HORIZON 2020

Information and Communication Technologies

Integrating experiments and facilities in FIRE+

Deliverable D1.1
Requirements Analysis

Grant Agreement number: 687992

Project acronym: **EMBERS**

Project title: **Enabling a Mobility Back-End as a Robust Service**

Type of action: **Innovation Action (IA)**

Project website address: **www.embers-project.eu**

Due date of deliverable: **2016-02-29**

Dissemination Level		
PU	Public	X
CO	Confidential, only for members of the consortium (including the Commission Services)	

Document properties

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Version	0.2

Abstract

The Mobility Back-end as a Service (MBaaS) will lower barriers to entry for app and device developers, making it easier for innovative SMEs to enter the market. Beyond its primary goal of bringing the MBaaS to market, EMBERS will stimulate the development of an entire ecosystem around the MBaaS smart city mobility API. Separating out the back-end from the other components will, however, require rigorous testing.

The aim of Work Package 1 is to set up the FIRE+ testbeds (Task 1.2) and the experimentation on those testbeds (Task 1.3). This requirements deliverable, the outcome of Task 1.1, forms the basis for those two tasks. EMBERS will experiment with the system on two testbeds that are part of the FIRE+ OneLab facility: the FUSECO Playground, for M2M communications, and FIT IoT-LAB, for wireless sensor devices.

This document contains the description of all technical requirements of M2M/IoT experimenters/testers, including infrastructural requirements, platform related requirements, application-specific requirements as well as requirements related to M2M/IoT experimentation.

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1 Introduction

Municipalities are seeking alternatives to all-in-one smart city mobility systems. They would like to be able to compose a system from multiple suppliers, each one of which provides a best-of-breed component for the particular niche that it serves, choosing sensors from one vendor and information panels from another provider, an app from a developer and a different app from a different developer, and so forth. For an enterprise in Europe to maintain a lead in the provision of smart city solutions to municipalities, it needs to keep ahead of this trend towards the breakdown of all-in-one systems into interoperable components.

EMBERS makes a decisive move in this direction for smart city mobility by developing one key element: the Citibrain mobility back-end [1], created by Ubiwhere. It ties together an intelligent city mobility system, receives inputs from devices that are deployed in the roads and on vehicles, enabling it to keep track of their location, the state of traffic on the roads, which parking spaces are available and which ones are free, and so on. It processes this data and communicates it through apps that help guide vehicles through cities and towards available parking spaces, for instance. This solution, used as a starting point, and separated out as a standalone service, will provide a free, open API that is specific to smart city mobility, allowing developers of devices and apps to start immediately exchanging information about vehicles, roads, routes, parking spaces, drivers, and so forth. This exchange will be possible without having to reinvent this vocabulary and its rules themselves or follow a closed, proprietary system.

Currently, the Citibrain mobility back-end offers proprietary and FIWARE NGSI interfaces [2] for developers and device manufacturers to use, as seen in Figure 1. Although, it lacks the ability to provide more M2M/IoT interfaces for developers and devices manufacturers to connect with it. To ensure that these parties can integrate with the mobility back-end via these specifications, EMBERS aims to provide a broad variety of protocols. With this, developers do not need to adapt their applications to any specification, which widens the spectrum of possible solutions for each use case.
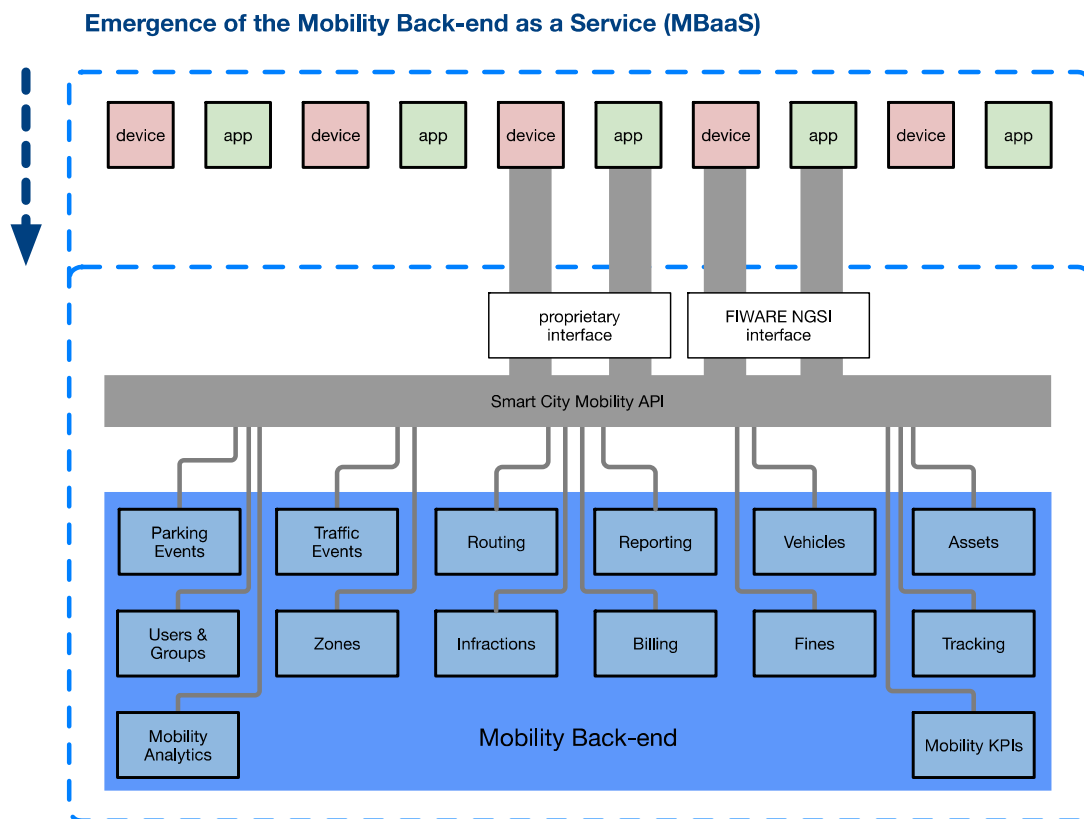

Figure 1 - MBaaS before EMBERS

As described above, EMBERS intends to expand the range of available protocols to access the MBaaS, which will empower the platform by ensuring that developers and device manufacturers can

easily communicate with it without having to re-work their applications. Figure 2 presents the state of the MBaaS after EMBERS.
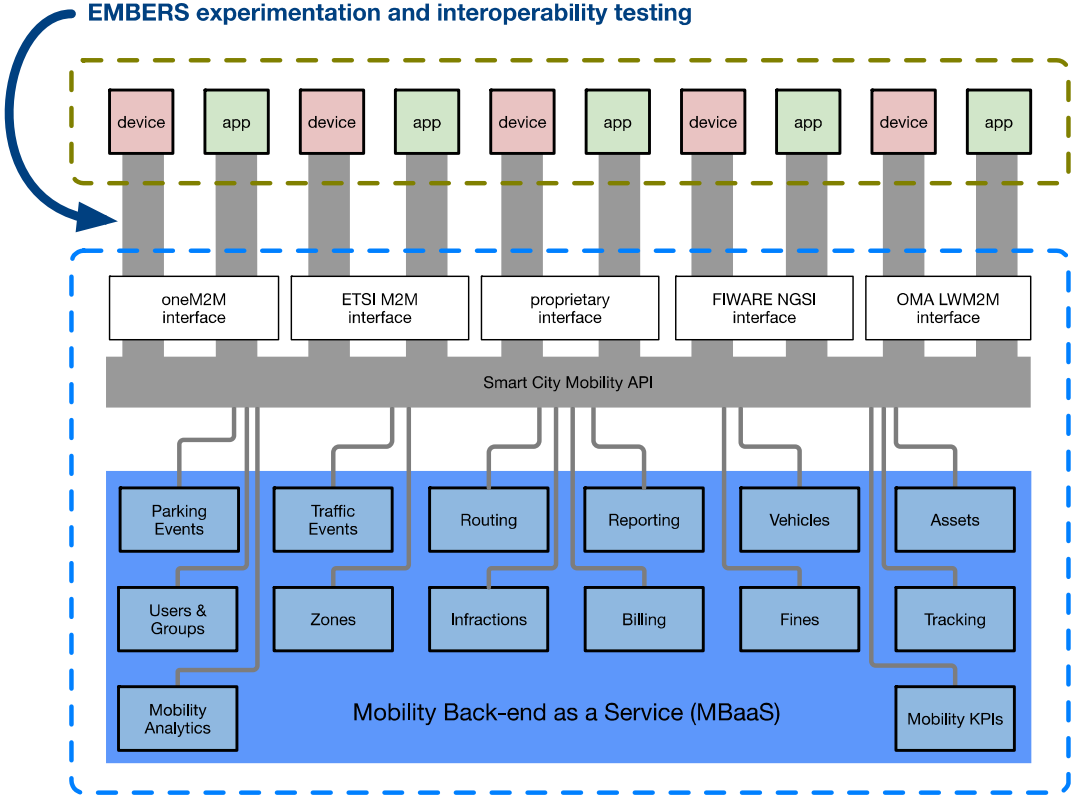

Figure 2 - MBaaS after EMBERS

After EMBERS the platform will have, alongside the proprietary and FIWARE NGSI interfaces, other generic interfaces which will be oneM2M [4], ETSI M2M [3] and OMA LwM2M [5]. This upgrade is a crucial advance for the MBaaS because a standard interface is yet to be defined. Beyond ensuring preparedness if one of these interfaces will emerge as a standard, EMBERS will lower the entry barriers to developers of apps and devices, which are now able to use any of the provided interfaces. At this point, it is important to explain that the hackathon, open call, and app challenge are of extreme relevance to ensure that every interface is working with real world scenarios. This report provides a detailed analysis of the requirements for integrating the mobility backend solution into the EMBERS infrastructure, with the aim of achieving all the proposed objectives (and Key Performance Indicators), as stated in the proposal:

- Develop the Citibrain MBaaS product so that it is ready to bring to market and deploy a truly multi-standard smart city mobility back-end;

- Give rise to an ecosystem of apps and devices designed around Ubiwhere's open smart city mobility API and enable new business models for Small-Medium Enterprises and start-ups;

- Demonstrate successful testing of a close-to-market product on FIRE+ facilities and straightforwardness of smart city experimentation on FIRE+ testbeds.

The aim of Work Package 1 is to set up the FIRE+ testbeds (Task 1.2) and the experimentation on those testbeds (Task 1.3). This requirements deliverable, the outcome of Task 1.1, forms the basis for those two tasks. The document starts by evaluating the necessary adjustments to make the MBaaS capable of integrating with the infrastructure provided by the project, both FIT IoT-Lab, and FUSECO Playground, namely concerning communication protocols, interface standards and the software modules susceptible to receive and process data from authorized physical sensors. In Chapter 3, one can find the use cases and test scenarios planned for the experimentation and testing phases with the previously mentioned infrastructure from the European Commission FIRE+ initiative [6]. The following chapter describes everything that is required for successful dissemination and integration events happening during the project: the Hackathon, the App Contest, and the Open Call. The deliverable comes to an end with the conclusions and references chapter.

2 Integration Requirements

The initial phase is planned to involve the adaptation of the Mobility platform to allow its integration with the experimentation facilities, available for this project. Since Ubiwhere's Mobility Backend as a Service platform (MBaaS) will work on a distinct cloud instance, remotely from the testing laboratories, it will need to support several communication protocols and open standards, not only for the dissemination events with third-party entities but also for the experimentation and testing phases. The final goal is to allow the communication through the most extensive set of protocols and to use the most diverse set of open standards possible, which will turn the platform into a solution ready for testing with an enormous number of devices from the experimentation facilities.

2.1 Communication Protocols

The emerging "Internet of Things" covers a vast range of industries and scales of devices/applications. Some different standardization bodies and groups are actively working on creating more inter-operable protocol stacks and open standards for the Internet of Things (IoT). As we move from the HTTP, TCP/IP stack to the IoT-specific protocol stack we are suddenly confronted with an acronym soup of protocols. Below we describe the requirements for the communication protocols that MBaaS should provide.

2.1.1 HTTP

HTTP is the well-known application protocol considered as the foundation of data communication for the World Wide Web, which is still widespread in the IoT context for communication between devices and platforms. It is widely used much due to the many implementations of REST architectures.

Requirement Name	Support for HTTP Protocol for device communication
Description	The MBaaS must provide interfaces to receive data from devices using the HTTP protocol.
KPIs	Bring the Citibrain MBaaS to the market
Category	Mandatory

Requirement Name	Support for HTTP Protocol for device registration
Description	The platform must allow registration of devices for message publishing using the HTTP protocol.
KPIs	Bring the Citibrain MBaaS to the market
Category	Mandatory

Requirement Name	Support for HTTP Protocol for data and services APIs
Description	MBaaS must provide data and services RESTful APIs using the HTTP protocol.
KPIs	Bring the Citibrain MBaaS to the market
Category	Mandatory

2.1.2 CoAP

The Constrained Application Protocol (CoAP) [10] is a specialized web transfer protocol for use with constrained nodes and limited networks in the Internet of Things, designed for machine-to-machine (M2M) applications. Its specification allows devices to communicate over the Internet and is objectively targeted for low powered sensors that require remote supervision, making it a very useful protocol for Smart Cities and Internet of Things scenarios.

CoAP was designed to easily translate to HTTP for an easier integration with the web and, at the same time, meeting requirements like multicast support and simplicity. Additionally, there is also a protocol extension that enables CoAP clients to observe resources, retrieve representations of the said resource and keep it updated over a period.

Requirement Name	Support for CoAP Protocol for device communication
Description	The MBaaS must provide interfaces to receive data from devices using the CoAP protocol.
KPIs	Bring the Citibrain MBaaS to the market
Category	Mandatory

Requirement Name	Support for CoAP Protocol for device registration
Description	The MBaaS should provide interfaces to register devices for message publishing using the CoAP protocol.
KPIs	Bring the Citibrain MBaaS to the market
Category	Desirable

2.1.3 MQTT

MQTT [11] is a machine-to-machine (M2M)/"Internet of Things" connectivity protocol. Designed as an extremely lightweight publish/subscribe messaging transport, it is useful for connections with remote locations where developers require a small code footprint and network bandwidth is at a premium. It supports three types of quality of service control for message delivery, so it is possible to ensure the delivery of critical messages.

Requirement Name	Support for MQTT Protocol for device communication
Description	The MBaaS must provide interfaces to receive data from devices using the MQTT protocol.
KPIs	Bring the Citibrain MBaaS to the market
Category	Mandatory

2.1.4 LwM2M

On top of CoAP, the Open Mobile Alliance (OMA) has defined "Lightweight M2M" [12] as a simple, low-cost remote management and service enablement mechanism. LwM2M provides device management functionalities, transfers service data to devices and is extensible to meet other application requirements.

Requirement Name	Support for LwM2M Protocol for device communication
Description	The platform must provide interfaces to receive data from devices using the LwM2M protocol.
KPIs	Bring the Citibrain MBaaS to the market
Category	Mandatory

Requirement Name	Support for LwM2M Protocol for device registration
Description	MBaaS should allow registration of devices for message publishing using the LwM2M protocol.
KPIs	Bring the Citibrain MBaaS to the market
Category	Desirable

2.2 Standards

Some different standardization bodies and groups are actively working on creating more interoperable protocol stacks and open standards for the Internet of Things. The complexity of these standardization efforts has evoked comparisons to the VHS and Betamax competition in the 1980s, and some authors believe there is no way all of these devices will be able to all talk to each other until all this gets settled. In the meantime, the MBaaS platform must assure interoperability with different end-devices and sensors, leveraging the standards-compliant M2M interfaces of the OpenMTC M2M platform, along with the already supported FIWARE open standard, NGSI.

2.2.1 NGSI

NGSI-10 is an open specification for exchanging context information, defined by OMA. FIWARE has created a version of this specification which consists of a RESTful API via HTTP, to permit the interaction between their architecture and other endpoints that want to communicate with its ecosystem.

The three main interaction types supported are:

• One-time queries for retrieving context information, which allows a user to get the current status of a given object or entity;

• Context information updates subscriptions, providing the possibility of getting real-time updates on the desired objects;

• Unsolicited updates invoked by the data providers, without the need for a previous subscription;

The primary goal of this API is to ensure interoperability with the FIWARE generic enablers (i.e. open-source technology modules) that expose NGSI interfaces. It enables different actors in the environment to provide/consume context information and discover context entities.

Requirement Name	Support for NGSI-compliant messages reception interface
Description	The platform should provide NGSI-10 operation resources for receiving messages (i.e. context updates).
KPIs	Bring the Citibrain MBaaS to the market
Category	Mandatory

Requirement Name	Support for NGSI-compliant messages provision interface
Description	The platform should provide NGSI-10 operation resources for consuming messages (i.e. context subscriptions).
KPIs	Bring the Citibrain MBaaS to the market
Category	Mandatory

Requirement Name	Provision of NGSI-compliant SDK
Description	The platform should provide SDKs for developers to quickly integrate their applications and devices with the NSGI-compliant interfaces.
KPIs	Bring the Citibrain MBaaS to the market
Category	Mandatory

2.2.2 OMA M2M

The Open Mobile Alliance is an association that develops open standards for the mobile communications industry, whose goals are:

- Provide open technical specifications that take into account market requirements and improve the extensibility and modularity of the systems while reducing the industry's implementation efforts;

- Ensure that their enablers provide interoperability across a broad range of endpoints, locations, service providers, networks, etc.;

- Strive for the consolidations of standards in the mobile industry by working with other existing standards organisations;

- Value its members regardless of where they stand in the value chain;

OMA maintains a large number of specifications including MMS (multimedia messaging), OMA IMPS (Instant messaging and presence service) and OMA LWM2M (Light Weight Machine-to-Machine), here simplified as OMA M2M.

Requirement Name	Provision of interface for registration compliant with OMA's M2M
Description	The platform should provide interfaces to allow developers to register the client and its objects (e.g. devices) following LwM2M's specification.
KPIs	Bring the Citibrain MBaaS to the market
Category	Mandatory

Requirement Name	Provision of interface for information reporting LwM2M's compliant
Description	The platform should provide interfaces that allow devices (objects) to publish notifications with new resource values (e.g. temperature) compliant with LwM2M's specification.
KPIs	Bring the Citibrain MBaaS to the market
Category	Mandatory

Requirement Name	Provide SDK compliant with OMA's M2M
Description	SDKs should be freely available for developers to quickly integrate their applications and devices with LwM2M-compliant interfaces.
KPIs	Bring the Citibrain MBaaS to the market
Category	Mandatory

2.2.3 ETSI M2M

ETSI states that the use of standards ensures interoperability and creates cost-effective solutions, opens new opportunities in different areas and allows the market to reach its full potential. Security is also a big concern, so the security standards are needed to protect individuals, businesses and governments. Some projects that ETSI has contributed to include SmartM2M and oneM2M, which thrive to standardise machine-to-machine communication.

Requirement Name	Provision of interface for registration compliant with ESTI's M2M
Description	The platform should provide interfaces to allow developers to register the devices following ETSI's specification.
KPIs	Bring the Citibrain MBaaS to the market
Category	Mandatory

Requirement Name	Provision of interface for data transfer compliant with ETSI M2M
Description	The platform should provide ETSI's M2M-compliant interfaces that allow developers to subscribe devices (containers) to receive updates on their applications.
KPIs	Bring the Citibrain MBaaS to the market
Category	Mandatory

Requirement Name	Provide SDK compliant with ETSI's M2M
Description	SDKs should be freely available for developers to quickly integrate their applications and devices with ETSI M2M-compliant interfaces.
KPIs	Bring the Citibrain MBaaS to the market
Category	Mandatory

2.3 Device Brokers

The M2M device broker is one of the essential components of Ubiwhere's MBaaS platform architecture since it is the one responsible for communication with physical devices. It is the entry point for data originated in the field, with the meaningful purpose of validating if the sensor is allowed to publish messages to the platform and allow the income of data through a diverse set of communication protocols. To comply with the different protocols and open standards already described, and to make the MBaaS a robust solution ready to market, here we present the requirements that the several alternatives should support.

2.3.1 Meshblu

Meshblu [9] is an open-source machine-to-machine instant messaging network and API, available on HTTP REST, real-time Web Sockets, MQTT, and CoAP. It seamlessly bridges all protocols, allowing devices that communicate via different protocols to interchange data between themselves. In this section, we provide the requirements that this component should support.

Requirement Name	Provision of interface for device registration via CoAP
Description	The device broker must provide an interface for device registration supporting CoAP.
KPIs	Bring the Citibrain MBaaS to the market
Category	Mandatory

Requirement Name	Provision of interface for message publication via HTTP
Description	Meshblu must provide an interface for message submission supporting HTTP.
KPIs	Bring the Citibrain MBaaS to the market
Category	Mandatory

Requirement Name	Provision of interface for message publication via CoAP
Description	The open-source device broker must provide an interface for message publication supporting the CoAP protocol.
KPIs	Bring the Citibrain MBaaS to the market
Category	Mandatory

Requirement Name	Provision of interface for message publication via MQTT
Description	Meshblu must provide an interface for message publication supporting MQTT.
KPIs	Bring the Citibrain MBaaS to the market
Category	Mandatory

Requirement Name	Provision of interface for message publication via Web Sockets
Description	Meshblu must provide an interface for message submission supporting Web Sockets.
KPIs	Bring the Citibrain MBaaS to the market
Category	Mandatory

Requirement Name	Acceptance of messages merely from registered devices
Description	Meshblu must only accept data messages from registered devices properly authenticated.
KPIs	Bring the Citibrain MBaaS to the market
Category	Mandatory

Requirement Name	Deactivation of local database storage of received messages
Description	The device broker must not store received messages in its local database.
KPIs	Bring the Citibrain MBaaS to the market
Category	Mandatory

Requirement Name	Protection of the interface for device discovery
Description	Meshblu must not allow unauthorized requests to the sensor directory interface that allows listing and discovery of available instances.
KPIs	Bring the Citibrain MBaaS to the market
Category	Mandatory

2.3.2 Eclipse Ponte

Ponte is an open source framework and API, built on NodeJS that shortens the space between the hardware layer and the software layer. It allows data to be received and published using HTTP, MQTT, and CoAP. This section provides the necessary requirements that will be supported by Ponte.

Requirement Name	Provision of interface for device registration via HTTP
Description	The device broker must provide a RESTful HTTP interface for device registration.
KPIs	Bring the Citibrain MBaaS to the market
Category	Mandatory

Requirement Name	Provision of interface for message publication via HTTP
Description	Ponte must provide RESTful HTTP interfaces for message publication.
KPIs	Bring the Citibrain MBaaS to the market
Category	Mandatory

Requirement Name	Provision of interface for message publication via MQTT
Description	Eclipse Ponte must provide an interface for message publication supporting the MQTT.
KPIs	Bring the Citibrain MBaaS to the market
Category	Mandatory

Requirement Name	Provision of interface for message publication via CoAP
Description	Ponte must provide CoAP interfaces for message publication.
KPIs	Bring the Citibrain MBaaS to the market
Category	Mandatory

2.3.3 (FIWARE) IDAS

IDAS [13] is the FIWARE equivalent to Ponte or Meshblu. It's an open source solution that allows a seamless gathering of data on the Internet of Things. It supports the following protocols: HTTP, MQTT and OMA's LWM2M/CoAP. This section presents the requirements that IDAS should fulfill to integrate with the MBaaS platform.

Requirement Name	Provision of interface for device registration
Description	The device broker must provide a RESTful HTTP interface for device registration in the platform.
KPIs	Bring the Citibrain MBaaS to the market
Category	Mandatory

Requirement Name	Provision of interface for message publication via HTTP
Description	IDAS must provide RESTful HTTP interfaces for message publication.
KPIs	Bring the Citibrain MBaaS to the market
Category	Mandatory

Requirement Name	Provision of interface for message publication via LwM2M/CoAP
Description	Ponte must provide interfaces for message publication that support LwM2M (CoAP).
KPIs	Bring the Citibrain MBaaS to the market
Category	Mandatory

Requirement Name	Provision of interface for message publication via MQTT
Description	IDAS must provide MQTT interfaces for message publication.
KPIs	Bring the Citibrain MBaaS to the market
Category	Mandatory

3 Experimentation and Testing Requirements

After making Ubiwhere's MBaaS capable of integrating with the testing facilities, here we present the requirements for enabling and seamlessly running the experiments and tests to mature Ubiwhere's product and make it ready for the market. For these phases, the authors of this document are assuming that all the requirements above are taken into consideration for the experimentation and testing phases since the MBaaS relies on the communication protocols and open standards from the previous chapter for the automatic execution of the tests described here.

3.1 FIT IoT-Lab

IoT-LAB [7] provides a vast scale infrastructure facility suitable for testing small wireless sensor devices and composite communicating objects (as displayed in Figure 3). FIT IoT-LAB offers full control of network nodes and direct access to the gateways to which nodes are connected, allowing researchers to monitor nodes energy consumption and network-related metrics, e.g., end-to-end delay, throughput or overhead. The facility offers quick experiments deployment, along with easy evaluation, results collection and analysis. The definition of complementary testbeds with different node types, topologies and environments allows for coverage of a broad range of real-life use-cases. The hardware infrastructure relies on a global networking backbone to provide power and connectivity to all nodes and guarantee the out of band signal network needed for command purposes and monitoring feedback.

Figure 3 - Example of stationary and mobile nodes from IoT-Lab

As one of the experimentation facilities in the project, one of its objectives is to thoroughly test the MBaaS platform and also to contribute back to FIRE+ infrastructure. Below there is a list of the use cases planned as emulated datasets and also the test scenarios for the experimentation phase of the project.

3.1.1 Use Cases

The integration with the MBaaS platform will follow an iterative strategy. The team will start, in a first stage, with the simplest collections of information possible (which are already available in the laboratory): temperature and luminosity signals. Subsequently, they will change the firmware on the devices to publish emulated data about parking events and, afterward, use mobile nodes to provide emulated positions, traffic speeds or other signals. To sum up, the experimentation strategy regarding the publication of information into the MBaaS is the following:

- Temperature / Luminosity signals

- Emulated Parking events

- Real-time emulated Traffic / Logistics / Positioning events

3.1.2 Test Scenarios

Provided the infrastructure available in the IoT-Lab, with the purpose of preparing the MBaaS for the market, there should occur stress tests to retrieve metrics about the performance limits. Regarding the scenarios intended to test, the desired metrics consist of the following:

- Number of sensors (limit)

- Frequency of measurements (limit)

- Latency of measurements (limit)

- Successful / Failed messages ratio

3.1.3 Requirements

The requirements that will be defined intend to cover the test scenarios enumerated above (e.g. stress test the number of sensors publishing information at the same time). Before displaying the specific requirements for each of the tests, the "horizontal" requirements that must be considered for each requirement are displayed below.

Requirement Name	Test the MBaaS with all the device brokers
Description	The platform must run all stress tests against every device broker (IDAS, Meshblu, and Ponte) to determine which one provides the best performance.
KPIs	Bring the Citibrain MBaaS to the market Contribute back to FIRE+
Category	Mandatory

Requirement Name	Test the platform with all the protocols available per device broker
Description	The platform must run all stress tests against every communication protocol (e.g. HTTP, CoAP, MQTT) to determine which one provides the best performance.
KPIs	Bring the Citibrain MBaaS to the market Contribute back to FIRE+
Category	Mandatory

Requirement Name	The reports must provide successful / failed messages ratio
Description	All stress tests reports must include the metric of successful messages versus failed messages, to help determine the most efficient protocol/device broker, when considering the different variables (number of sensors, frequency, etc.).
KPIs	Bring the Citibrain MBaaS to the market Contribute back to FIRE+
Category	Mandatory

Requirement Name	**The platform must provide tools to run tests automatically**
Description	The MBaaS must provide tools for developers (including Ubiwhere) to run efficiently the experimentation tests described here automatically or programmatically.
KPIs	Bring the Citibrain MBaaS to the market Contribute back to FIRE+
Category	Mandatory

For instance, the "Number of sensors" test shall be performed for every device broker and every communication protocol, allowing a complete analytical report (including the successful vs. failed messages ratio) about the performance of the MBaaS.

3.1.3.1 Number of sensors

This scenario will validate that the platform can handle a determined number of sensors. Tests will be conducted to understand its limits and to enhance the overall performance of the platform.

Requirement Name	**Stress test the platform with increasing number of devices**
Description	The team must experiment the MBaaS against an increasing number of devices communicating with it at the same time to understand its scalability and determine its limits regarding the maximum amount of sensors sending events simultaneously.
KPIs	Bring the Citibrain MBaaS to the market Contribute back to FIRE+
Category	Mandatory

3.1.3.2 Frequency of measurements

This scenario validates that the platform will be capable of handling different rates of measures. Therefore, it is necessary to conduct tests to understand the limits of the platform regarding the frequency of messages supported.

Requirement Name	**Stress test the MBaaS with fixed number of devices and increasing frequency of messages**
Description	The platform must be experimented against an increasing frequency of signals from a fixed amount of devices, to determine what will be its breaking point.
KPIs	Bring the Citibrain MBaaS to the market Contribute back to FIRE+
Category	Mandatory

Requirement Name	**Stress test the MBaaS with increasing number of devices and increasing frequency of messages**
Description	This MBaaS must be tested with an increasing amount of sensors and different rates of communication to understand the data input capabilities of the platform.
KPIs	Bring the Citibrain MBaaS to the market
	Contribute back to FIRE+
Category	Mandatory

3.1.3.3 Latency of measurements

Here we intend to validate how the distance of the platform server to the data origin could raise issues related to performance.

Requirement Name	**Stress test the MBaaS with increasing latency**
Description	The platform must be tested in different physical locations (regions) to understand how much the network distance affects the performance of communication.
KPIs	Bring the Citibrain MBaaS to the market
	Contribute back to FIRE+
Category	Mandatory

3.2 FUSECO Playground

The Future Seamless Communication (FUSECO) Playground [8] offers a unique, independent and open testbed for research and prototype development of mobile broadband communication and service platforms. The flexible and modular design of the FUSECO Playground allows fast prototyping and simplified proof-of-concept (PoC) validation. Through FITeagle, instances of OpenIMS, OpenEPC (now Open5GCore), and OpenMTC [14] can be provided as a federated, remotely accessible service. Users (experimenters/testers) can get exclusive access to such an instance for a given amount of time and during this period, they can change configuration parameters, add additional services, etc., which roll back to the initial state when another user gains access to the same instance later on. One can differentiate every case by the particular radio access network infrastructure dedicated to it, determining which instance an experimenter needs to apply for his/her experiment. Also, dedicated end-devices are available to be included in the experiments/tests.
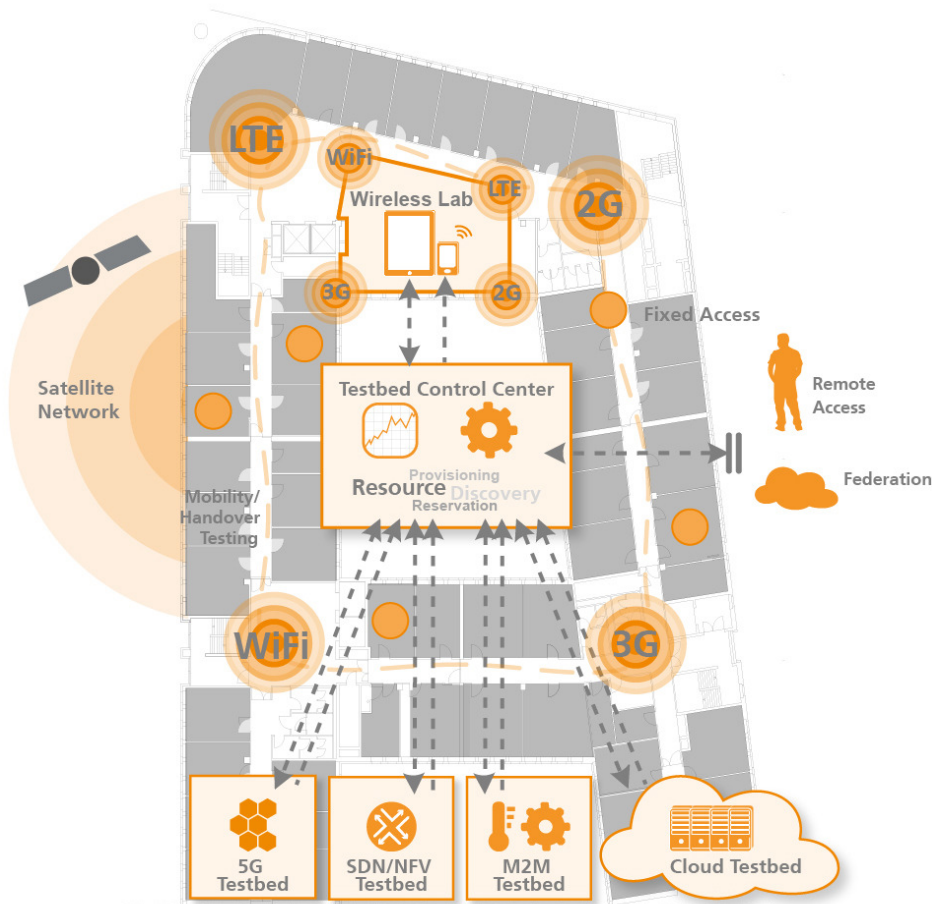

Figure 4 - The FUSECO Playground

As shown in Figure 4, the FUSECO Playground is evolving in various dimensions, by now already ranging beyond its initial focus on telecom-centric mobile broadband technologies. The primary interest for the MBaaS platform concerns the M2M Testbed and the OpenMTC platform, an open cloud-enabled solution for conducting applied research activities and developing innovative Machine-to-Machine (M2M) and Internet of Things (IoT) applications. Used for interconnecting various sensors and actuators from different vertical domains with a cloud-enabled, open platform, which aggregates collected data, forwards data to the application and mediates instructions to end devices for event-based control. Currently aligned with ETSI M2M and oneM2M standards, supporting both HTTP and CoAP as transport protocols and managing connectivity for devices with Android or Linux OS. Recently the protocol OMA LWM2M device management was added. With the purpose of integrating with the OpenMTC solution, the MBaaS platform must support the previously mentioned M2M standards, from OMA and ETSI.

3.2.1 Use Cases

The strategy followed with the FUSECO Playground will be the same as the one done with FIT IoT-Lab, by going through the following different types of data:

- Temperature / Luminosity signals
- Emulated Parking events
- Real-time emulated Traffic / Logistics / Positioning events

3.2.2 Test Scenarios

The requirements below are almost the same prepared for the FIT-IOT LAB, which is due to the nature of the tests that will be conducted in similar ways. The main differences are the desired protocols and some use cases. The focus of these requirements is to experiment the platform when using the OMA M2M and ETSI M2M specifications.

3.2.2.1 Number of sensors (limit)

This scenario will validate that the platform can handle a determined number of sensors. Tests will be conducted to understand its limits and to enhance the overall performance of the platform.

Requirement Name	Stress test the platform with increasing number of devices
Description	The project must experiment MBaaS against an increasing number of devices communicating with it at the same time to understand its scalability and determine its limits regarding the maximum amount of sensors sending events simultaneously.
KPIs	Bring the Citibrain MBaaS to the market Contribute back to FIRE+
Category	Mandatory

3.2.2.2 Frequency of measurements (limit)

This scenario validates that the platform will be capable of handling different rates of messages. Therefore, it is necessary to conduct tests to understand the boundaries of the platform regarding the frequency of messages supported.

Requirement Name	Stress test the MBaaS with fixed number of devices and increasing frequency of messages
Description	The platform must be checked against an increasing frequency of signals from a fixed amount of devices, to determine what will be its breaking point.
KPIs	Bring the Citibrain MBaaS to the market Contribute back to FIRE+
Category	Mandatory

Requirement Name	**Stress test the MBaaS with increasing number of devices and increasing frequency of messages**
Description	This MBaaS must be tested with an increasing amount of sensors and different rates of communication to understand the data input capabilities of the platform.
KPIs	Bring the Citibrain MBaaS to the market Contribute back to FIRE+
Category	Mandatory

3.2.2.3 Latency of measurements (limit)

Here we intend to validate how the distance of the platform server to the data origin could raise issues related to performance.

Requirement Name	**Stress test the MBaaS with increasing latency**
Description	The platform must be tested in different physical locations (regions) to understand how much the network distance affects the performance of communication.
KPIs	Bring the Citibrain MBaaS to the market Contribute back to FIRE+
Category	Mandatory

3.2.3 Specific SDK requirements

Since FUSECO relies on specific open standards, which the MBaaS will support at the end of the project, there should be open-source SDKs available for the community to integrate with the platform.

Requirement Name	**Provide OMA M2M compliant SDK**
Description	There must be an open-source SDK created using OpenMTC, published on GitHub, to allow developers to interact with the MBaaS in the scope of FIRE+ experimentation using the interfaces implemented following OMA M2M.
KPIs	Contribute back to FIRE+
Category	Mandatory

Requirement Name	**Provide ETSI M2M compliant SDK**
Description	There must be an open-source SDK available on GitHub, created using OpenMTC, to allow developers to effortlessly interact with the MBaaS in the scope of FIRE+ experimentation using the interfaces implemented following ETSI M2M
KPIs	Contribute back to FIRE+
Category	Mandatory

4 Third-Party Usage Requirements

EMBER's success relies highly on the success of its dissemination events (Hackathon, App Challenge, and Open Call), scheduled for the project's lifetime. In these events, freelance developers, start-ups, and SMEs will have the possibility to develop applications on top of the MBaaS. For its success, these implementations must occur smoothly, with a vast amount of support and recipes to rapidly come up with a solution. Here we describe all the requirements necessary for third-party developers to avoid wasting time on integration issues and focus on their business and application ideas. Like in the experimentation chapter, the authors assume that these requirements depend on the first chapter ones, given that, without the multiple communication protocols and several open standards, the MBaaS would not be appealing to the events participants.

4.1 Hackathon

The hackathon will ensure that the tests were fruitful and work with real scenarios. For that purpose, the platform must ensure that developers have access to the developed and tested APIs, with the intent of building their applications on top of the platform, i.e. consuming data and invoking services through those interfaces.

Requirement Name	The MBaaS must provide API documentation
Description	The platform must provide documentation about the APIs it supports plus their content, usage and limitations.
KPIs	Stimulate the smart city mobility ecosystem in Europe
Category	Mandatory

Requirement Name	The platform must provide a support forum
Description	The platform must have a support forum for hackathon participants to report issues and ask questions about the MBaaS.
KPIs	Stimulate the smart city mobility ecosystem in Europe
Category	Mandatory

Requirement Name	The platform must provide high-level data APIs
Description	The platform must provide access to the APIs responsible for delivering data.
KPIs	Stimulate the smart city mobility ecosystem in Europe
Category	Mandatory

Requirement Name	The platform should provide low-level data APIs
Description	The platform should provide access to the interfaces directly connected to devices.
KPIs	Stimulate the smart city mobility ecosystem in Europe
Category	Desirable

Requirement Name	**The platform must provide an interface for user registration**
Description	The platform must allow the registration of new users to get access to the MBaaS APIs.
KPIs	Stimulate the smart city mobility ecosystem in Europe
Category	Mandatory

Requirement Name	**The platform should provide an interface for device registration**
Description	The platform should allow the registration of new devices to start providing data through the MBaaS.
KPIs	Stimulate the smart city mobility ecosystem in Europe
Category	Desirable

Requirement Name	**The platform must provide documentation for configuration of FIT IoT-Lab devices**
Description	Developers must be able to access documentation that will help them quickly configure devices from the IoT-Lab.
KPIs	Stimulate the smart city mobility ecosystem in Europe Contribute back to Fire+
Category	Mandatory

Requirement Name	**The platform must provide documentation for configuration of FUSECO Playground devices**
Description	Developers must be able to access documentation that will provide them with all the information needed for rapid setting of devices from the FUSECO Playground.
KPIs	Stimulate the smart city mobility ecosystem in Europe Contribute back to Fire+
Category	Mandatory

Requirement Name	**The platform must provide open-source SDKs to book devices in the FIT IoT-Lab**
Description	Developers must have access to open-source libraries that will allow them to book devices available in the FIT IoT-Lab to communicate with their applications through the MBaaS.
KPIs	Stimulate the smart city mobility ecosystem in Europe Contribute back to Fire+
Category	Mandatory

Requirement Name	**The platform must provide open-source SDKs to book devices in the FUSECO Playground**
Description	Developers must have access to open-source libraries that will allow them to book devices available in the FUSECO Playground to communicate with their applications through the MBaaS.
KPIs	Stimulate the smart city mobility ecosystem in Europe Contribute back to Fire+
Category	Mandatory

Requirement Name	**Booked devices must actively send data through the MBaaS**
Description	Developers must be able to receive data in their applications built on top of the MBaaS platform from selected equipment.
KPIs	Stimulate the smart city mobility ecosystem in Europe
Category	Mandatory

4.2 App Challenge

The App Challenge will allow developers from every part of the world to interact with the platform. Contrarily to the Hackathon, this event will not be held in any venue, enabling anyone to contribute from their workplace or house.

Requirement Name	**The MBaaS must provide API documentation**
Description	The platform must provide documentation about the APIs it supports plus their content, usage and limitations.
KPIs	Stimulate the smart city mobility ecosystem in Europe
Category	Mandatory

Requirement Name	**The platform must provide a support forum**
Description	The platform must have a support forum for the app challenge participants to report issues and ask questions about the MBaaS.
KPIs	Stimulate the smart city mobility ecosystem in Europe
Category	Mandatory

Requirement Name	**The platform must provide high-level data APIs**
Description	The platform must provide access to the APIs responsible for delivering data.
KPIs	Stimulate the smart city mobility ecosystem in Europe
Category	Mandatory

Requirement Name	**The platform should provide low-level data APIs**
Description	The platform should provide access to the interfaces directly connected to devices.
KPIs	Stimulate the smart city mobility ecosystem in Europe
Category	Desirable

Requirement Name	**The platform must provide an interface for user registration**
Description	The platform must allow the registration of new users to get access to the MBaaS APIs.
KPIs	Stimulate the smart city mobility ecosystem in Europe
Category	Mandatory

Requirement Name	**The platform should provide an interface for device registration**
Description	The platform should allow the registration of new devices to start providing data through the MBaaS.
KPIs	Stimulate the smart city mobility ecosystem in Europe
Category	Desirable

Requirement Name	**The platform must provide documentation for configuration of FIT IoT-Lab devices**
Description	Developers must be able to access documentation that will help them quickly configure devices from the IoT-Lab.
KPIs	Stimulate the smart city mobility ecosystem in Europe Contribute back to Fire+
Category	Mandatory

Requirement Name	**The platform must provide documentation for configuration of FUSECO Playground devices**
Description	Developers must be able to access documentation that will provide them with all the information needed for rapid setting of devices from the FUSECO Playground.
KPIs	Stimulate the smart city mobility ecosystem in Europe Contribute back to Fire+
Category	Mandatory

Requirement Name	**The platform must provide open-source SDKs to book devices in the FIT IoT-Lab**
Description	Developers must have access to open-source libraries that will allow them to book devices available in the FIT IoT-Lab to communicate with their applications through the MBaaS.
KPIs	Stimulate the smart city mobility ecosystem in Europe Contribute back to Fire+
Category	Mandatory

Requirement Name	The platform must provide open-source SDKs to book devices in the FUSECO Playground
Description	Developers must have access to open-source libraries that will allow them to book devices available in the FUSECO Playground to communicate with their applications through the MBaaS.
KPIs	Stimulate the smart city mobility ecosystem in Europe Contribute back to Fire+
Category	Mandatory

Requirement Name	Devices assigned to a user must actively send data through the MBaaS
Description	Developers must be able to receive data in their applications built on top of the MBaaS platform from devices assigned to them.
KPIs	Stimulate the smart city mobility ecosystem in Europe
Category	Mandatory

4.3 Open Call

The open call will enable start-ups and SMEs to access the platform and interact with the developed APIs. The role of start-ups and SMEs is to bring their ideas and use the platform as a tool to feed them. Below the requirements are listed.

Requirement Name	The MBaaS must provide API documentation
Description	The platform must provide documentation about the APIs it supports plus their content, usage and limitations for start-ups and SMEs to use.
KPIs	Stimulate the smart city mobility ecosystem in Europe
Category	Mandatory

Requirement Name	The platform must provide a support forum
Description	The platform must have a support forum at the open call to allow the report of issues and raise questions about the MBaaS.
KPIs	Stimulate the smart city mobility ecosystem in Europe
Category	Mandatory

Requirement Name	The platform must provide high-level data APIs
Description	The platform must provide access to the APIs responsible for delivering data.
KPIs	Stimulate the smart city mobility ecosystem in Europe
Category	Mandatory

Requirement Name	The platform must provide low-level data APIs
Description	The platform should provide access to the interfaces directly connected to devices.
KPIs	Stimulate the smart city mobility ecosystem in Europe
Category	Mandatory

Requirement Name	The platform must provide an interface for user registration
Description	The platform must allow the registration of new users to get access to the MBaaS APIs.
KPIs	Stimulate the smart city mobility ecosystem in Europe
Category	Mandatory

Requirement Name	The platform must provide an interface for device registration
Description	The platform must allow the registration of new devices to start providing data through the MBaaS.
KPIs	Stimulate the smart city mobility ecosystem in Europe
Category	Mandatory

Requirement Name	The platform must provide documentation for configuration of FIT IoT-Lab devices
Description	Developers must be able to access documentation that will help them quickly configure devices from the IoT-Lab.
KPIs	Stimulate the smart city mobility ecosystem in Europe

Contribute back to Fire+ |
| Category | Mandatory |

Requirement Name	The platform must provide documentation for configuration of FUSECO Playground devices
Description	Developers must be able to access documentation that will provide them with all the information needed for rapid setting of devices from the FUSECO Playground.
KPIs	Stimulate the smart city mobility ecosystem in Europe

Contribute back to Fire+ |
| Category | Mandatory |

Requirement Name	The MBaaS must provide open-source SDKs to book devices in the FIT IoT-Lab
Description	Developers must have access to open-source libraries that will allow them to book devices available in the FIT IoT-Lab to communicate with their applications through the MBaaS.
KPIs	Stimulate the smart city mobility ecosystem in Europe

Contribute back to Fire+ |
| Category | Mandatory |

Requirement Name	**The MBaaS must provide open-source SDKs to book devices in the FUSECO Playground**
Description	Developers must have access to open-source libraries that will allow them to book devices available in the FUSECO Playground to communicate with their applications through the MBaaS.
KPIs	Stimulate the smart city mobility ecosystem in Europe Contribute back to Fire+
Category	Mandatory

Requirement Name	**Devices booked by a user must actively send data through the MBaaS to his application**
Description	Developers must be able to receive data in their applications built on top of the MBaaS platform from devices assigned to them.
KPIs	Stimulate the smart city mobility ecosystem in Europe
Category	Mandatory

5 Conclusions

This requirements deliverable is the outcome of two tasks (Task 1.1 and 1.2) from Work Package 1, whose aim is to set up the FIRE+ testbeds and the experimentation on those testbeds (Task 1.3). EMBERS will experiment with the system on two testbeds that are part of the FIRE+ OneLab facility: the FUSECO Playground, for M2M communications, and FIT IoT-LAB, for wireless sensor devices. The requirements here documented will not only involve adaptations and integrations on Ubiwhere's MBaaS side but also from the partners responsible for the experimentation facilities

Third-party developers will have three opportunities during the project lifetime to develop applications on top of the platform, in innovative and stimulating events. Therefore, the MBaaS must support a vast set of features, protocols and standards, making it the *de facto* default solution for smart cities ecosystems.

After EMBERS, the platform will have a diverse set of open interfaces, which is a crucial advance for the MBaaS because a standard interface is yet to be defined. Beyond ensuring preparedness if one of these interfaces will emerge as a standard, EMBERS will lower the entry barriers to developers of devices and apps. By the time the EMBERS project has ended, developers will be able to integrate their applications with the MBaaS using any of the available interfaces, without having to connect only to sensors that implement a particular protocol.

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