.

7.2.2 Findings for Phase 2

In order to receive a feeling of the variety of stakeholders (Phase 2) each key industrial partner performed a CANVAS analysis and during the 3rd Plenary Meeting at Vienna an "Innovation Workshop", led by ATOS, was organized. Details of the received result was presented in Section 4.2.2. The followed main findings were identified for Phase 2 in Task T1.2:

- Depending on the use cases the stakeholders are different, due to the specific area the use cases are linked to.
- Stakeholders come from different areas with different knowledge and requests.
- Stakeholders will be final users, collaborators, early adopters, clients, influencers or competitors.
- Mapping of stakeholders into specific groups highly depends of the viewing angle (e.g., general or specific groups). Manifold stakeholders are involved in todays IoT market and also in symbIoTe.
- Stakeholders have common and different requirements and requests in place that might be specialized for the working area or service offered.

7.2.3 Future Steps

The outcome of the CANVAS analysis for each use case will be used as a basis for the envisioned next steps in the upcoming period. Further, the identified building blocks per use case highlight the requirements for each use case to be successful. These are considered by the use case owners and developers to ensure that the work targets useful integration of platforms to provide services that could become a commercial reality or at least show a benefit that can be seen as valuable to citizens. One important aspect identified during the CANVAS analysis was to address security and privacy concerns of users independent of the use case even when not mentioned explicitly. The symbIoTe consortium already identified these issues and included the respective research activities into WP 3, because it is clear that any future IoT platform or middleware can be accepted by stakeholders only if security and privacy is supported by default and design. This becomes very important as soon as the user loses control of own data, e.g., when it was transmitted to a symbIoTe service or module, meaning leaving the measurement point.

The IoT business market and stakeholder analysis was part of the first 12 months and was summarized in the two aforementioned sections. Depending on the development on the IoT market especially looking on the building blocks in CANVAS an update on identified items might be necessary, to be documented in deliverable D1.5.

The main focus in the next period will be the value network analysis in Phase 3 and as briefly introduced in Section 3.2. This will build upon the findings from this deliverable to further strengthen symbIoTe's outcome. Intermediate and final results are recommended to the other work packages responsible for implementation and dissemination. Further the initial business market analysis leading towards the opportunities of symbIoTe will be finalized.

8 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 enable 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.

To address these challenges and to set stage for a development of such a middleware solution, a set of use cases is identified, analysed and described. In symbIoTe, a two-step approach was chosen, with an initial use case description in D1.1 [23], and with the final, and significantly more precise description of those use cases in this deliverable.

The five use cases link many services and IoT domains, while targeting scenarios in both indoor and outdoor environments in an effort of assisting people in their daily activities. The range of highlights stretches from indoor, house environment (*Smart Residence*), where interoperability of collected deployments is enabled by symbIoTe's function of automatic discovery and configuration of platforms and sensors, to the outside environment, where symbIoTe in the use case of *Smart Yachting* securely establishes the interoperability of IoT platforms at the application domain. Providing (analytical) services based on data collected from several different IoT platforms is shown in *Smart Mobility and Ecological Routing* use case, while *Smart University Campus* allows symbIoTe to establish a federation of IoT platforms in public environments. Finally, interoperability using symbIoTe between IoT platforms is presented in *Smart Stadium* that covers integration of location indoor platforms with various context-based information services.

A set of showcases with their coupled workflows, identified IoT platforms, sensors and actors is developed for each use case. Likewise, for each showcase, a set of (technical) requirements is given, and all with the purpose of establishing a finalized document for steering the foreseen activities in the project, specifically in relation to deployments and trials in WP5. Further, this deliverable presents initial results of Task 1.2 on business models after first 12 months of work. Different methods were introduced and used to address the defined three phases. First, Tussle Analysis was used in combination with partner interviews and interested community on conferences and workshops to identify stakeholders for symbIoTe as well as their tussles that need to be addressed to develop a successful IoT framework as envisioned for symbIoTe. Second, the value network analysis was briefly introduced as a method to identify different factors influencing the stakeholders and symbIoTe's offered services. This method will be used to address Phase 3 within the next period to recommend on the sustainability of symbIoTe. Furthermore, Task T1.2 performed a business model analysis to identify relevant building blocks for each use case. Investigations showed that different models are in place, with the drawback that they are application-dependent. Only two models were identified that are application-independent and the CANVAS model was selected to be applied on the specific use cases of symbIoTe. CANVAS defines different building blocks that include different items for each use case as identified by performed CANVAS model by each use case owner and key industrial partners of symbIoTe. The identified items reflect the stakeholder analysis result and complement the already identified requirements for each use case and showcase. The findings are forwarded to the corresponding work package dealing with the implementation of the solution. One specific concern was raised in this analysis: Security and privacy support. This concern needs to be addressed in a fine-grained manner to address stakeholder's concern and to bring a successful solution on the market. The made findings will also influence the value network analysis in the next months to conclude Phase 3 of Task T1.2. The current business market ecosystem analyse showed that for symbIoTe four main business opportunities a highly interesting, namely two-sided markets, subscription, open source, and pay per use.

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10 Acronyms

3GPP	3rd Generation Partnership Project
AAL	Ambient Assisted Living
ACK	"Acknowledged" Message
AIT	Austrian Institute of Technology GmbH
API	Application Programming Interface
APP	Application
ASP	Application Service Providers
ATOS	ATOS Spain SA
B2B	Business-to-Business
B2B2C	Business to Business to Consumer
B2C	Business-to-Consumer
BLE	Bluetooth Low Energy Beacon
CO	Carbon Monoxide
CO2	Carbon Dioxide
CoAP	Constraining Application Protocol
CPS	Cyber Physical Systems. A mechanism controlled or monitored by computer-based algorithms
DNA	Design Needs and Asiprations Model
DoA	Description of Action
DPI	Deep Packet Inspection
EDITA	Exploiting the Scientific and Business Potential when Integrating Smart Data Analytics into Internet of Things Applications
EC	European Commission
ECSIP	European Consortium for Sustainable Industrial Policy
eduroam	EDUcation ROAMing
EU	European Union
FER	Faculty of Electrical Engineering and Computer Science, University of Zagreb
FN	Future Networks
GPS	Global Positioning System
H2020	"Horizon 2020" EU Research and Innovation Programme
HTTP	Hypertext Transfer Protocol
HVAC	Heating, Ventilating and Air Conditioning

ICOM	Intracom Sa Telecom Solutions
ICT	Information and Communication Technology
IMO	International Maritime Organization
IOSB	Fraunhofer Gesellschaft zur Förderung der Angewandten Forschung ev
IoT	Internet of Things
ISP	Internet Service Provider
ITU-T	ITU Telecommunication Standardization Sector
KIOLA	Telehealth Service Platform
KIT	Karlsruhe Institute of Technology
KMC	KIOLA Mobile Client
LIP6	Labortoire d'informatique de Paris 6
LoRa	Low Range
LoRaWAN	LoRa Alliance TechnologyLow Power Wide Area Network
LwM2M	Light Weight Machine to Machine Protocol
MBaaS	Mobility Backend As A Service
MMSI	Maritime Mobile Service Identity
MOP	Multiple Open Platform Model
NAVIGO	Na.Vi.Go. Societa Consortile a Responsabilita Limitata
ND	Navigo Digitale platform
NFC	Near Field Communication
NGSI	Next Generation Service Interfaces
NO2	Nitrogen Dioxide
NWX	Nextworks
OSM	Open Street Map
OSS	Open Source Software
P2P	Peer-to-Peer
POI	Point of Interest
RAP	Resource Access Proxy
R&D	Research and Development
REST	REpresentational State Transfer
S&C	Sensing & Control Systems SL
SO2	Sulphur Dioxide
SOC	System On Chip

SSN	Semantic Sensor Network
STB	Set-Top Box
symbIoTe	Symbiosis of Smart Objects across IoT Environments
TELCO	Telecommunications Company
ToC	Table of Contents
UC	Use Case
UCUM	Unified Code for Units of Measure
UID	Unique Identifier
UNIDATA	Unidata Spa
UNIVIE	Universität Wien
UNIZG-FER	Sveučilište u Zagrebu, Fakultet Elektrotehnike i Računarstva
UPMC	Université Pierre et Marie Curie
URL	Uniform Resource Locator
USP	Unique Selling Point
UW	Ubiwhere Lda
UWEDAT	Stationary Air Quality Platform, “(U)m(we)lt(dat)embank”
TCP	Transmission Control Protocol
VIP	Vipnet Društvo sa ograničenom odgovornošću za usluge javnih komunikacija
WP	Work Package

11 Appendix

The appendix of D1.3 includes an example for Tussle Analysis and the sequence diagrams of the envisioned workflows in the specific showcases per use case as defined and specified in Section 4. This means

- Section 11.2.1 includes sequence diagrams for use case Smart Residence.
- Section 11.2.2 includes sequence diagrams for use case EduCampus
- Section 11.2.3 includes sequence diagrams for use case Smart Stadium
- Section 11.2.4 includes sequence diagrams for use case Smart Mobility and Ecological Routing
- Section 11.2.5 includes sequence diagrams for use case Smart Yachting

11.1 Tussle Analysis Example

The example of a tussle [3, 5] and its evolution described in this section has the intention to clarify the concepts of tussles. The tussle presented here addresses TCP's (Transmission Control Protocol) bandwidth sharing algorithm and is illustrated Figure 27 [3]. Circles correspond to (temporary) tussle outcomes. The vertical positioning of a circle denotes which of the stakeholders shown on the left favours the outcome. In particular, if the circle is vertically centred, all stakeholders consider their share appropriate/fair.

TCP's bandwidth sharing algorithm is considered fair, because when k TCP connections are instantaneously active in a bottleneck link, then each of them will receive 1/k of the bandwidth. Since each user of the bottleneck link desires to increase its share of the link, interests of users of a bottleneck link collide. Thus, with the introduction of the Peer-to-Peer (P2P) technology, TCP's bandwidth sharing algorithm lead to instabilities, since P2P users opened multiple TCP connections for the same file and, therefore, got disproportionate bandwidth share in relation to traditional users. While not fair, this outcome was not stable either, since the ability of an ISP to offer other services was threatened by the increase of P2P traffic. Therefore, ISPs responded by introducing middle boxes for inspecting data packets. These dedicated machines used advanced technology, such as Deep Packet Inspection (DPI) techniques, in order to identify and throttle P2P traffic. Even though this allowed for enforcing fair bandwidth sharing in links once more, it was not a stable outcome again: P2P applications started performing traffic obfuscation, e.g., by encryption, in order to decrease the download time. At the same time, DPI technology, which was installed to throttle P2P traffic, allowed ISPs to identify traffic that directly competes with complementary services they offer. A famous example has been an ISP's attempt to degrade the quality of third-party Voice-over-IP services offered by Application Service Providers (ASPs) that threatened traditional telephony services often offered by an affiliate of the ISP. This is an example of a spillover to another functionality, which was solved by affected users asking the regulator to intervene (judicial means) for discouraging anti-competitive tactics. [3, 5]

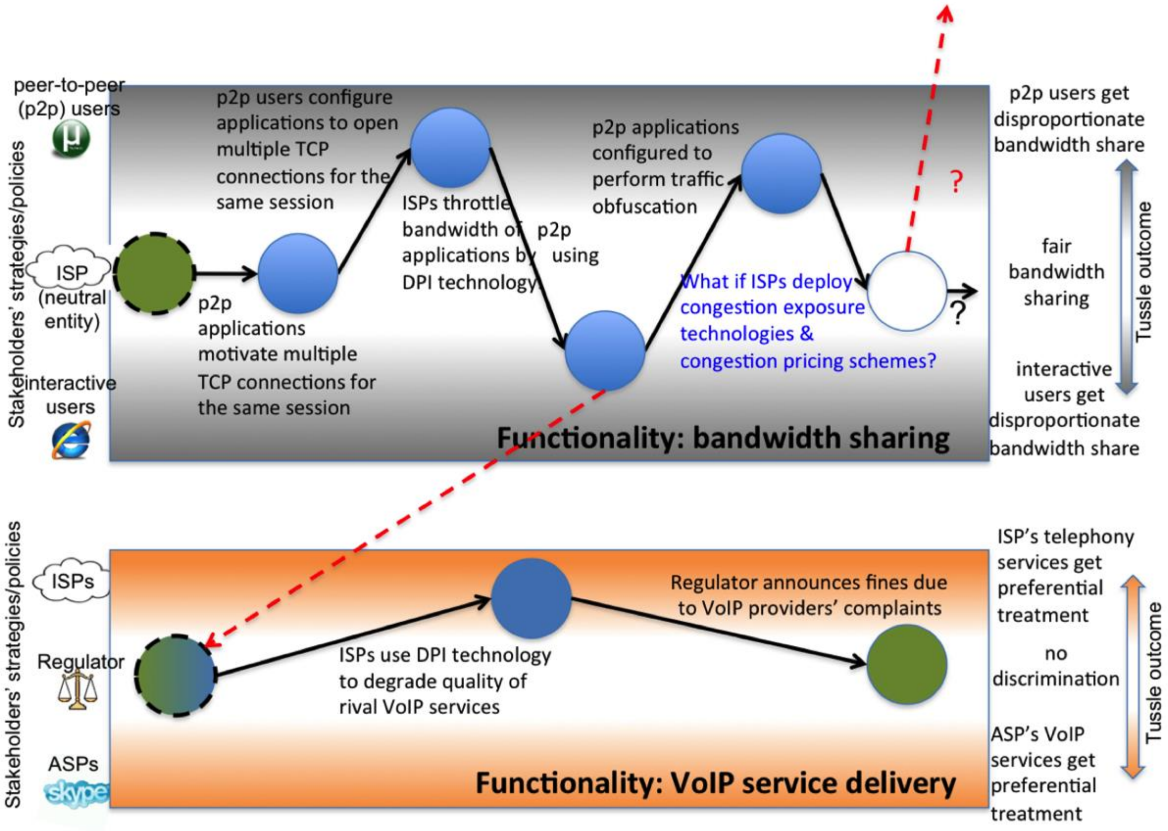

Figure 27 Example of applying Tussle Analysis for Bandwidth Sharing

Similar to the aforementioned example the Tussle Analysis can be applied to symbIoTe. Starting by identifying stakeholders and their tussles, following how those can be solved when symbIoTe comes on the market and might raise new tussles or even spillovers.

11.2 Sequence Diagrams for Use Case

11.2.1 Sequence Diagrams for Use Case 1 – Smart Residence

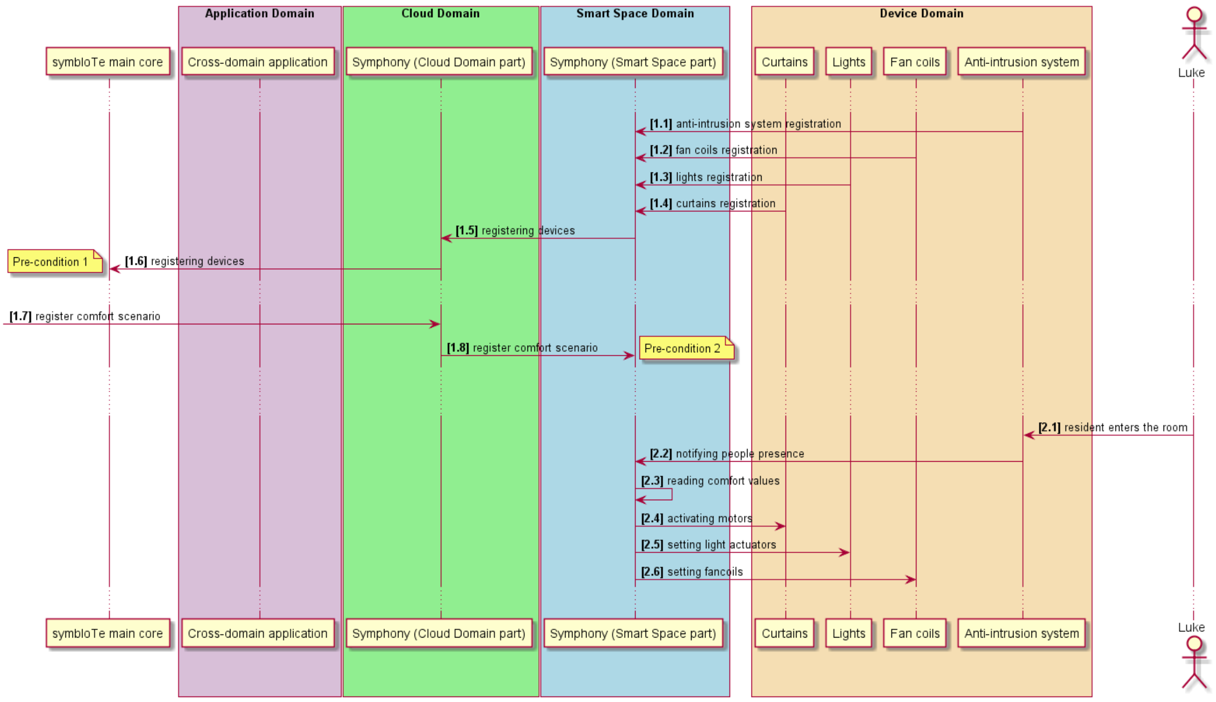

Figure 28: Use case 1 - Sequence diagram of the Energy Saving workflow

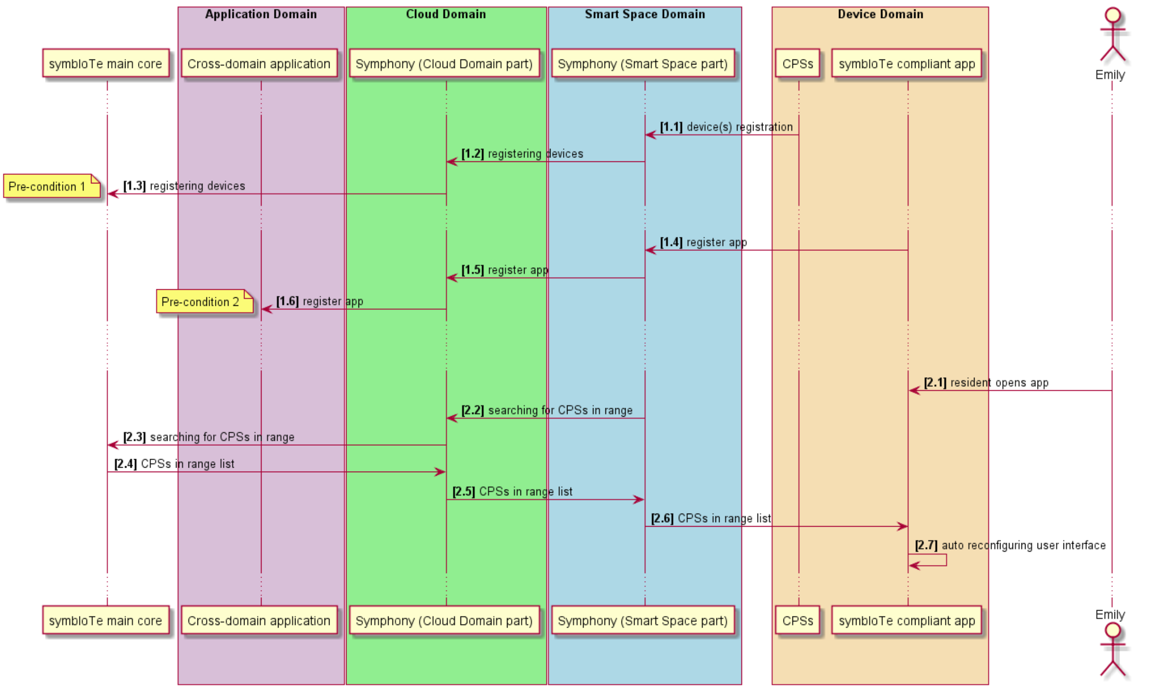

Figure 29: Use case 1 - Sequence diagram of the Dynamic Interface Adaption workflow

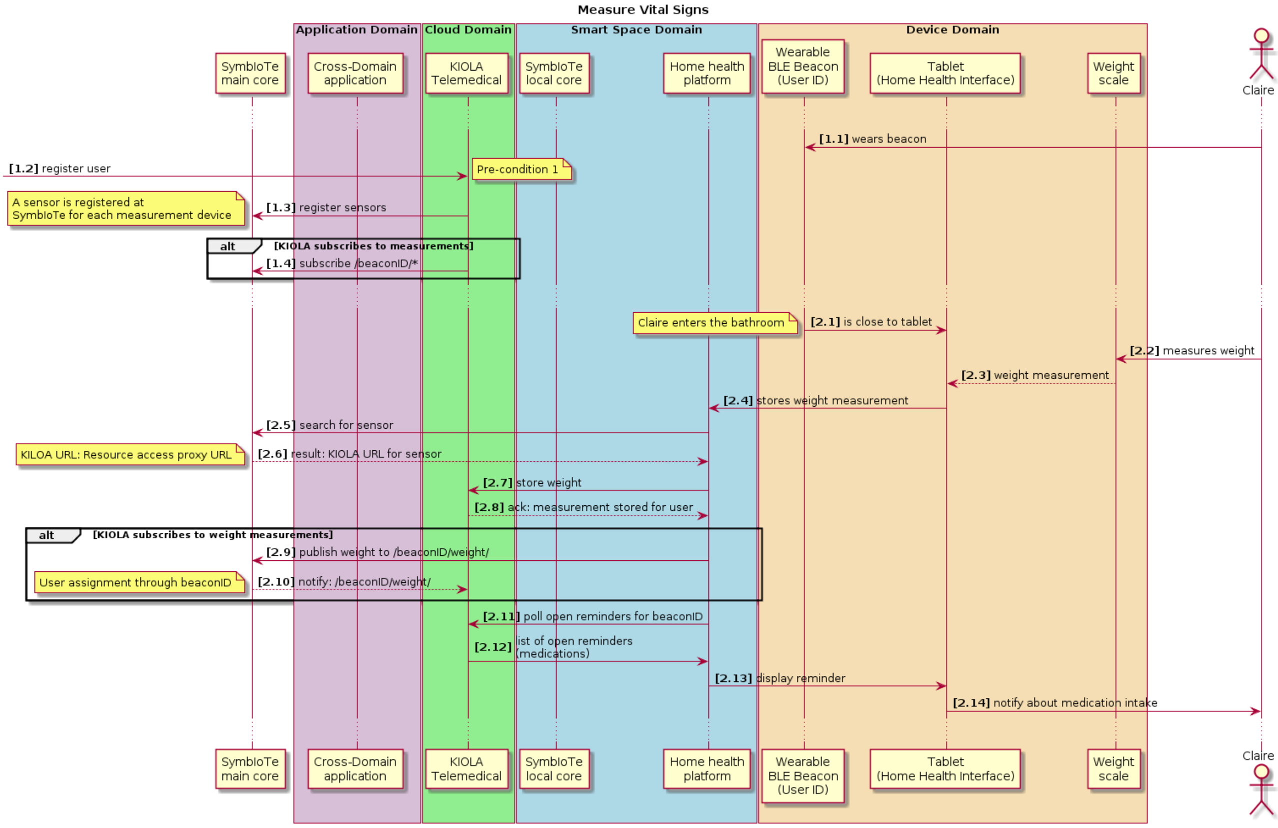

Figure 30: Use case 1 - Sequence diagram for *Measure Vitale Signs/Medication Reminder* workflow

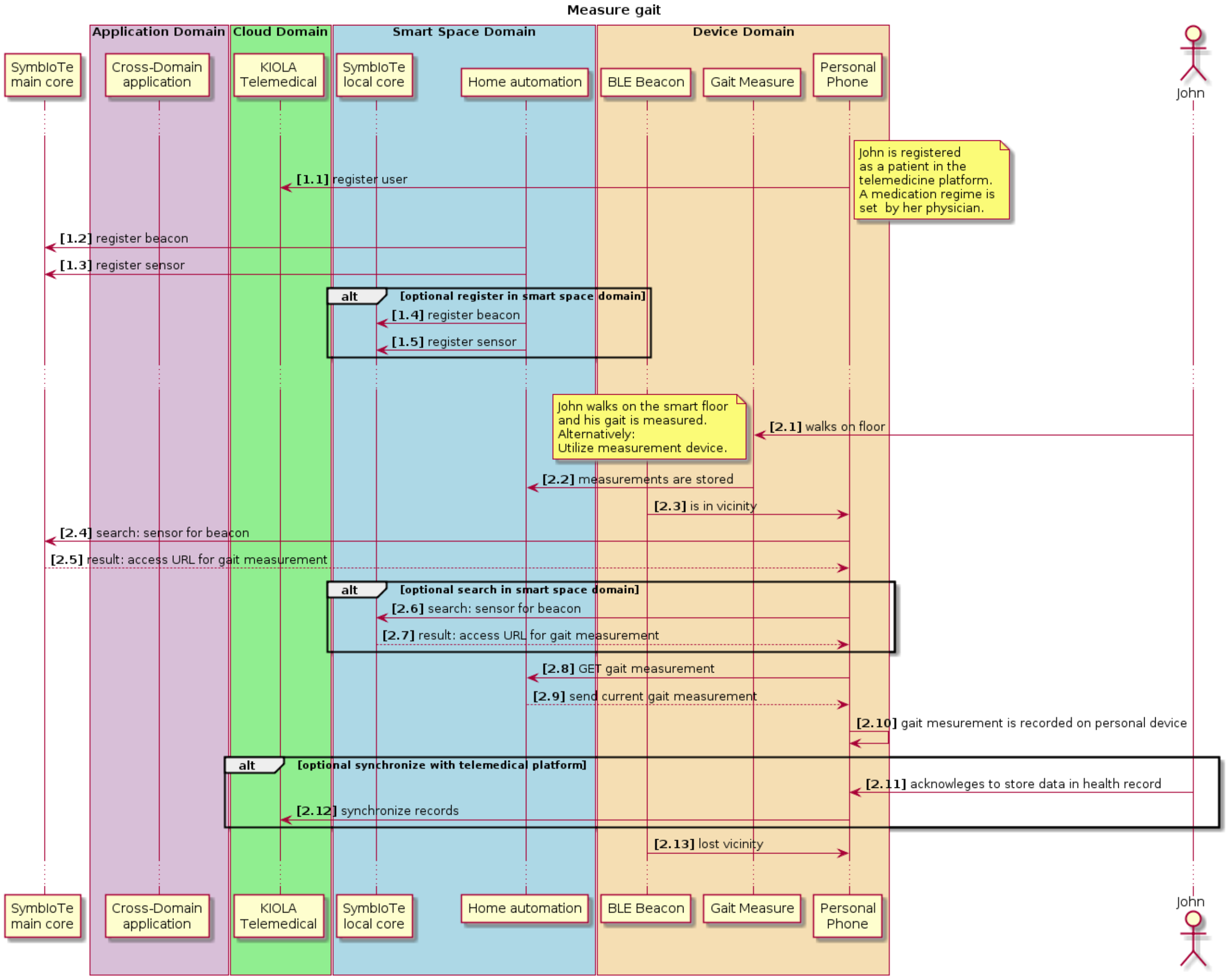

Figure 31: Use case 1 - Sequence diagram for *Measure Gait* workflow

11.2.2 Sequence Diagram for Use Case 2 – EduCampus

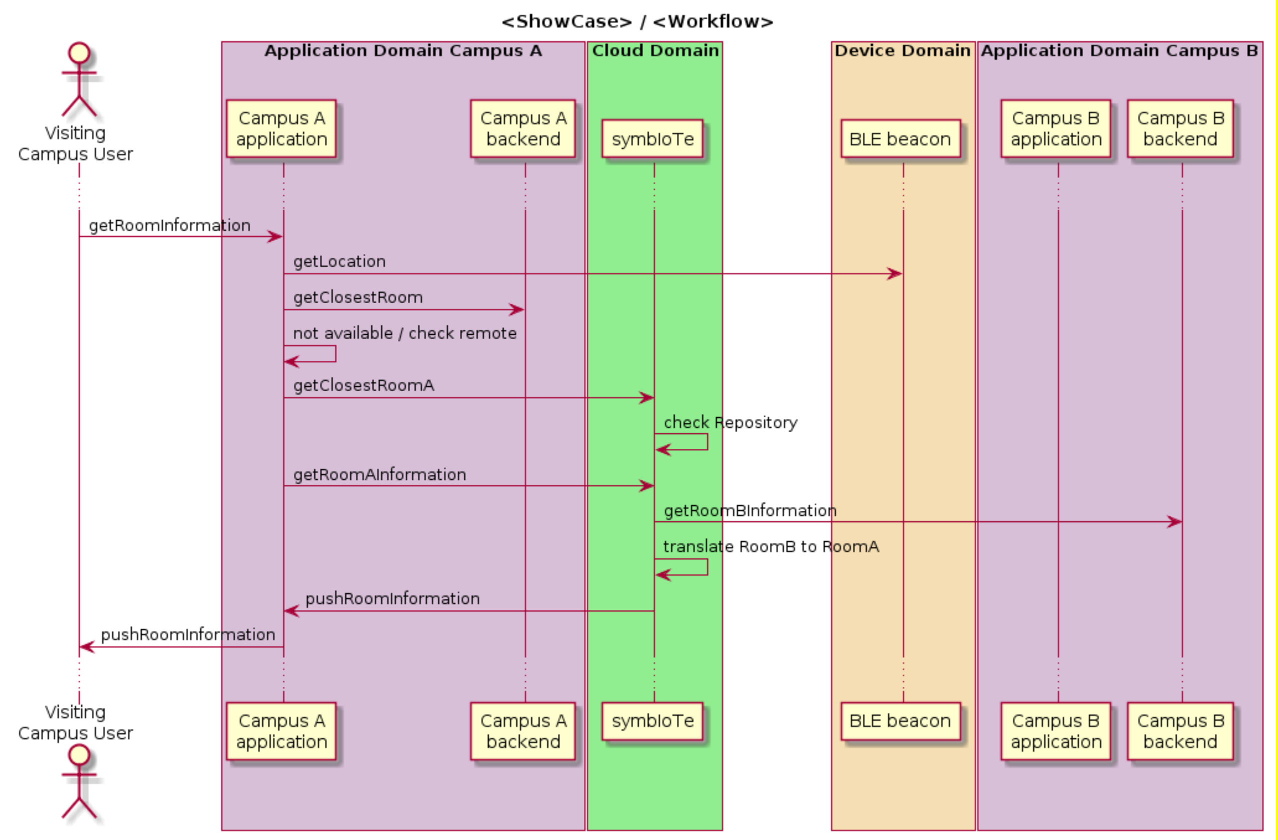

Figure 32: Use case 2 - Sequence diagram for *Get Room Information* workflow

11.2.3 Sequence Diagrams for Use Case 3 – Smart Stadium

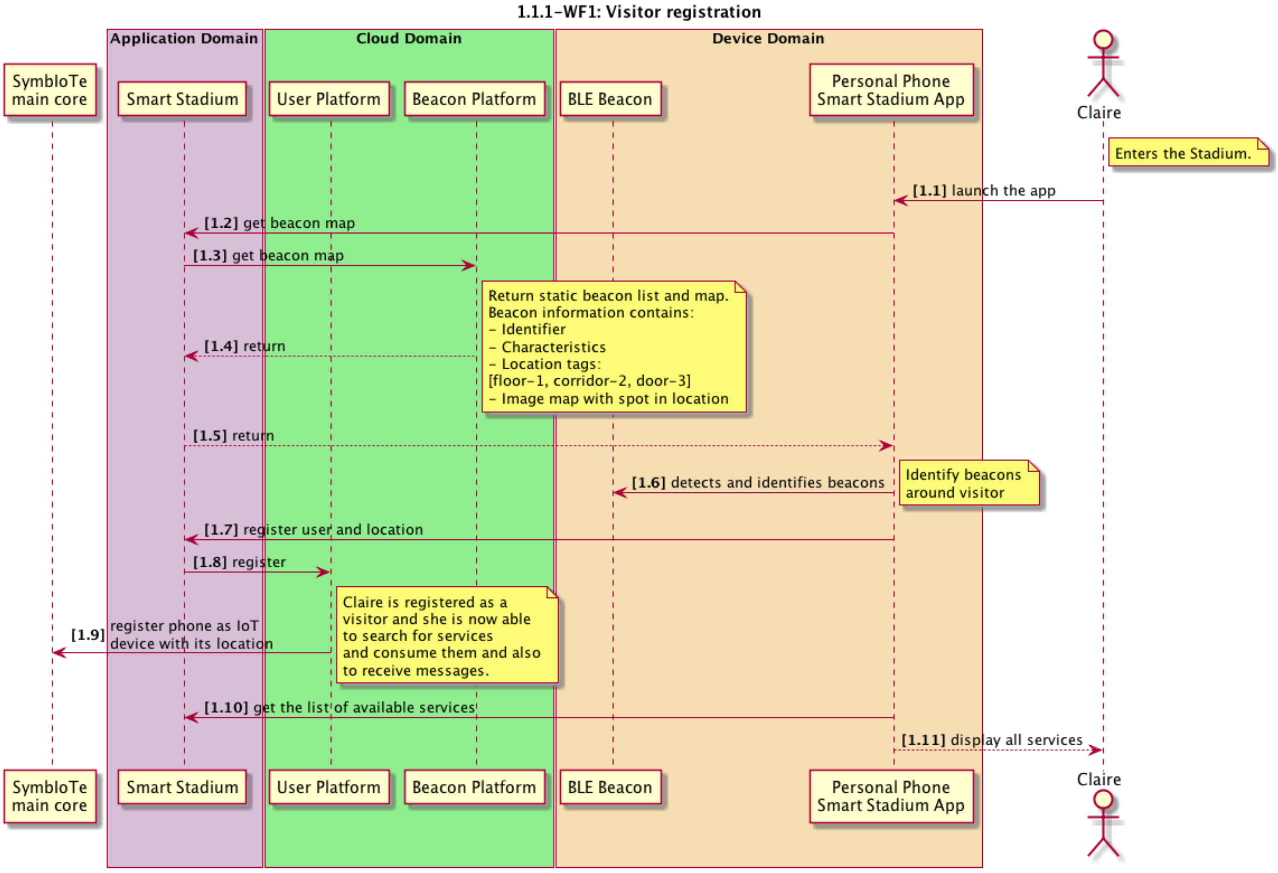

Figure 33: Use case 3 - Sequence diagram of the *Visitor Registration* workflow

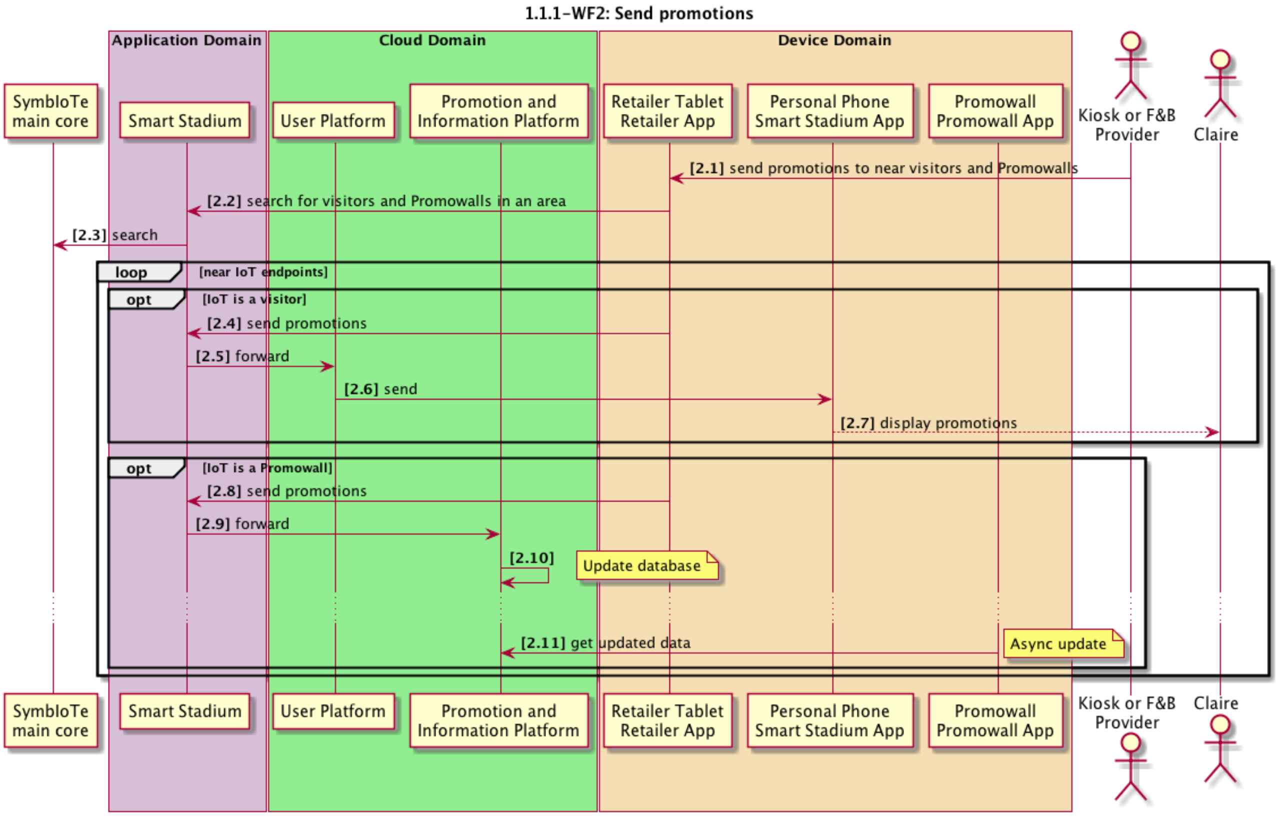

Figure 34: Use case 3 - Sequence diagram of the *Send Promotions* workflow

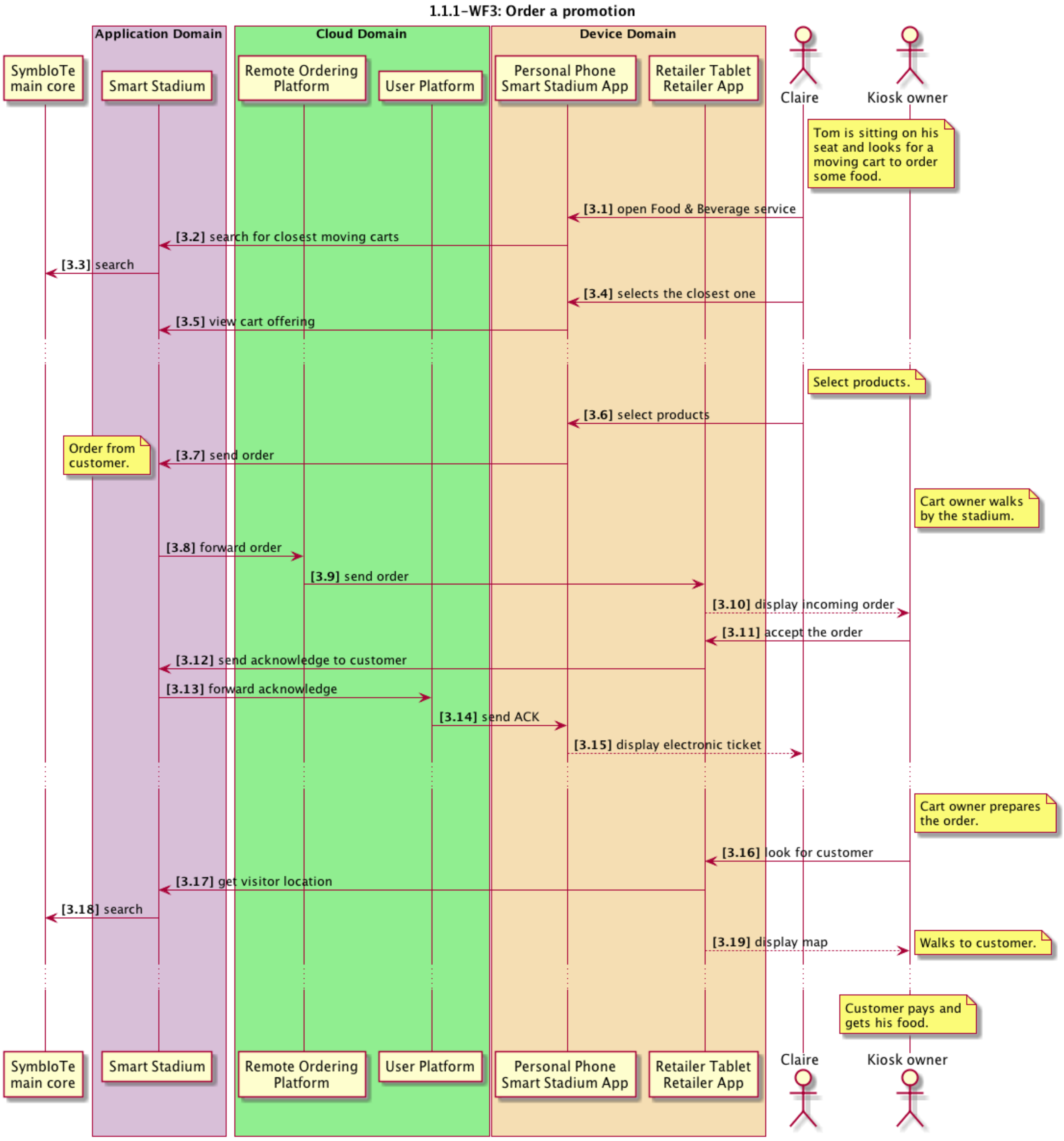

Figure 35: Use case 3 - Sequence diagram of the *Order a Promotion* workflow

11.2.4 Sequence Diagrams for Use Case 4 – Smart Mobility and Ecological Routing

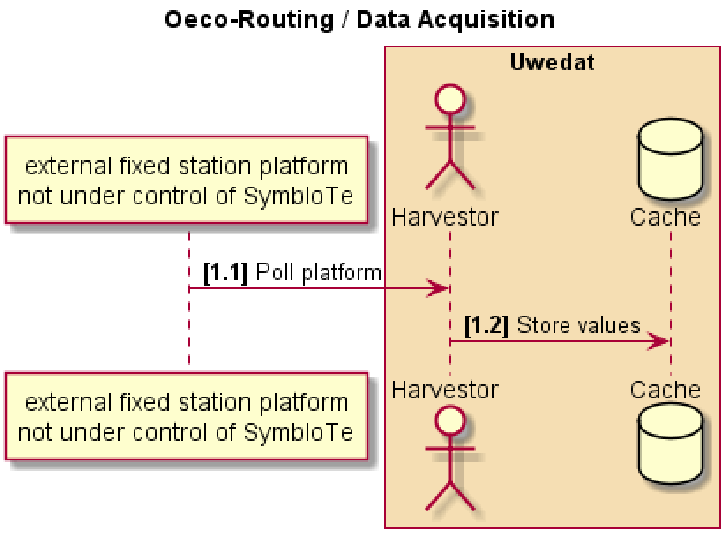

Figure 36: Use case 4 - Sequence diagram for the *Data Acquisition* process of workflow

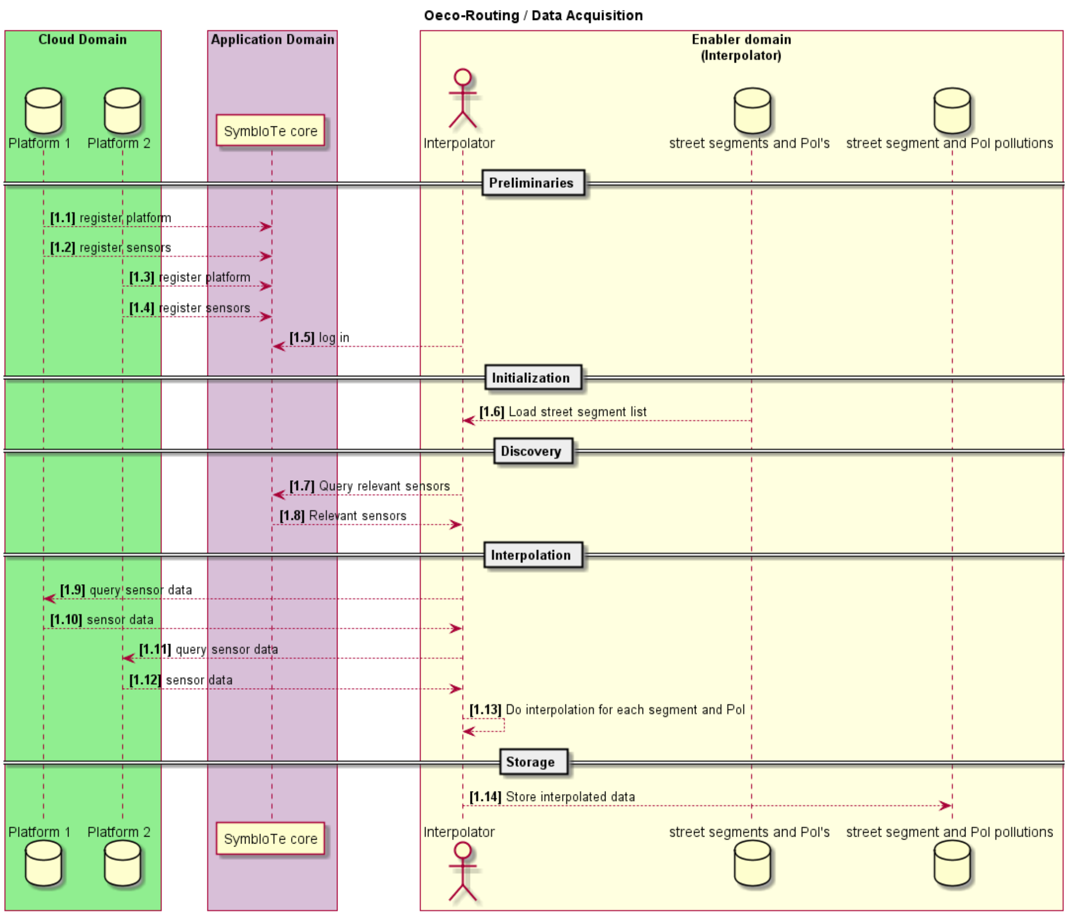

Figure 37: Use case 4 - Sequence diagram for *Data Interpolation* process of workflow

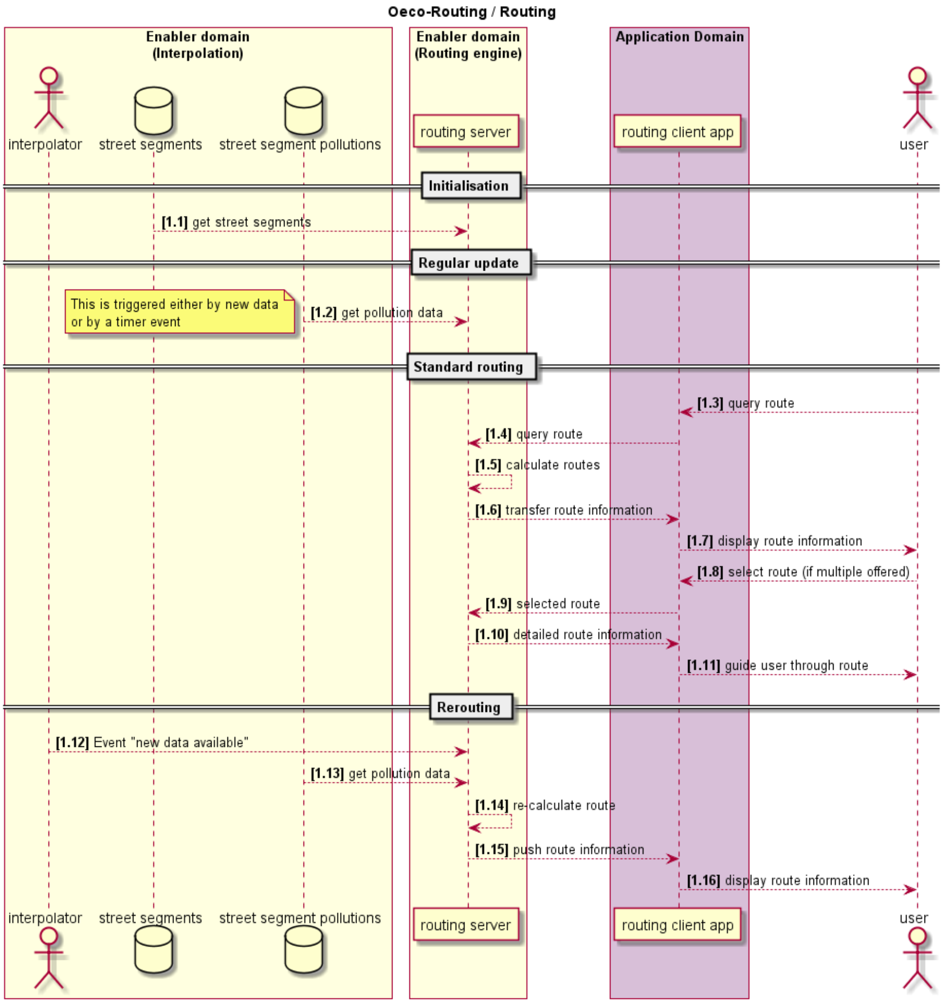

Figure 38: Use case 4 - Sequence diagram for the *Calculation of Green Route* workflow

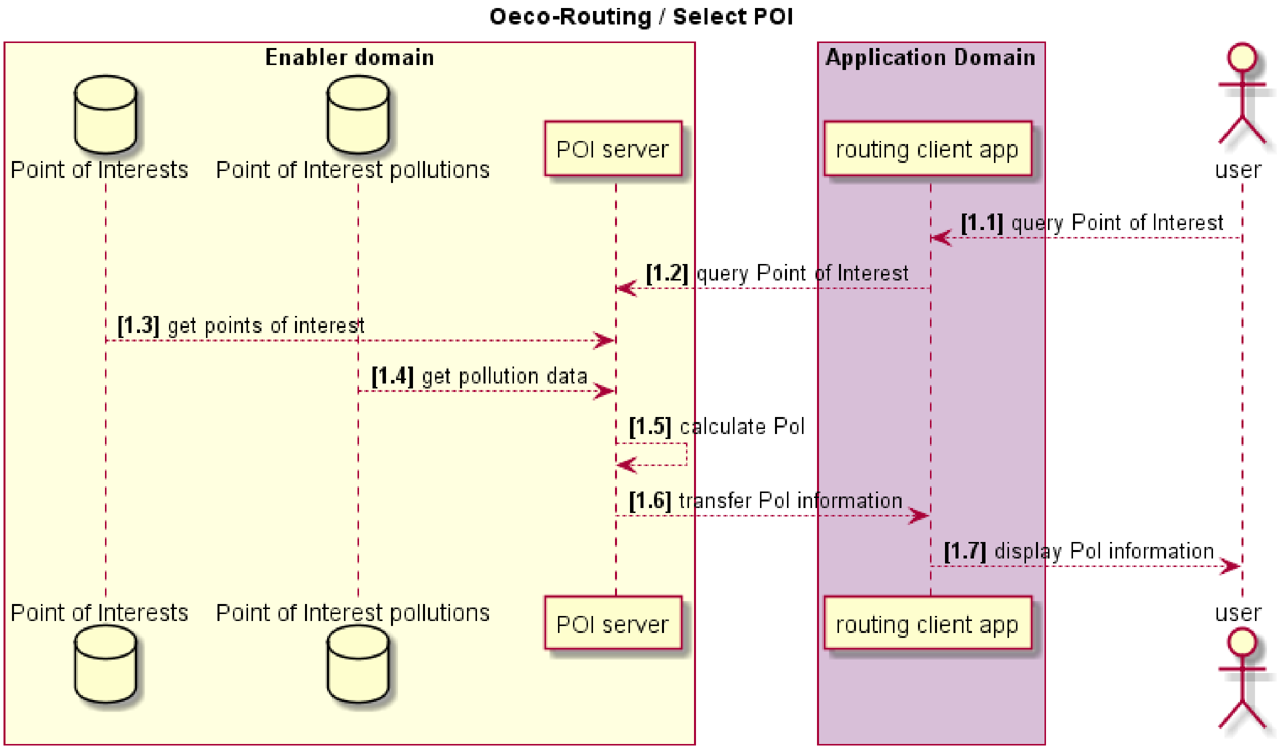

Figure 39: Use case 4 - Sequence diagram for *Point of Interest Search* workflow

11.2.5 Sequence Diagrams for Use Case 5– Smart Yachting

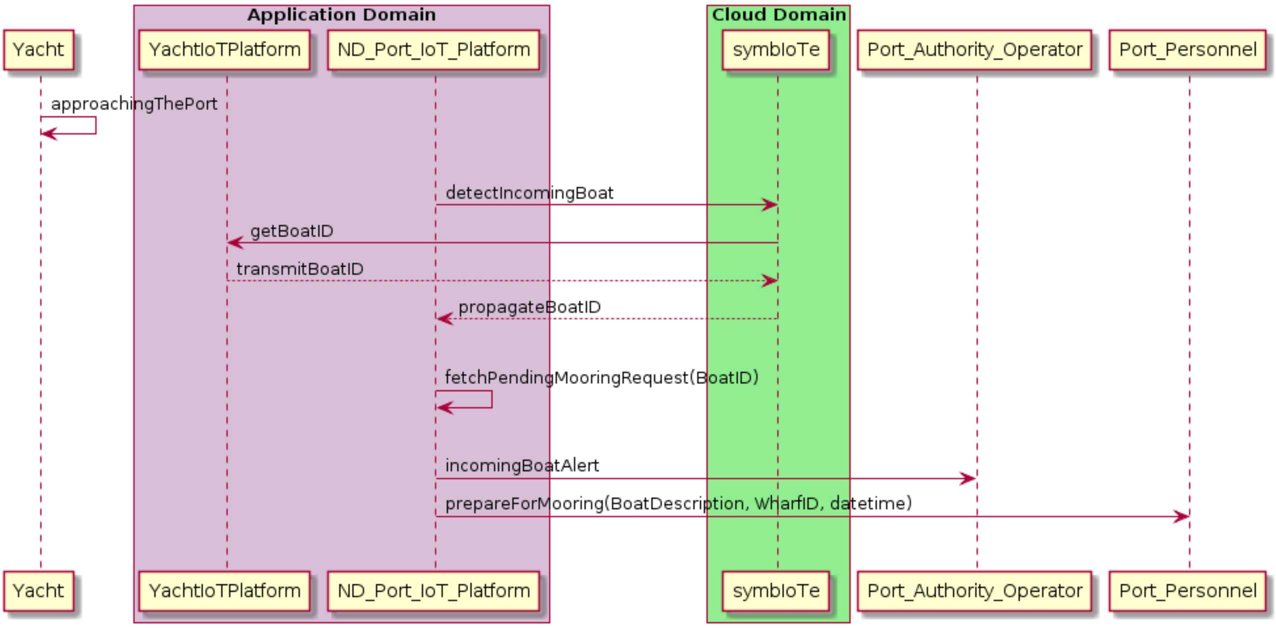

Figure 40: Use case 5 - Sequence diagram of *Yacht Approaching the Port* workflow

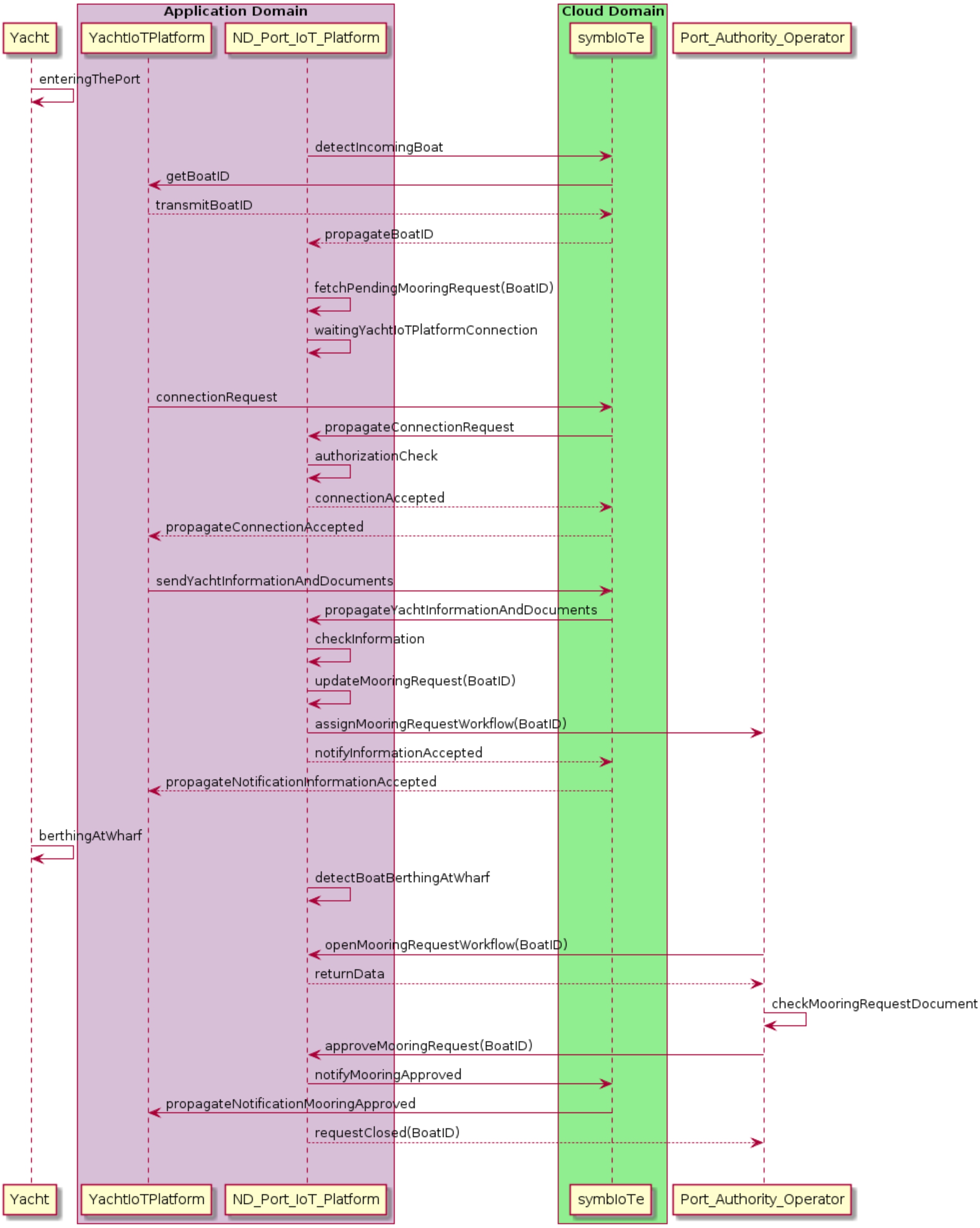

Figure 41: Use case 5 - Sequence diagram of *Mooring Procedure Completion* workflow

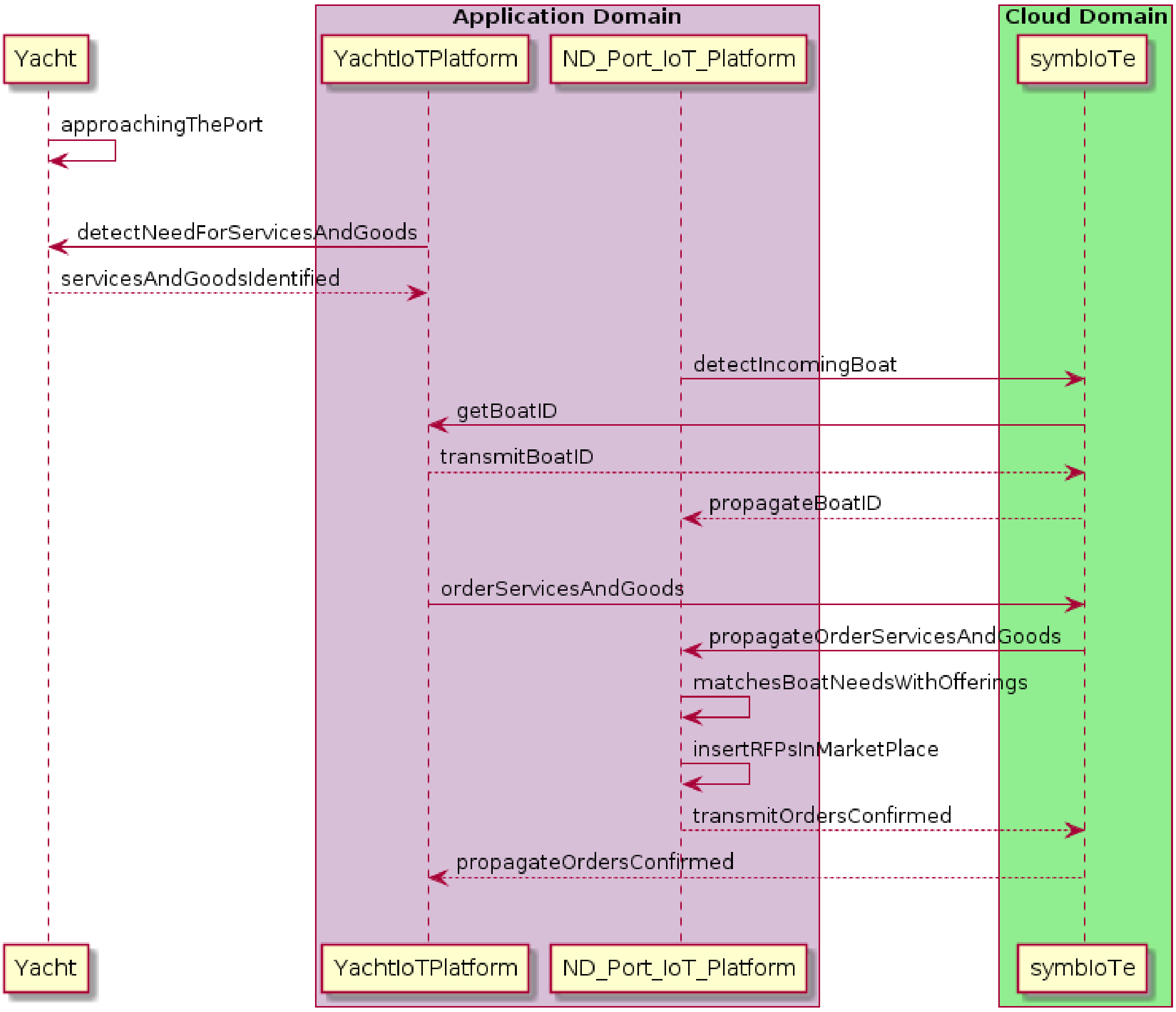

Figure 42: Use case 5 - Sequence diagram of *Supply Chain* workflow