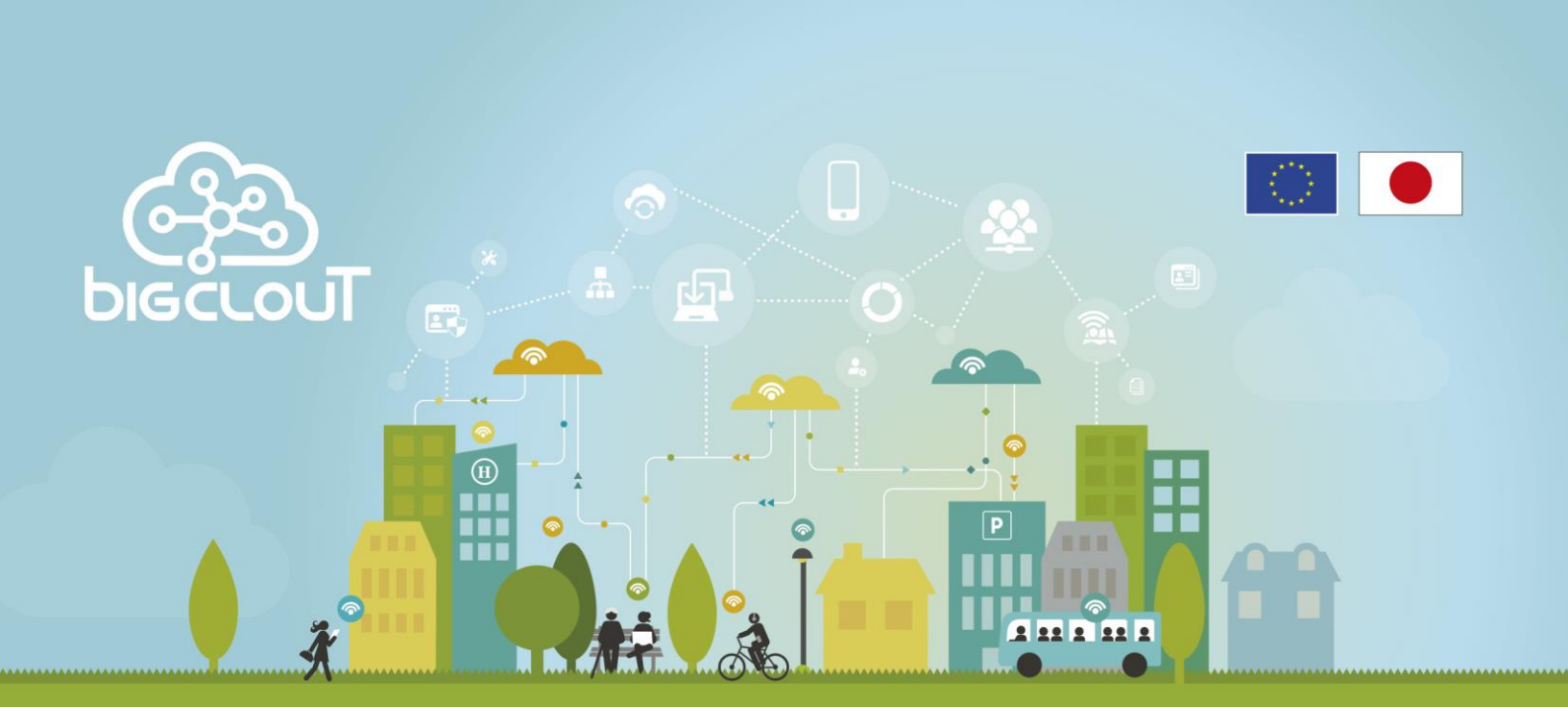


WP1 Use Cases, Requirements, Architecture
D1.2 Citizen centric use cases and requirements

Grant Agreement N°723139
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BIGCLOUT

Big data meeting Cloud and IoT
for empowering the citizen ClouT in smart cities

H2020-EUJ-2016 EU-Japan Joint Call

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ABSTRACT

This deliverable provides a selection of use cases from the partner cities, which will be identified by taking into account citizens' real needs and requirements. It presents the use cases that will be deployed in the project, the requirements that stem from these use cases, along with a rich set of technical side requirements that need to be addressed in order to provide the desired functionality. The document concludes with a detailed and consolidated requirements list.

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		the respective partners.	
V1.0	19.05.2017	New refinements and contributions by the use case providing partners. Finalization of the document.	All involved partners.

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GLOSSARY

TERM	DEFINITION
API	Application Programming Interface
CDMI	Cloud Data Management Interface: SNIA standard that specifies a protocol for self-provisioning, administering and accessing cloud storage
CDN	Content Delivery Networks
CRUD	Acronym of the four basic functions of persistent storage : create, read, update and delete
DBMS	Database Management System
EU	European Union
GPS	Global Positioning System
GUI	Graphic User Interface
HTTP	HyperText Transfer Protocol
ICT	Information and Communication Technologies
IoT	Internet of Things
JSON	JavaScript Object Notation : "lightweight" exchange data format
KPI	Key Performance Indicator
LDAP	Lightweight Directory Access Protocol
MAC	Medium Access Control
NFC	Near Field Communication
NFV	Network Functions Virtualization
NGSI	Next Generation Service Interfaces
OLAP	Online Analytical Processing
OS	Open Source

REST	The REpresentational State Transfer is an architectural paradigm
RF	Radio Frequency
SDK	Software Development Kit
SLA	Service Level Agreement
SME	Small Medium Enterprise
SNS	Social Networking Service
UC	Use Case
UML	Unified Modelling Language
UX	User Experience
WP	WorkPackage
XML	eXtensible Markup Language
XMPP	Extensible Messaging and Presence Protocol

EXECUTIVE SUMMARY

This deliverable provides an analysis of the BigClouT requirements from the technical and user perspective. It presents the use cases that will be deployed in the project, the requirements that stem from these use cases, along with a rich set of technical side requirements that need to be addressed in order to provide the desired functionality.

The deliverable gives, at first, an overview of the project context as far as it concerns the objectives and the goals of the task it refers to. A relation to other WPs and tasks is also presented for showing the alignment with the other activities of the project. The methodology that is followed in this document starts with the definition of the BigClouT concept, an overview of the technologies that will be deployed, similar past projects and continues with the description of the use cases, the elicitation of the requirements and their consolidation. Eight (8) use cases are described having as common pattern a brief overview of the smart city context within which they will be implemented, the description of the use case scenario as a set of functionalities offered, the various stakeholders that are involved in their execution and the user-centric requirements analysis perspective.

The requirements analysis process relies heavily on the involvement of the stakeholders in the whole value chain that the project brings. The BigClouT consortium includes all necessary stakeholders of the BigClouT value chain and the whole methodology followed has been aligned with this feature of the project. The consortium includes smart city infrastructure providers (i.e. Grenoble, Bristol, Tsukuba and Fujisawa), technology providers as well as service providers and integrators (i.e. the technical partners from EU and JP side), end users as these are going to be recruited in WP4 by the smart cities partners and the open source community with which the project plans to develop liaison. This approach allows for a credible validation of the BigClouT concept, along with different deployment configurations and services operations plans.

The overall requirements analysis coding and consolidation has been based on the well-established process of dividing the requirements into functional and non-functional ones. The functional view of a requirements analysis process focuses on what the system must do to produce the required operational behaviour. It includes inputs, outputs, states, and transformation rules. The functional requirements are the primary sources of the requirements that will eventually be reflected in the system specification. The non-functional view of a requirements analysis process focuses on what other technical features the system must have in order to facilitate the service provision.

The document concludes with a detailed and consolidated requirements list.

1 Introduction

1.1 Objectives and goals of the task and deliverable

The current document is the deliverable 'D1.2 Citizen centric use cases and requirements' which comprises the major outcome of the task 'Task 1.1 – Citizen centric use cases and requirements extraction'. The task T1.1 is in charge of identifying use cases reflecting real citizens needs and extracting requirements (end-user oriented and technical ones) that will be necessary to be addressed by the BigClouT platform. The first step in such an action is to provide a list of use cases from the cities, with the help of the technological partners. The use cases are described based on a common template, highlighting various characteristics such as their innovative nature, interaction with stakeholders, requirements for the technological base of BigClouT project, etc. The second step is to involve the citizens in the process of choosing the use cases that are most important to them. Different means have been used to involve them in this activity such as dedicated workshops, surveys, electronic platforms, etc. A particular attention has been given to use cases that are of common interest in partner cities, relevant for cross-border deployments and demonstrating technical innovations.

The primary audience of this document consists of the people that will participate in the design and development of the BigClouT system. Primarily, the audience concerns members of the consortium who need to undertake the tasks of designing the components and modules of the system and finally implement them. Additionally, the document is of wider interest to stakeholders that are active in the areas of smart cities, Internet of Things and Big Data, including researchers participating and contributing to H2020 projects under the aforementioned topics.

1.2 Relation to other WPs and Tasks

Relationship to other tasks: The T1.1 will provide functional and non-functional requirements to the T1.3 for driving the design of the system architecture. It will also help defining the pilot scenarios that will be performed in WP4.

1.3 Methodology followed

The analysis starts with a definition of the BigClouT concept, including an overview of the use cases, use case diagrams (described through Unified Modelling Language - UML) and the stakeholders involved so as to understand the context of the project and identify the various stakeholders. As a next step, the consortium partners give an overview of the technologies that are going to be involved in the project and the perspective of using them in order to implement the BigClouT concept. Similar projects and background from previous projects are also mentioned in order to present the state-of-the-art and the previous achievements that can be used as a starting point. In the sequel, the elicitation of requirements is derived from the definition of the desired functionality of the BigClouT system given from the perspectives of the functional components and the non-functional attributes that the end system has to expose. Finally, the requirements are gathered and consolidated into one list, grouped and coded accordingly in order to comprise the reference for the design, implementation and validation phases of the project. The following figure gives an overview of the methodology that has been followed.

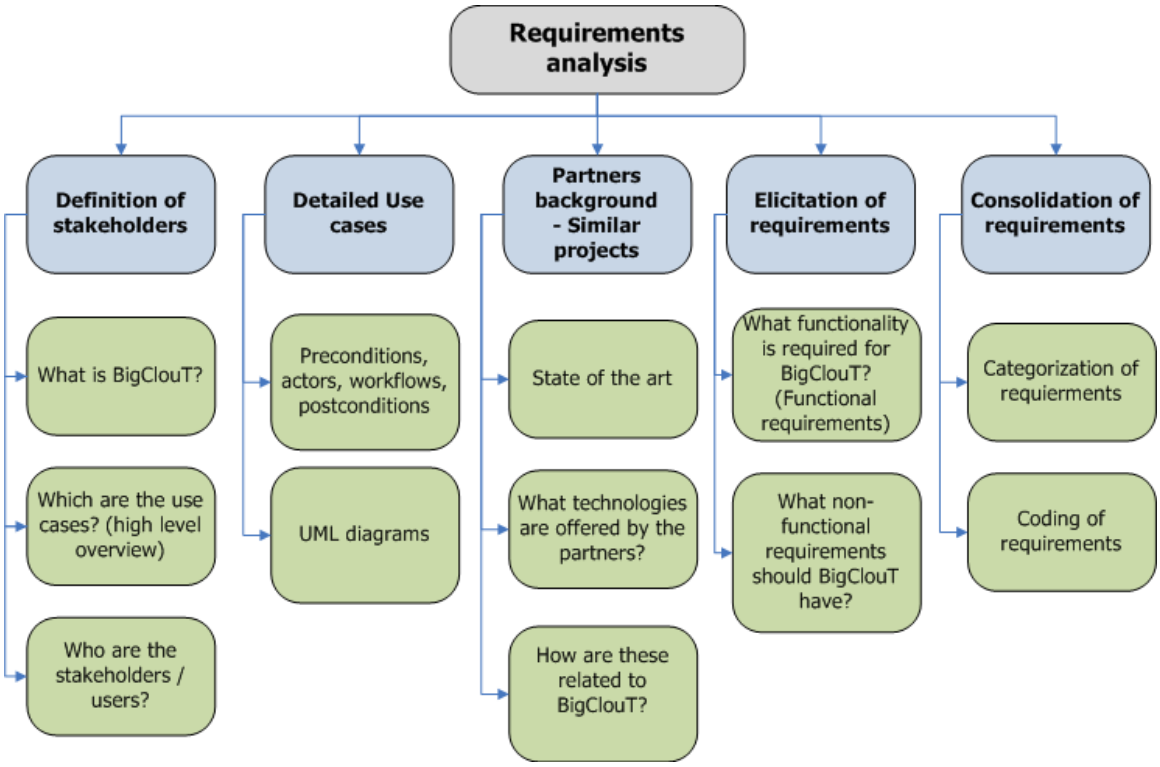


FIGURE 1 : BIGCLOUT – REQUIREMENTS ANALYSIS METHODOLOGY

2 Project definition

2.1 What is BigClouT ?

The world is facing a number of critical challenges such as global warming, economic crisis, security threats, inequality, natural disasters, and ageing society. ICT solutions have the potential to change the world and improve the **quality of life and security of its citizens**.

BigClouT project will in particular make use of today's three key technologic enablers, **Internet of Things (IoT), cloud computing and big data**, for the objective of increasing the efficiency in using urban infrastructure, economic and natural resources shared by the increasing population.

BigClouT will offer an analytic mind to the city by creating **distributed intelligence** that can be implanted throughout the whole city network either for large or smaller urban areas.

BigClouT will leverage the results of the EU-Japan ClouT project and will bring them beyond, by adding for instance distributed intelligence with edge computing principles, big data analytics capability, in addition to self-awareness and dependability properties towards a **programmable smart city platform**.

Resources and knowledge from prestigious European and Japanese institutions are now together to keep on creating a long-lasting synergy **between EU and Japan** for tackling future city challenges.

2.2 BigClouT's use cases: a bird's eye view

The BigClouT project brings together 8 Use Cases (UC) provided by the 4 smart city partners.

Use cases provided by Grenoble-Alpes:

- GRE-UC1: Monitoring of Economic Impacts of Business Events
- GRE-UC2: Monitoring of Industrial Estates

Use cases provided by Bristol Is Open:

- BIO-UC1: Smart Energy: predictive analysis of users' power consumption
- BIO-UC2: Mobility Prediction: predicting mobility patterns of citizens in the city context

Use cases provided by Tsukuba:

- TSU-UC1: Provide tourism, traffic and environmental information in real time to visitors to Tsukuba
- TSU-UC2: Grasp status about foreign visitors to Tsukuba and provide concierge service to them

Use cases provided by Fujisawa:

- FUJ-UC1: Optimizing the incidence on local economy of Fujisawa
- FUJ-UC2: Fine-grained city infrastructure management

A detailed analysis of the use cases is provided in section 3 of the current document.

2.3 BigClouT's stakeholders and users

The requirements analysis process relies heavily on the involvement of the stakeholders in the whole value chain that the project brings. The following figure gives an overview of the BigClouT value chain.

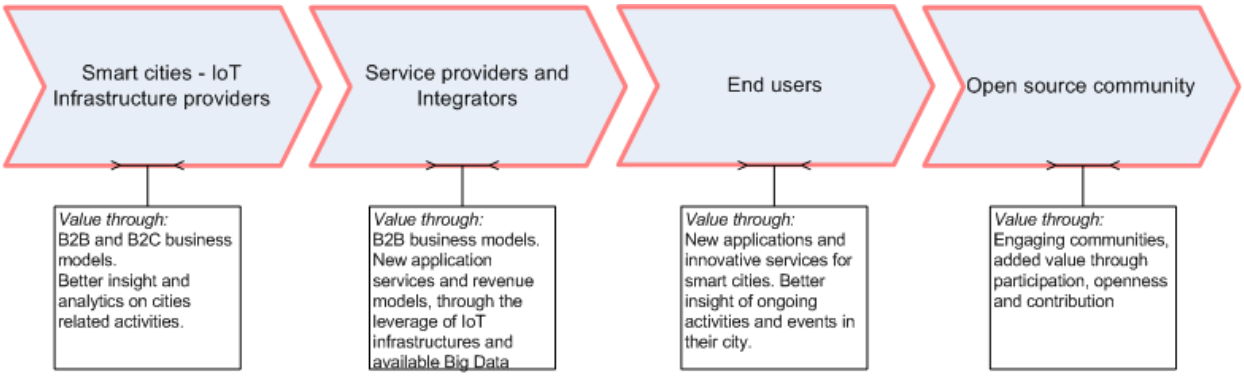


FIGURE 2 : BIGCLOUT – STAKEHOLDERS VALUE CHAIN AS BASIS FOR THE REQUIREMENTS ELICITATION

Note that BigClouT consortium includes all necessary stakeholders of the BigClouT value chain. In particular, the consortium includes smart city infrastructure providers (i.e. Grenoble, Bristol, Tsukuba and Fujisawa), technology providers as well as service providers and integrators (i.e. the technical partners from EU and JP side), end users as these are going to be recruited in WP4 by the smart cities partners and the open source community with which the project plans to

develop liaison. This approach will allow for a credible validation of the BigClouT concept, along with different deployment configurations and services operations plans.

Smart Cities - IoT Infrastructure Providers: they provide their sensing infrastructure and the captured events to the BigClouT ecosystem. These providers will offer or lease their infrastructures in exchange of some cost/fee, or based on other participation incentive.

Service Providers and integrators: they will offer technology and application services over the infrastructures of one or more infrastructure providers. The service providers for instance can establish Service Level Agreements (SLAs) with infrastructure providers to offer B2B services on the basis of the BigClouT capabilities on big data analytics. Service providers will possibly endeavour to generate revenue streams based on subscriptions/fees of corporate end-users or individuals. The role of technology providers and integrators in the value chain is associated with the integration of the platform, as well as in the enhancement of the platform with new added value capabilities. Overall, integrators of BigClouT systems can use the software and/or middleware libraries of the project in order to build and deploy applications that leverage the BigClouT capabilities to offer added value services.

End Users: Consumers and individuals (including tourists) registering to the BigClouT services and consuming them mainly through smart phones. Individual users are less likely to employ subscription services, but they are likely to participate in the platform based on other forms of incentives (e.g. credits for using the platform as soon as they also contribute to the platform).

Open source community: BigClouT is in the most part an open source project. It will be implemented based on open source technologies (as much as possible) and one of the strategic goals of the project is to have liaison with the open source community around it. The community is very important for sustaining and evolving the project results, especially after the end of the project. Therefore, the open source community is a stakeholder of the project, and the open source developers are also users.

3 Detailed Use Cases and requirements

3.1 Grenoble Use Cases and requirements

The Greater Grenoble City Area (Grenoble-Alpes Métropole) brings together 49 different municipalities and almost half a million inhabitants who have chosen to work together on key areas for the development of the territory. The City Area is the most important local government structure in charge of areas such as economic development, universities, research, innovation, energy, water and sanitation, rubbish collection, urban planning and transport – all key fields for 'smart cities'.



Situated in the heart of the Alps and surrounded by mountain ranges, the City Area has a population that is very sensitive to the environment with higher than average rates of recycling and of use of public transport and bikes increasing annually. The City Area is also home to a unique economic ecosystem, representing industry, research and higher education.

University

- World-class universities (Grenoble Ecole de Management, Grenoble-Alpes University, INP Engineering school…)
- 1/5 inhabitants is a student
- Over 10% of these students are international
- 42% of students study sciences

Industry

- Unique ecosystem with big global players (ST Microelelctronics, Schneider Electric, Xerox, Orange, HP, Caterpillar and others) and dynamic start-ups and SMEs
- Specializing in cutting edge fields: electronics and microelectronics, software, energy, healthcare, chemicals
- All aspects for smart cities are covered

Research

- 25 000 researchers: 15 000 public researchers and 10 000 private researchers
- Fundamental, Applied and Interdisciplinary Research
- World-renowned labs (CEA, ESRF, EMBL, ILL, CNRS…)

Grenoble is lucky to have world-renowned researchers, top universities, big, global companies and cutting edge SMEs but what the city is most proud with is how all the actors from its ecosystem work together.

As a local government structure, the job of the Greater Grenoble City Area is to foster this collaborative spirit and to support technology transfer and joint projects in order to contribute to its economic development which in turn, contributes to improve the quality of life of its citizens.

3.1.1 Use Case 1: Monitoring of Economic Impacts of Events

1. Description

Grenoble-Alpes Métropole hosts several large events, trade shows and fairs every year in its Alpexpo exhibition centre. In the future, it would like to host an increasing number of events in order to boost the attractiveness of the area and in turn to boost economic development.

Currently, there is no way for the Métropole to measure the economic impact of these events - for example - the use of hotels, shops, restaurants and transport – by the people attending these events.

The Métropole would like to develop a tool that allows this monitoring to take place. The objective is to measure the impact of those events in the local economy, to better attribute public resources to improve public services, as well as to improve the quality of experience of the business tourists in Grenoble (better information, personalised transportation service, tourism information, discounts in shops, etc.).

A typical use case scenario would include for instance an event participant (i.e., business tourist) receiving interesting information about Grenoble city during his/her stay, information such as cultural events, souvenir shops, restaurants, transport information from his/her hotel to the event location, special offers and discounts, etc. The challenge is to be able to collect the necessary information about the tourist such as the stayed hotel, restaurants/shops used, localisation, general profile information, etc. The collected data will be used to obtain statistical information about the event and asses its impact to the city local economy. This implies involvement of various stakeholders in this use case such as listed in the next section.

2. Stakeholders involved and means of interaction / engagement

The following stakeholders have been identified for the specific use case:

- Grenoble-Alpes Métropole
- Exhibition Centres
  - Alpexpo exhibition centre
  - World Trade Centre
  - Minatec exhibition centre
- Insight Outside (events management company)
- Chamber of Commerce & Industry
- Tourism office
- Club des hoteliers (grouping of hotels)
- Réseau Label Ville (grouping of shopkeepers)
- Business tourists

The majority of these actors have already been contacted concerning the BigClouT project (more information about the trial planning can be found at the Deliverable 4.1). At least one physical meeting per stakeholder has been organised with the participation of the Grenoble Métropole and CEA. A clear interest in the results of the project has been identified. The fact that currently an evaluation tool for the economic impact of events is missing clearly represents a significant problem for event organisers.

3. Use Case Diagram

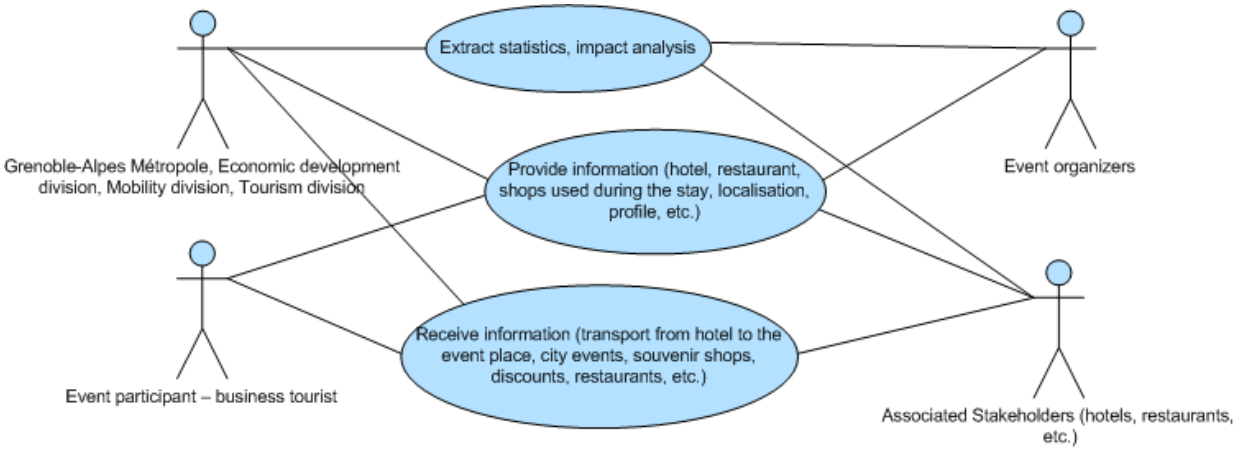


FIGURE 3 : GRE-UC1 MONITORING OF ECONOMIC IMPACTS OF EVENTS UML DIAGRAM

4. Requirements summary

Below we provide a summary of requirements that have been elicited for the specific use case:

- The application for the business tourist should be distributed as a mobile app as an interaction mean with the services based on the BigClouT platform.
- Event organisers and Grenoble tourism office should promote/distribute the mobile application for the event participants/business tourists.
- The hotels, shops and restaurants should be able to share the participant information with the application (how many nights stayed, how much spent, etc.).
- The application may collect this information automatically by using sensors from the mobile phone (GPS localisation, proximity sensors such as NFC or Bluetooth Low Energy).
- The application should provide a tool to analyse data and extract statistics in simple and easily understandable way for the city economic development division and for the event organisers.
- The event organisers may share some information about the participant collected during his/her registration to the event. (hotel stayed, personal profile, etc.).
- The Grenoble mobility service should provide the information about the transportation system in Grenoble (bus/tram stations, real-time traffic, car-sharing, etc.).
- The application should protect the privacy of the end-user and propose several levels of management of personal data, and give the possibility of modifying the privacy parameters any time.
- The application should provide means for shops and restaurants to announce interesting offers to the business tourists, as well as for Grenoble tourism office to notify about city events (cultural, sportive, etc.).
- The application should provide means to gather satisfaction information from the user.

3.1.2 Use Case 2: Monitoring of Industrial Estates

1. Description

Grenoble-Alpes Métropole owns or manages several different industrial estates on its territory. These estates range in size and in the areas of activities, from high tech companies to artisans to shops and services.

The Métropole wants to be able to know who is using these estates and how. For example, how many people arrive each day by different modes of transport, how many people leave the sites for lunch, how many deliveries are received on the site, etc.

The goal is to be able to improve the services proposed by the Métropole in these zones for increasing the quality of experience of its citizens in their daily work life, (for example, is there a need for improved public transport? Or other means of transportation? Is there a need to put in place a new canteen? A concierge service or mail relay service?) and also to create a social network enabling for grouped orders and potentially car-sharing solutions. Moreover, the goal is to be able to better attribute public resources, to improve the working conditions on these zones and also to improve their environmental impact.

2. Stakeholders involved and means of interaction / engagement

The following stakeholders have been identified and contacted for the specific use case:

- Inovallée Industrial Estate
- Presqu'île group of employers

- Espace Comboire Industrial Estate

As the most organised industrial estate in the city area, it has been decided to use the Inovallée area as a test case. It is therefore with the management of this estate that discussions have progressed the most.

Four (4) physical meetings have been organised with the management of the Inovallée zone. During the discussions, we have steered the project in a direction in which we will mainly focus to put in place a tool which could be used by the people working in the zone.

Several different uses have been identified:

- Plan of the zone with contact details and descriptions of all the companies (which already exists in a paper format)
- Information about the transport options, the location of cars available in the car-sharing programme "Cité Lib", link with the "Métromobilité" app which gives real time information about public transport
- Information about building works/ traffic disruptions in the area
- Information about restaurant options, times and menus
- Information about sporting and cultural activities available
- Events, training, workshops, general communication that could interest employees in the area.

3. Use Case Diagram

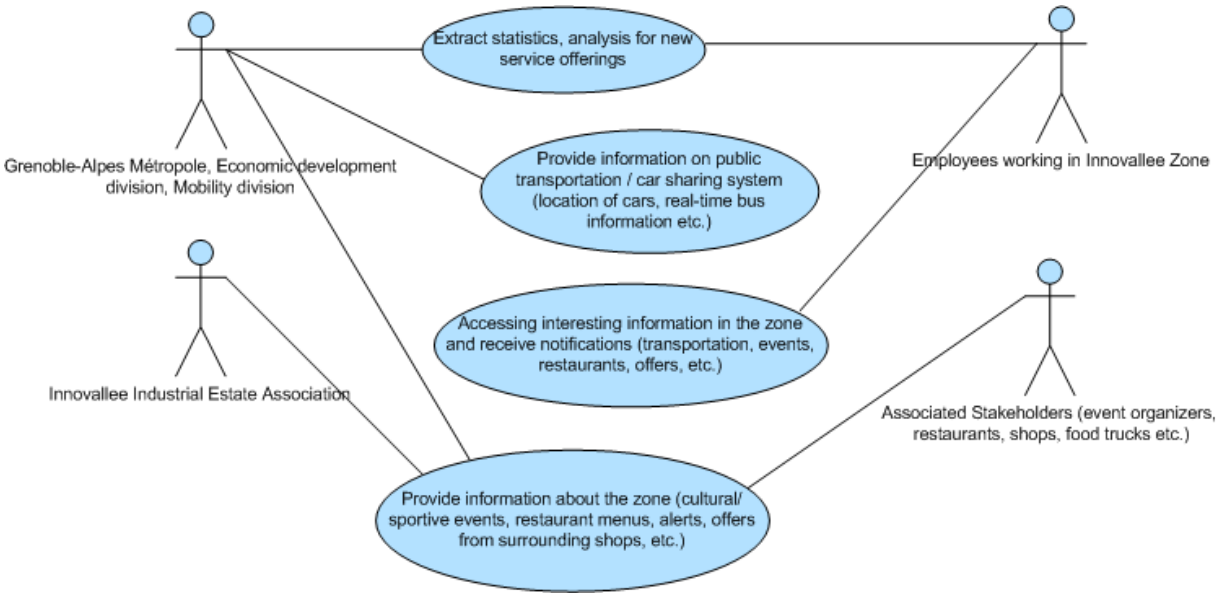


FIGURE 4 : GRE-UC2: MONITORING OF INDUSTRIAL ESTATES UML DIAGRMAM

4. Requirements summary

Below we provide a summary of requirements that have been elicited for the specific use case:

- The application should be distributed as a mobile app for the employees of the Innovallée industrial zone.
- Innovallée and Grenoble Metropole should promote/distribute the mobile application for the Innovallée employees.
- The Innovallée association should be able to collect (in real-time when relevant) information from the associated stakeholders (restaurants, shops, company associations, etc.) and provide it to the BigClouT platform
- The application may provide means (via the same mobile app) for associated stakeholders to directly enter necessary information (bypassing Innovallée), such as restaurants announcing menus, waiting time, shops providing interesting offers, food trucks announcing location and offers, etc.
- The Grenoble mobility service should provide the information about the transportation system in Grenoble (bus/tram stations, timetables, real-time traffic information, car-sharing, etc.).
- The user may accept to provide some personal information such as profile, location, company, transportation mode used, etc, for receiving customised information.
- The application should protect the privacy of the end-user and propose several levels of management of personal data, and give the possibility of modifying the privacy parameters any time.
- The application should provide a tool to analyse data and extract statistics in simple and easily understandable way for the city economic development division and for Innovallée Association
- The application should notify the user when interesting events occur and/or customised recommendations to be provided
- The application should provide means to gather satisfaction information from the user.

3.2 Bristol Use Cases and requirements

Bristol is a city with a population of nearly half a million people in south west England, situated between Somerset and Gloucestershire on the tidal River Avon. It has been among the country's largest and most economically and culturally important cities for eight centuries. The Bristol area has been settled since the Stone Age and there is evidence of Roman occupation. A mint was established in the Saxon burgh of Brycgstow by the 10th century and the town rose to prominence in the Norman era, gaining a charter and county status in 1373. The change in the form of the name 'Bristol' is due to the local pronunciation of 'ow' as 'ol'.



Bristol is regarded as the capital of the South West of England. Lively yet laid-back, Bristol blends its rich maritime heritage with an innovative, dynamic culture, making it one of the most cosmopolitan centres outside London. It is a leader on the green scene and was proud to be European Green capital 2015 – the only UK city ever to hold the title. It also has an enviable cycling culture. Compact enough to get around on foot, yet big enough to boast an exciting line-up of entertainment, Bristol has much to offer. The city's most celebrated sights include the Clifton

Suspension Bridge – which was designed by Isambard Kingdom Brunel and celebrated its 150th anniversary in December 2014.

Bristol's modern economy is built on the creative media, electronics and aerospace industries, and the city-centre docks have been redeveloped as centres of heritage and culture. The city has the largest circulating community currency in the U.K.- the Bristol pound, which is pegged to the Pound sterling. The city has two universities, the University of the West of England and the University of Bristol and has a variety of artistic and sporting organisations and venues including the Royal West of England Academy, the Arnolfini, Spike Island, Ashton Gate and the Memorial Stadium. It is connected to London and other major UK cities by road, rail, sea and air by the M5 and M4 (which connect to the city centre by the Portway and M32), Bristol Temple Meads and Bristol Parkway mainline rail stations, and Bristol Airport.

In 2014 The Sunday Times named it as the best city in Britain in which to live, and Bristol also won the EU's European Green Capital Award in 2015.

3.2.1 Use Case 1: Smart Energy - predictive analysis of users' power consumption

1. Description

This use case is about exploiting BigClouT's novel data-adaptive machine learning techniques for predictive analysis and the power consumption of users. We will use the infrastructure installed for the European project REPLICATE[1].

The objective is to make householders aware about different phenomena, that otherwise would be very difficult to detect for example 'the phantom load' also known as 'vampire power'. This is the electricity consumed by electronic and electrical appliances while they are switched off (but are designed to draw some power) or in a standby mode. Consumption may be of the order of 10% of the electrical energy used by a typical household.

Saving electricity not only will affect the householders' pocket. Electricity is very often generated by combustion of hydrocarbons (oil, coal, gas) or other substances, which release substantial amounts of carbon dioxide, implicated in global warming, and other pollutants such as sulphur dioxide, which produces acid rain, so at the same time the user is helping to take care of the planet.

[1] http://replicate-project.eu

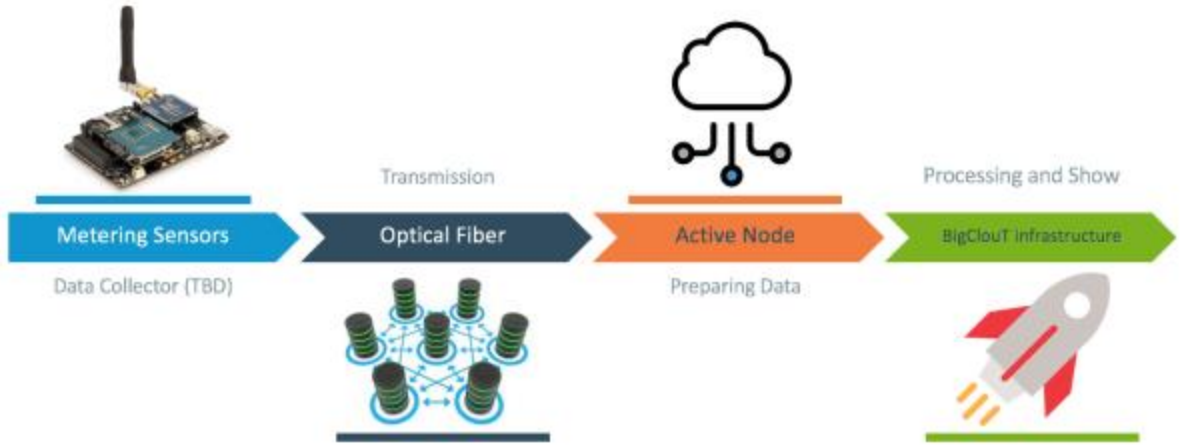


FIGURE 5 : DATA FLOW IN USE CASE BIO-UC1

The scenario of the use case would be:

- Collect real time data from the sensors deployed.
- Analyse the citizen involved usage of electricity.
- Predict future behaviour with this information.
- Show this information in an understandable way to the users in a dashboard.
- Merge this information with other available sources (i.e. weather information).
- Compare their usage with other people in similar situations.
- Get feedback from the users, for example: did it change their behaviour in some way?

2. Stakeholders involved and means of interaction / engagement

The following stakeholders have been identified for the specific use case:

1. Bristol City Council has established contacts at Warm Up Bristol and Bristol Energy.

   - Warm Up Bristol is a Bristol City Council scheme designed to make the citizens' home warmer, cozier and cheaper to heat. They are dedicated to tackling cold homes and reducing fuel poverty. Selected homes will be chosen by Warm Bristol.
   - Bristol Energy is a gas and electricity company that offers fair and transparent electricity and gas tariffs for domestic and business customers across Bristol, the South West and nationwide. They will survey properties from the ones chosen by Warm Up Bristol, they will calculate the cost of installations and install the sensors in the citizen homes.

2. Bristol Is Open (BIO) is the test bed for the pilots. They are providing and managing the infrastructure of Bristol (i.e. RF-Mesh, Optic Fiber, Blue wireless and Microwave).

3. KWMC[2] (who is a partner in the REPLICATE project) will share its knowledge from previous pilots from deploying sensors in citizens' houses.

[2] http://kwmc.org.uk/

An engagement workshop between Bristol City Council, University of Bristol and Bristol Is Open has been undertaken which is where the idea of merging Smart Energy with Smart Homes will be further elaborated. Future meetings are being planned. Following steps involve also KWMC, who have previous experience deploying sensors within homes.

3. Use Case Diagram

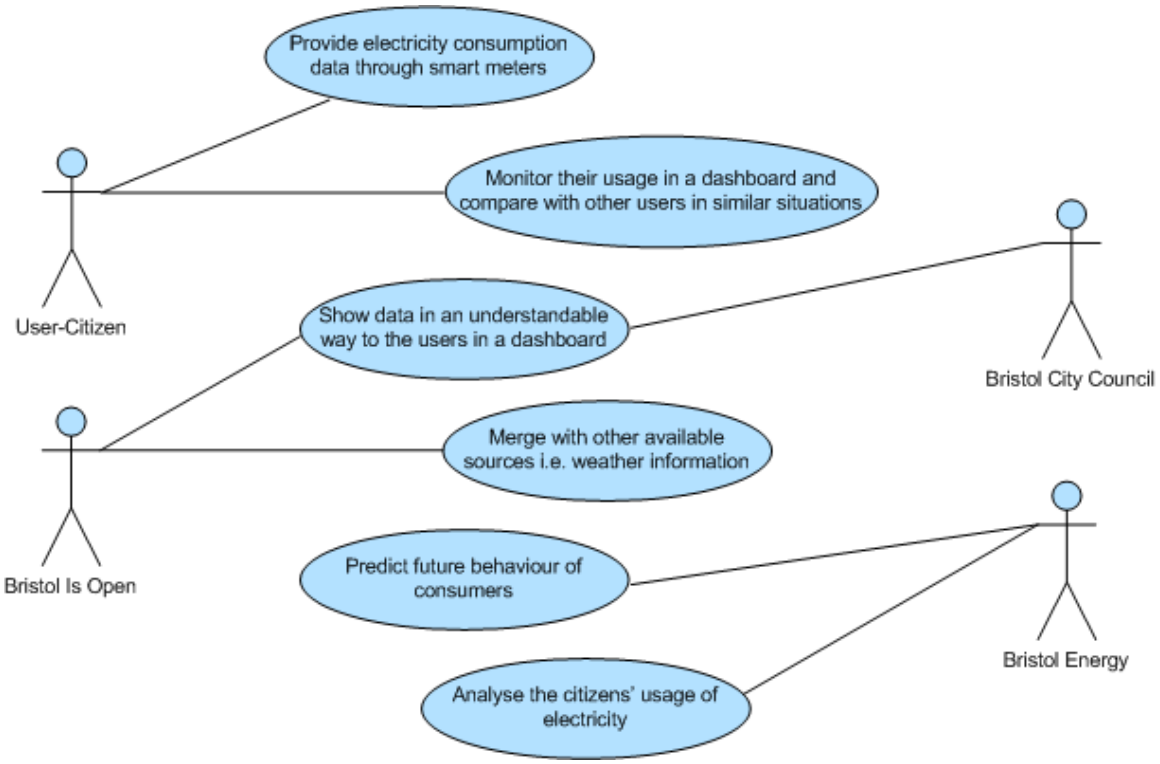


FIGURE 6 : BIO-UC1: SMART ENERGY UML DIAGRMAM

4. Requirements summary

Below we provide a summary of requirements that have been elicited for the specific use case:

- The BigClouT platform should be able to collect information from sensors deployed inside citizen homes.
- The BigClouT platform should be able to collect detailed weather information in a real time and in an accurate way.
- The BigClouT platform should be able to store the information from different sources for post processing.
- The BigClouT platform should be able to provide prediction tools for energy usage mapping for further decision making by the relevant stakeholders.
- The BigClouT platform should be able to provide tools for comparing citizens' energy consumption scenarios.
- The BigClouT platform should be able to provide an easy to use dashboard.
- The BigClouT platform should provide a user management system, where citizens can consult only their data and manage their profiles.

- BigClouT platform should be compatible with Next Generation Service Interfaces (NGSI[3]) API.

3.2.2 Use Case 2: Mobility Prediction- predicting mobility patterns of citizens in the city context

1. Description

This specific use case will use Bristol Is Open's infrastructure for extracting the citizen's mobility pattern in a smart city environment. The mobility patterns will on the one hand ensure citizens have better streaming services and on the other hand can provide information to citizens in order to avoid over-crowded situations in the downtown area. For example, decide on the place to have lunch if they have limited time or choose a shorter route on their way to the office.

Content Delivery Networks (CDNs) is the key for network operators, in order to meet user demands for Internet and media content. Software Defined Networks (SDN) and Network Functions Virtualization (NFV) are able to provide load balancing, scalability and reliability whilst remaining simple and fast in deployment. Through this use case, we aim to support fast adaptability on rapidly evolved scenarios. Given the dynamic nature of the end user behaviour, in terms of mobility or generated traffic, Data Analytics can drive the cache placement decision in order to enhance self-adaptation and self-optimisation of the content delivery mechanism.

Bristol is Open infrastructure will host the testbed of this use case. The BigClouT platform will be used for the deployment, management and profiling of this use-case's service. Through the use-case we will provide experimental answers to the questions: regarding how far from the edge the modelling should happen and how close to the edge the model matching should take place.

Extracting movement knowledge, which would take place in a continuous way, this can be used by network providers and media delivery services and as a result less packet losses, optimized bandwidth will be obtained; in addition faster performance will minimize timeouts, latency and jitter, while improving overall user experience.

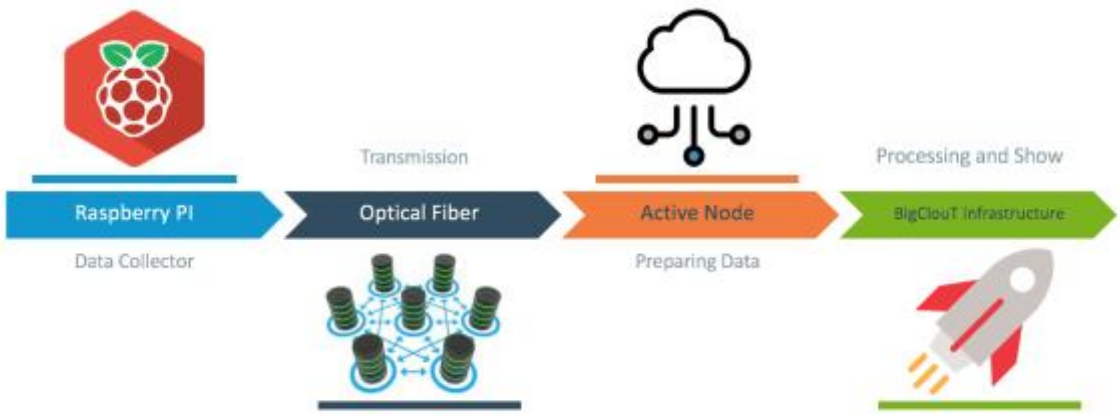


FIGURE 7 : DATA FLOW IN USE CASE BIO-UC2

The scenario of the use case contains the following items:

- Scan and collect MAC addresses from the citizens

[3] https://forge.fiware.org/plugins/mediawiki/wiki/fiware/index.php/FI-WARE_NGSI-10_Open_RESTful_API_Specification

- Analyse citizens' mobility patterns.
- Use data analytics for the prediction of future citizens' mobility patterns.
- Show real time and future hot paths around the city in a dashboard.
- Merge information with other available sources (i.e. weather information).
- Reduce the citizens time spent on their tasks.
- Improve the user experience (UX) of streaming services used by citizens.

2. Stakeholders involved and means of interaction / engagement

The following stakeholders have been identified for the specific use case:

1. Bristol University: High Performance Networks Group (HPN), specialises in the application of advanced hardware and software technologies, targeting the future optical networks for Internet of Things, data centres, grid/cloud based applications and distributed technologies etc. The Group is equipped with world-class laboratories, including state-of-the-art optical transmission testbeds and software-defined network experimental platforms.

2. Bristol Is Open is the test bed for the pilots. They are providing and managing the infrastructure of Bristol (i.e. RF-Mesh, Optic Fibre, Blue wireless and Microwave).



FIGURE 8 : BIO-UC2: TESTBED OVERVIEW

BIO and UoB (University of Bristol) have been working together during the last 2 months, and we are holding several catch-up events weekly. Initial discussion about the legal and ethical approaches had been undertaken and the UoB has triggered the process for the University's Ethics Policy. During this period, some of the proof of concepts already deployed inside the university's lab has been discussed.

3. Use Case Diagram

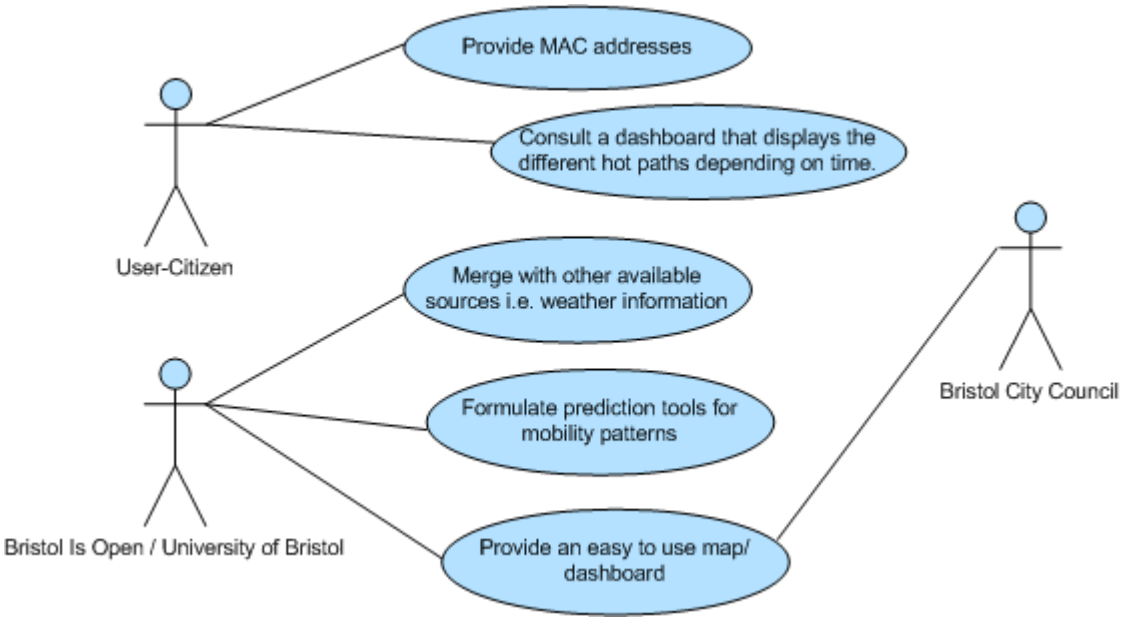


FIGURE 9 : BIO-UC2: MOBILITY PREDICTION UML DIAGRMAM

4. Requirements summary

Below we provide a summary of requirements that have been elicited for the specific use case:

- Users should be able to provide / share their MAC addresses as well as other information related to their location (under informed consent).
- The BigClouT platform should be able to scan and collect MAC addresses from the citizens
- The BigClouT platform should be able to analyse citizens' mobility patterns and use data analytics for the prediction of future citizens' mobility patterns.
- The BigClouT platform should be able to show real time and future hot paths around the city in a dashboard.
- The BigClouT platform should be able to merge information with other available sources (i.e. weather information).
- The BigClouT platform should be able to store data from different sources for post-processing.
- BigClouT platform should be compatible with NGSI API.
- BigClouT platform should provide a map (Dashboard) that displays the different hot paths depending on time.

3.3 Tsukuba Use Cases and requirements

Tsukuba city is located in south-western part of Ibaraki prefecture. It is a town spreading out in the south foot of beautiful Mt. Tsukuba in Kanto area with "Science, History and Nature". Area is 287km^2 and population is about 230,000. It is close to Tokyo Metropolitan and takes 45 minutes by Tsukuba Express to get there.

One of the city's special features is Tsukuba Science City. It was approved at cabinet meeting in 1963. There are more than 100 research laboratories including 29 governmental organizations, there are 20,000 researchers and 7,000 people who have doctoral degree. The research field extends from space development to nanotechnology, biotechnology, and robot development. It is one of the biggest research and development bases in Japan.

The city is also known as a place for international conferences. G7 science and technology ministers' meeting was held in Tsukuba city from May 15 to 17, 2016. G7 (Japan, Italy, Canada, France, USA, England, Germany) and EU participated in this meeting and had fruitful discussion regarding science and technology related matters.

The joint statement "Tsukuba Communiqué" was announced to the world on May 17 after discussion about science technology. With these experiences, Tsukuba city is aiming at the further progress as an international technology innovation base.







3.3.1 Use Case 1: Provide tourism, traffic and environmental information in real time to visitors

1. Description

The aim of the use case is to provide useful information, including environmental data collected by IoT in real time in addition to the city's attractive and convenient information to visitors' to Tsukuba by push based delivery, so that visitors will stay longer time to stop by sightseeing points or restaurants and revisit.

Scenario

1. Collect attribute information such as purpose for visiting to Tsukuba, transportation, gender, generation, hobby and tastes.

2. Collect behaviour history of the visitor.

- Collect visitors' satisfaction rate for purpose of the visit and other demands.
- Collect environmental information (weather, temperature and so on).

3. Analyze the trends of visitors' behaviour according to their attribute and environmental information and the trends of satisfaction rate.

4. Collect real time weather information, Social Network Service comments, traffic and facilities' congestion situation, and visitors' location information.

5. Select the best tourism, transportation or restaurant information for the visitor according to their attribute and real-time location information by data of 3 and 4.

- Predict this information for the future by accumulated information.

6. Deliver this information to visitors.

7. Get feedbacks about information delivered by questionnaires and so on.

- Improve recommendation accuracy based on feedbacks.

2. Stakeholders involved and means of interaction / engagement

Tsukuba use case scenarios are targeting visitors to Tsukuba city. So candidates of stakeholders listed up are organizations in Tsukuba city who are related to tourism or international conference and would cooperate on the project.

The following stakeholders have been identified for the specific use case:

Stakeholder	***Role***	***Interaction / Engagement***
Tsukuba city IT division	Point of contact for BigClouT project, stakeholders etc. Get questionnaires or have meetings with users for the result measurement	Periodical meetings
Tsukuba city tourism section	Point of contact for tourism related stakeholders. Provide comments about use cases	Meetings anytime it is needed
Tsukuba city traffic section	Point of contact for railway companies Provide usage data for Tsukuba taxi on demand Provide comments about use cases	Meetings anytime it is needed Provide usage data by signage if needed
Tsukuba city international division	Provide access data to English pages of Tsukuba city website	Provide data online

Center for Computational Science	Provide weather and environment data	Provide data online if needed
Other Stakeholders in Tsukuba city (under negotiation)	Provide usage data of public transportation	Provide usage data online if needed
	Provide places to install signage at stations	Deploy it according to their rules or laws
	Recommend tour plans	Provide tour information on website
	Provide incentives for users	Provide coupons or novelties

3. Use Case Diagram

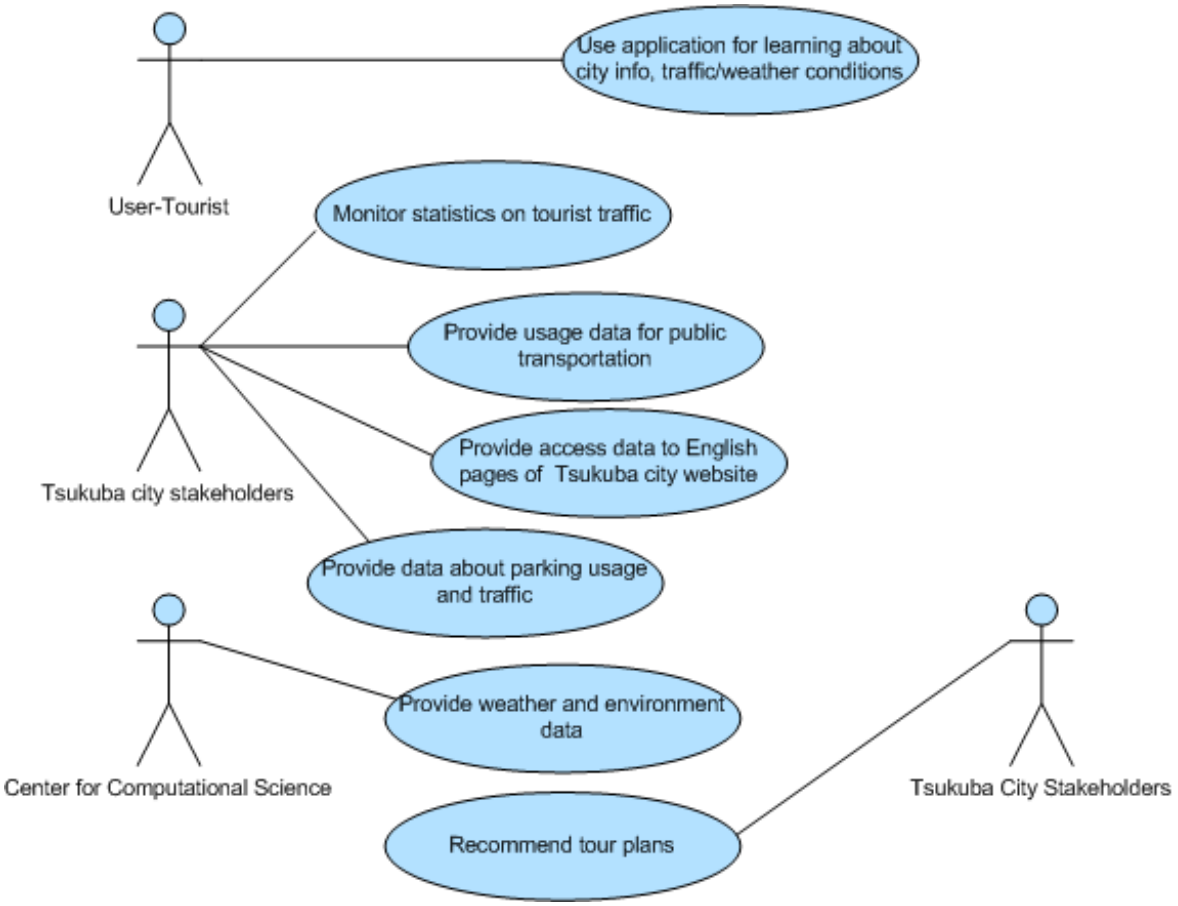


FIGURE 10 : TSU-UC1: PROVIDE TOURISM, TRAFFIC AND ENVIRONMENTAL INFORMATION IN REAL TIME TO VISITORS UML DIAGRAM

4. Requirements summary

Below we provide a summary of requirements that have been elicited for the specific use case:

- The tourist should install a smartphone app as an interaction with the services based on the BigClouT platform
- The city and BigClouT project should promote/distribute the smartphone application for the tourists.

- A method (e.g.: Social Networking Service (SNS) analysis, questionnaires by smart phone or interactive signage) should be provided for collecting information to analyse visitors' trends below:
    - visitors' attribute
    - visitors' behaviour history
    - location information
    - satisfaction rate for visitors' purpose and their needs
    - environmental information
    - statics from local government
- The application should be able to provide the most suitable information in real time such as weather information, SNS comments, traffic and facilities congestion information by their attribute and location information.
- The application should be able to analyse the trend of satisfaction rate, weather information and visitors' behaviour by their attribute.
- The application should be able to recommend the most suitable information about tourism and transportation by their attribute, real time environmental information and trend of satisfaction rate.
- The application should be able to predict future recommendation information by accumulated information.
- The application should be able to provide the useful information by location and time. (e.g.: SNS, smart phone application and interactive signage).
- The application should be able to provide predicted future information by accumulated information (e.g.: SNS, smart phone application and interactive signage).

3.3.2 Use Case 2: Grasp status about foreign visitors to Tsukuba and provide concierge service to them

1. Description

Provide multilingual concierge service for foreign visitors to Tsukuba to solve their needs and problems such as tourism, emergency, disaster prevention and transportation since Tsukuba city has many international conferences.

Scenario

1. Collect foreign visitors' attribute information such as purpose for visiting to Tsukuba, transportation, gender, generation, hobby, tastes and language.

2. Collect needs and problems of foreign visitors to grasp their situation.

3. Collect behaviour histories of foreign visitors.

4. Collect and accumulate information that would solve the needs and problems.

5. Prepare for the most suitable information for the demands (problems) of foreign visitors to Tsukuba from collected and accumulated data.

Example:

・Instruction to the local destination (for any vague needs such as "I want wine!").

・Guide the instruction to the area including downtown, not a specific shop (e.g.: an area with many sushi restaurants).

・Place (or direction) that is easy to get a taxi.

・Emergency contacts (hospital, police).

・Restroom map (degree of cleanliness).

・Getting information to avoid dangerous areas.

・Waiting time of restaurants and List up of the restaurants by waiting time.

6. Deliver answers for the inquiries from foreign visitors according to their attribute and real time location information.

- Deliver additional recommended information to the person who inquires

7. Get feedbacks about information delivered by questionnaires and so on.

- Improve recommendation accuracy based on feedbacks.

2. Stakeholders involved and means of interaction / engagement

Tsukuba use case scenarios are targeting visitors to Tsukuba city. So candidates of stakeholders listed up are organizations in Tsukuba city who are related to tourism or international conference and would cooperate on the project.

The following stakeholders have been identified for the specific use case:

Stakeholder	***Role***	***Interaction / Engagement***
Tsukuba city IT division	Point of contact for BigClouT project, stakeholders etc. Get questionnaires or have meetings with users for the result measurement	Periodical meetings
Tsukuba city tourism section	Point of contact for tourism related stakeholders. Provide comments about use cases	Meetings anytime it is needed
Tsukuba city traffic section	Point of contact for railway companies Provide usage data for Tsukuba taxi on demand Provide comments about use cases	Meetings anytime it is needed Provide usage data by signage if needed
Tsukuba city international division	Provide access data to English pages of Tsukuba city website	Provide data online
Center for Computational Science	Provide weather and environment data	Provide data online if needed
Other Stakeholders in Tsukuba city (under	Provide usage data of public transportation	Provide usage data online if needed

negotiation)	Provide places to install signage at stations	Deploy it according to their rules or laws
	Provide data about parking usage and traffic	Provide data online if needed
	Recommend tour plans	Provide tour information on website
	Provide incentives for users	Provide coupons or novelties

3. Use Case Diagram

The UML diagram of the specific use case is similar with the one provided for TSU-UC1 as the stakeholders involved (actors) the functionalities and the purpose of interaction are common.

4. Requirements summary

Below we provide a summary of requirements that have been elicited for the specific use case:

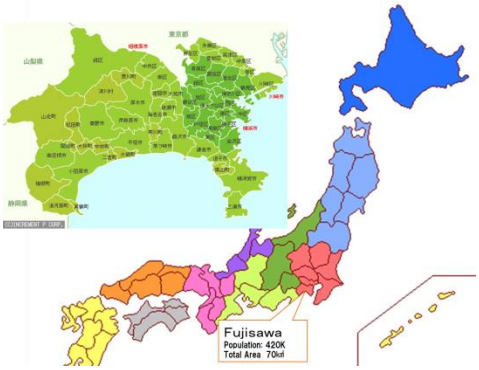
- The foreign tourists should install a smartphone app as an interaction with the services based on the BigClouT platform
- The city and BigClouT project should promote/distribute the smartphone application for the foreign tourists.
- A method(e.g.: Social Networking Service (SNS) analysis, questionnaires by smart phone or interactive signage) should be provided for collecting information to analyse foreign visitors' trends below:
    - visitors' attribute
    - visitors' behaviour history
    - GPS information
    - location information
    - satisfaction rate for visitors' purpose and their needs
    - environmental information
    - statics from local government
    - Foreign visitors' needs and problems
- The application should be able to collect accumulated information to provide the most suitable information.
- The application should be able to prepare to answer to solve their needs and problems by collected data according to visitors' behaviour and their attribute.
- The application should be able to provide the useful and multilingual information to foreign visitors by their location and time (e.g. SNS, smart phone application and interactive signage).
- The application should be able to provide additional useful information by accumulated information (e.g. SNS, smart phone application and interactive signage).

3.4 Fujisawa Use Cases and requirements

Fujisawa city is about 50km from Tokyo, and it takes about one hour by train. Population is 420,809 and total area is 69.5 km^2. One of the most famous places in Fujisawa is an island, called Enoshima. Enoshima, in recorded history, had already flourished as a tourist spot in the Edo era. Fujisawa is the central city in "Shonan", one of the most popular beach areas in Japan. It is known as a city of residence, sightseeing, business and education.



In addition, Enoshima is chosen in the sailing competition of the 2020 Tokyo Olympic and Paralympic Games as a venue. And in the same year, Fujisawa city will reach the municipal organization enforcement 80th anniversary. The city would like to utilize ICT to treat Olympic participants and visitors from all over the world, and lead this big event success in this memorial year.



The city and some of Japan's leading companies established a smart town called "Fujisawa Sustainable Smart Town". The plan is to apply comprehensive solutions for an entire house, entire building and entire town, combining energy technologies to provide a safe and secure environment. They will effectively create an advanced model of a town demonstrating efficient use of energy by promoting widespread use of energy-saving devices and proposing new solutions that integrate measures for energy creation, storage and management.

3.4.1 Use Case 1: Optimizing the incidence on local economy of Fujisawa

1. Description

City needs to provide event, local and environmental information for both citizen and visitors. In terms of visitors, not only domestic visitors but also international visitors must be targeted, especially for coming Tokyo Olympic Paralympics 2020. By providing such city information in real-time, city can solve several problems such as traffic jam, visiting recommendation, or disaster prevention.

Scenario:

(1) Collect physical and virtual information about Fujisawa city by leveraging any information resources such as IoT sensors, Web sensors or human sensors.
(2) Analyze the real-time collected data by comparing it with historical data.
(3) Visualize the analyzed data to optimize the incidence on local economy for stakeholders

2. Stakeholders involved and means of interaction / engagement

The following stakeholders have been identified for the specific use case:

Stakeholder	*Role*	*Interacting functionalities*
Fujisawa city IT division	Point of contact for BigClouT project, stakeholders etc. Get questionnaires or have meetings with users for the result measurement	Periodical meetings
Fujisawa city tourism section	Point of contact for tourism related stakeholders Comments about use cases	Meetings anytime it is needed
Fujisawa city traffic section	Point of contact for railway companies Provide usage data for Fujisawa transportation on demand Comments about use cases	Meetings anytime it is needed
Fujisawa city international division	Provide access data to English pages of Fujisawa city website	Provide data online

We already had several meetings with Fujisawa city staffs and Fujisawa resource association to discuss the use case.

3. Use Case Diagram

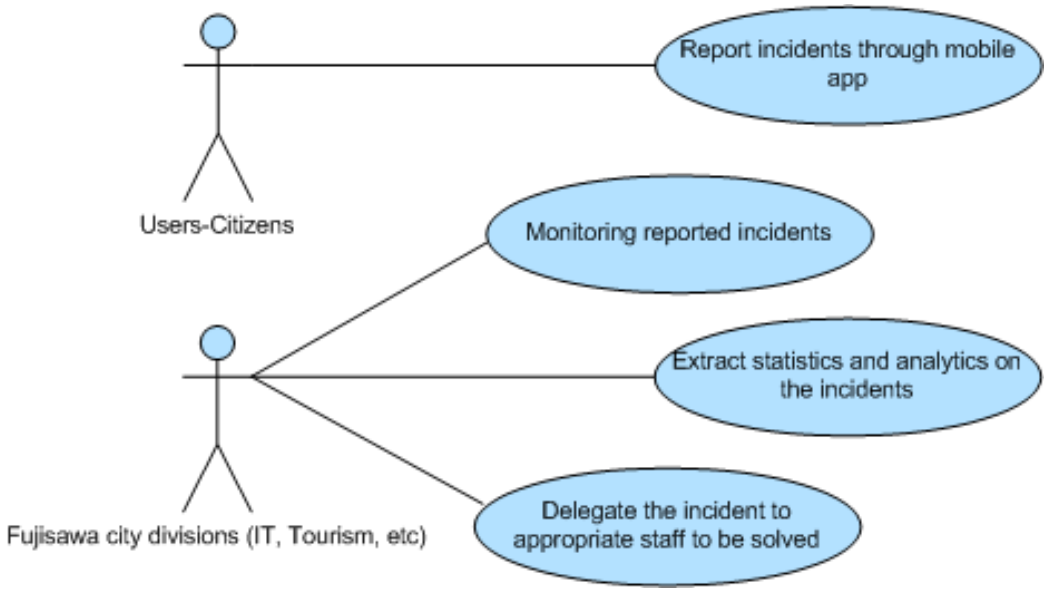


FIGURE 11 : FUJ-UC1 UML DIAGRAM

4. Requirements summary

Below we provide a summary of requirements that have been elicited for the specific use case:

- The citizens and tourists should install a smartphone app as an interaction with the services based on the BigClouT platform
- The city and BigClouT project should promote/distribute the smartphone application for the citizens and tourists.
- Users should be able to report through smart phones various incidents through a dedicated mobile phone application.
- Various city stakeholders (from IT or city tourism division) should be able to monitor these incident reporting.
- The BigClouT platform should be able to collect real-time city data from various information resources with low cost.
- The application should be able to provide and share collected data among various stakeholders.
- The application should be able to analyse real-time data efficiently and effectively.
- The application should be able to visualize analysed data effectively and intuitively.

3.4.2 Use Case 2: Fine-grained city infrastructure management

1. Description

Managing city infrastructure is one of very important tasks for city operation. As the first step of managing the city infrastructure, understanding current condition such as road damage or road mark damage is necessary. To solve the problem, we leveraged sensorized garbage trucks to collect massive information about city infrastructure. Several sensors such as accelerometer, temperature, humidity, sound and camera captures information of city infrastructure in a way of high frequent sensing rate. Such information is analysed at edge-side first to reduce data size, and then send to the cloud-side.

2. Stakeholders involved and means of interaction / engagement

The following stakeholders have been identified for the specific use case:

Stakeholder	***Role***	***Interacting functionalities***
Fujisawa city IT division	Point of contact for BigClouT project, stakeholders etc. Get questionnaires or have meetings with users for the result measurement	Periodical meetings
Fujisawa city environmental section	Point of contact for garbage collection related stakeholders. Comments about use cases	Meetings anytime it is needed
Fujisawa resource association	Point of contact for garbage collection related stakeholders.	Meetings anytime it is needed

Fujisawa had already several meetings with above stakeholders and has formed a regional consortium for engaging stakeholders towards smart city services.

3. Use Case Diagram

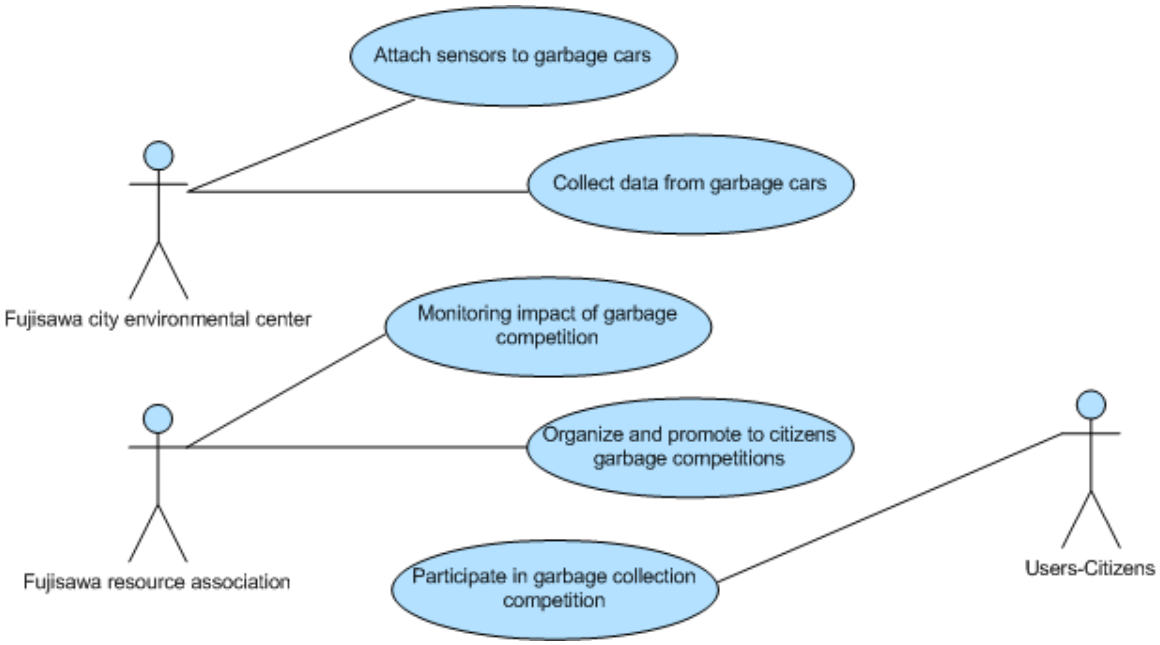


FIGURE 12 : FUJ-UC2 UML DIAGRAM

4. Requirements summary

Below we provide a summary of requirements that have been elicited for the specific use case:

- BigClouT project should install sensors on garbage collection trucks as an interaction with the services based on the BigClouT platform.
- City stakeholders should be able to collect data from sensors attached to garbage collection trucks.
- City stakeholders should be able to organize and promote various competitions related to garbage saving and or collection.
- The BigClouT platform should provide a method to visualize analysed data effectively and intuitively.
- The BigClouT platform should provide a method to collect real-time city data from various information resources with low cost.
- The BigClouT platform should provide edge-side computing technology to reduce data size with finding important aspect of the data.
- The BigClouT platform should provide cloud-side computing technology to store massive data effectively and analyse the data for city infrastructure management.
- The BigClouT platform should provide a method to share collected data among various stakeholders.
- The BigClouT platform should provide a method to analyse real-time data efficiently and effectively.

4 Elicitation of requirements

4.1 Functional requirements of BigClouT

The **functional** view of a requirements analysis process focuses on what the system must do to produce the required operational behaviour. It includes inputs, outputs, states, and transformation rules. The functional requirements are the primary sources of the requirements that will eventually be reflected in the system specification.

Functional view information includes:

- System functions,
- Tasks or actions to be performed,
- Inter-function relationships,
- Hardware and software functional relationships,
- Functional constraints,
- Interface requirements.

BigClouT is a complex project, with many different components that should work together to offer interesting services to the users. In order to construct an integrated system, the development process must fulfil some requirements. These functionalities requirements are intended for developers and integrators as well as for final users. Each component of BigClouT must be developed according accepted good programming practices, in order to reduce the complexity of code comprehension and difficulty of maintenance tasks. For instance, the code must be well documented, well indented and clear in general. The architecture must be modular with a clear separation between the modules. The components should be loosely coupled, allowing the development of new components that can be easily added. The architecture of BigClouT must be layered, providing separation of concerns.

4.2 Non-functional requirements of BigClouT

The **non-functional** view of a requirements analysis process focuses on what other technical features the system must have in order to facilitate the service provision. These include among others:

- Scalability
- Performance
- Reliability and availability
- Manageability and flexibility
- Modularity
- Security
- Openness and Extensibility Requirements

Non-functional requirements are very important in setting the foundation of a complex integrated system as is the case of BigClouT. To this end, the project consortium has taken them into consideration in the current analysis as it can be seen in the following section.

4.3 Overall requirements consolidation and coding

This section provides a consolidated view of the requirements described above so as to conclude to a unique coding of all individual requirements in order to be tracked throughout the lifecycle of the project. The following table gives an overview of the elicited requirements of the BigClouT project. It has to be underlined that the requirements are derived not only from the use cases, but also from a range of other factors including the partners' background projects, state-of-the-art projects and requirements expressed by the project stakeholders. The selection of requirements has been also driven by:

- The need to address, design and implement the innovative features of the BigClouT framework.
- The functionalities that have to be offered in the use cases.
- Non-functional features that the final BigClouT system has to include.

The first column of the table below provides the unique coding of the requirement that will make it traceable within the lifecycle of the project. The second column gives the description of the requirement while the third column describes any dependencies or comments. The fourth and fifth columns provide the details on the origin of the document and the relevant stakeholder respectively, linking it thus with the requirements summary as this has been provided by the partners in section 3 of the document.

TABLE 1 : CONSOLIDATED AND CODED BIGCLOUT REQUIREMENTS

Category: R1 Functional Requirements				
Group 1: BigClouT platform generic functional requirements				
Code	**Description**	**Dependencies with other requirements and Comments**	**Origin of requirement**	**Relevant Stakeholders**
R1.1.1	The platform should be able to access data from sensors on demand and through subscriptions.	*The generic functional requirements of the BigClouT platform have been derived as system requirements from the technical partners of the consortium after analysing the use case requirements from the end users. For this reason there is a strong dependency with requirements*	All use cases	Service providers, IoT infrastructures
R1.1.2	The platform should provide big data analytics functionalities.		All use cases	Service providers & Integrators
R1.1.3	The platform should be able to perform predictive analysis.		All use cases	Service providers & Integrators
R1.1.4	The platform should provide a dashboard in order to present results of analysis.		All use cases	Service providers & Integrators
R1.1.5	The platform should provide real-time data processing functionalities.		All use cases	Service providers & Integrators
R1.1.6	The platform should be able to access online data, e.g. from web		All use cases	Service providers &

	sites and social networks.	*under Group 2.*		Integrators
R1.1.7	The platform should provide data machine learning and distributed machine learning functionalities.		All use cases	Service providers & Integrators
R1.1.8	The platform should provide edge processing functionalities.		All use cases	Service providers & Integrators, IoT infrastructure providers
R1.1.9	The platform should be able to collect and store data.		All use cases	Service providers & Integrators
R1.1.10	The platform should be able to provide stored historical data.		All use cases	Service providers & Integrators
R1.1.11	The platform should be able to be integrated with existing sensor networks.		All use cases	Service providers & Integrators, IoT infrastructure providers
R1.1.12	BigClouT should be able to collect data from heterogeneous data sources (open data from the city, real-time traffic information, localisation of users, etc.)		All use cases	Service providers & Integrators, IoT infrastructure providers
R1.1.13	BigClouT should provide means to push data from the users and relevant stakeholders into the platform.		All use cases	Service providers & Integrators, IoT infrastructure providers
R1.1.14	BigClouT should be able to issue notifications to end users when interesting events occur.		All use cases	Smart Cities, End Users
Group 2: Use Case specific requirements				
Code	**Description**	**Dependencies and Comments**	**Origin of requirement**	**Relevant Stakeholders**
R1.2.1	The application for the business tourist should be distributed as a mobile app as an interaction mean with the services based on the BigClouT platform.		GRE-UC1	Smart Cities, End Users
R1.2.2	Hotels, shops and restaurants should be able to share the participant information with the application (how many nights stayed, how much	R1.1.13	GRE-UC1	Smart Cities, End Users

	spent, etc.).			
R1.2.3	The application may collect this information automatically by using sensors from the mobile phone (GPS localisation, proximity sensors such as NFC or Bluetooth Low Energy).	R1.1.12	GRE-UC1	Smart Cities, End Users
R1.2.4	The application should provide a tool to analyse data and extract statistics in simple and easily understandable way for the city economic development division and for the event organisers.	R1.1.7, R1.1.4	GRE-UC1	Smart Cities, End Users
R1.2.5	The event organisers may share some information about the participant collected during his/her registration to the event. (hotel stayed, personal profile, etc.).	R1.1.13	GRE-UC1	Smart Cities, End Users
R1.2.6	The Grenoble mobility service should have the means to provide the information about the transportation system in Grenoble (bus/tram stations, real-time traffic, etc.).	R1.1.6	GRE-UC1	Smart Cities, End Users
R1.2.7	The application should protect the privacy of the end-user and propose several levels of management of personal data, and give the possibility of modifying the privacy parameters any time.		GRE-UC1	Smart Cities, End Users
R1.2.8	The application should provide means for shops and restaurants to announce interesting offers to the business tourists, as well as for Grenoble tourism office to notify about city events etc.	R1.1.13, R1.1.14	GRE-UC1	Smart Cities, End Users
R1.2.9	The application should provide means to gather satisfaction information from the user.		GRE-UC1	Smart Cities, End Users
R1.2.10	The application should be distributed as a mobile app for the employees of the Innovallée industrial zone.		GRE-UC2	Smart Cities, End Users
R1.2.11	The Innovallée association should be able to collect (in real-time when relevant) information from the associated stakeholders (restaurants, shops, company associations, etc.) and provide it to the BigClouT	R1.1.12	GRE-UC2	Smart Cities, End Users

	platform			
R1.2.12	The application should provide means (via the same mobile app) for associated stakeholders to directly enter necessary information (bypassing Innovallée), such as restaurants announcing menus, waiting time, shops providing interesting offers, food trucks announcing location and offers, etc.	R1.1.13	GRE-UC2	Smart Cities, End Users
R1.2.13	The Grenoble mobility service should provide the information about the transportation system in Grenoble (bus/tram stations, timetables, real-time traffic information, car-sharing, etc.).	R1.1.12	GRE-UC2	Smart Cities, End Users
R1.2.14	The user may accept to provide some personal information such as profile, location, company, transportation mode used, etc., for receiving customised information.		GRE-UC2	Smart Cities, End Users
R1.2.15	The application should protect the privacy of the end-user and propose several levels of management of personal data, and give the possibility of modifying the privacy parameters any time.		GRE-UC2	Smart Cities, End Users
R1.2.16	The application should provide a tool to analyse data and extract statistics in simple and easily understandable way for the city economic development division and for Innovallée Association	R1.1.4, R1.1.2	GRE-UC2	Smart Cities, End Users
R1.2.17	The application should notify the user when interesting events occur and/or customised recommendations to be provided		GRE-UC2	Smart Cities, End Users
R1.2.18	The application should provide means to gather satisfaction information from the user.		GRE-UC2	Smart Cities, End Users
R1.2.19	BigClouT should collect information from sensors deployed inside citizen homes.	R1.1.1	BIO-UC1	Smart Cities, End Users
R1.2.20	BigClouT should collect detailed weather information in a real time and in an accurate way.	R1.1.9	BIO-UC1 and UC2	Smart Cities, End Users

R1.2.21	BigClouT should store the information from different sources for post processing.	R1.1.9	BIO-UC1	Smart Cities, End Users
R1.2.22	Provide prediction tools for energy usage mapping.	R1.1.3	BIO-UC1	Smart Cities, End Users
R1.2.23	Provide tools for comparing citizens' energy consumption scenarios.		BIO-UC1	Smart Cities, End Users
R1.2.24	Provide an easy to use dashboard.	R1.1.4	BIO-UC1 and UC2	Smart Cities, End Users
R1.2.25	Collect MAC address from citizens' devices.		BIO-UC2	Smart Cities, End Users
R1.2.26	Provide a SDN real time adaptive network.		BIO-UC2	Smart Cities, End Users
R1.2.27	The platform should be able to store the information from different sources for post processing.	R1.1.9	BIO-UC2	Smart Cities, End Users
R1.2.28	Provide prediction tools for citizens' mobility patterns.	R1.1.3	BIO-UC2	Smart Cities, End Users
R1.2.29	NGSI API compliance should be provided.		BIO-UC1 and BIO-UC2	Smart Cities, End Users
R1.2.30	A User Management System should be available for citizens to consult only their data and manage their profiles.		BIO-UC1	Smart Cities, End Users
R1.2.31	A Map (dashboard) should be provided showing different hot paths around the city.	R1.1.4	BIO-UC2	Smart Cities, End Users
R1.2.32	The tourist should install a smartphone app as an interaction with the services based on the BigClouT platform.		TSU-UC1	Smart Cities, End Users
R1.2.33	The city and BigClouT project should promote/distribute the smartphone application for the tourists.		TSU-UC1	Smart Cities, End Users
R1.2.34	The application should be able to provide the most suitable information in real time such as weather information, SNS comments, traffic and facilities congestion information by their attribute and location information.	R1.1.7	TSU-UC1	Smart Cities, End Users
R1.2.35	The application should be able to analyse the trend of satisfaction rate,	R1.1.7	TSU-UC1	Smart Cities,

	weather information and visitors' behaviour by their attribute.			End Users
R1.2.36	The application should be able to recommend the most suitable information about tourism and transportation by their attribute, real time environmental information and trend of satisfaction rate.	R1.1.7	TSU-UC1	Smart Cities, End Users
R1.2.37	The application should be able to predict future recommendation information by accumulated information.	R1.1.7	TSU-UC1	Smart Cities, End Users
R1.2.38	The application should be able to provide the useful information by location and time. (e.g.: SNS, smart phone application and interactive signage).	R1.1.7	TSU-UC1	Smart Cities, End Users
R1.2.39	The application should be able to provide predicted future information by accumulated information (e.g.: SNS, smart phone application and interactive signage).	R1.1.7	TSU-UC1	Smart Cities, End Users
R1.2.40	The foreign tourists should install a smartphone app as an interaction with the services based on the BigClouT platform		TSU-UC2	Smart Cities, End Users
R1.2.41	The city and BigClouT project should promote/distribute the smartphone application for the foreign tourists.		TSU-UC2	Smart Cities, End Users
R1.2.42	The application should be able to collect accumulated information to provide the most suitable information.	R1.1.2, R1.1.3	TSU-UC2	Smart Cities, End Users
R1.2.43	The application should be able to prepare to answer to solve their needs and problems by collected data according to visitors' behaviour and their attribute.	R1.1.3	TSU-UC2	Smart Cities, End Users
R1.2.44	The application should be able to provide the useful and multilingual information to foreign visitors by their location and time (e.g. SNS, smart phone application and interactive signage).		TSU-UC2	Smart Cities, End Users
R1.2.45	The application should be able to provide additional useful	R1.1.5	TSU-UC2	Smart Cities, End Users

	information by accumulated information (e.g. SNS, smart phone application and interactive signage).			
R1.2.46	Collect information to analyze visitors' trend (e.g. GPS information, visitors' behaviour history etc.).	R1.1.5	TSU-UC1and UC2	Smart Cities, End Users
R1.2.47	Collect other real time information from third sources such as weather information, social network comments etc.	R1.1.5	TSU-UC1and UC2	Smart Cities, End Users
R1.2.48	Provide recommendation services about tourism related issues and transportation.	R1.1.7, R1.1.5	TSU-UC1and UC2	Smart Cities, End Users
R1.2.49	Provide useful information by location and time.	R1.1.7	TSU-UC1and UC2	Smart Cities, End Users
R1.2.50	Provide useful and multilingual information to foreign visitors by their location and time.	R1.1.7	TSU-UC2	Smart Cities, End Users
R1.2.51	The citizens and tourists should install a smartphone app as an interaction with the services based on the BigClouT platform		FUJ-UC1	Smart Cities, End Users
R1.2.52	The city and BigClouT project should promote/distribute the smartphone application for the citizens and tourists.		FUJ-UC1	Smart Cities, End Users
R1.2.53	Users should be able to report through smart phones various incidents through a dedicated mobile phone application.		FUJ-UC1	Smart Cities, End Users
R1.2.54	Various city stakeholders (from IT or city tourism division) should be able to monitor these incident reporting.		FUJ-UC1	Smart Cities, End Users
R1.2.55	Collect real-time city data from various information resources with low cost.	R1.1.9	FUJ-UC1	Smart Cities, End Users
R1.2.56	Share collected data among various stakeholders.		FUJ-UC1	Smart Cities, End Users
R1.2.57	Analyse real-time data efficiently and effectively.	R1.1.5, R1.1.2	FUJ-UC1	Smart Cities, End Users
R1.2.58	Visualize analysed data effectively and intuitively.		FUJ-UC1 and FUJ-UC2	Smart Cities, End Users

R1.2.59	BigClouT project should install sensors on garbage collection trucks as an interaction with the services based on the BigClouT platform.		FUJ-UC2	Smart Cities, End Users
R1.2.60	City stakeholders should be able to collect data from sensors attached to garbage collection trucks.	R1.1.11	FUJ-UC2	Smart Cities, End Users
R1.2.61	City stakeholders should be able to organize and promote various competitions related to garbage saving and or collection.		FUJ-UC2	Smart Cities, End Users
R1.2.62	The BigClouT platform should provide a method to collect real-time city data from various information resources with low cost.	R1.1.5	FUJ-UC2	Smart Cities, End Users
R1.2.63	The BigClouT platform should provide edge-side computing technology to reduce data size with finding important aspect of the data.	R1.1.8	FUJ-UC2	Smart Cities, End Users
R1.2.64	The BigClouT platform should provide cloud-side computing technology to store massive data effectively and analyse the data for city infrastructure management.	R1.1.8, R1.1.2	FUJ-UC2	Smart Cities, End Users
R1.2.65	The BigClouT platform should provide a method to share collected data among various stakeholders.		FUJ-UC2	Smart Cities, End Users
R1.2.66	The BigClouT platform should provide a method to analyse real-time data efficiently and effectively.	R1.1.2	FUJ-UC2	Smart Cities, End Users
R1.2.67	End users should be able to download the mobile application and learn about the various events that are happening in the area.		GRE-UC1 and UC2, FUJ-UC1, TSU-UC1, TSU-UC2	Smart Cities, End Users
Category R2: Non-functional Requirements				
Group 1: Security & Privacy				
Code	**Description**	**Dependencies and Comments**	**Origin of requirement**	**Relevant Stakeholders**
R2.1.1	The BigClouT platform should be capable of managing different users profiles distinguishing between stakeholders, actors and roles.		All use cases	All
R2.1.2	The platform should store privacy covered data in a protected way.	R2.1.4	All use cases	All

	Access to protected data should be possible only to authorized users.			
R2.1.3	The BigClouT platform, in accordance to local security policies, should be capable of applying digital signature to content before storing them.	R2.1.4	All use cases	All
R2.1.4	The applications and technologies used in BigClouT must respect all regulations concerning the ethical aspects, especially those related with data protection and privacy.	R1.2.25 and R1.2.7.	All use cases	All
R2.1.5	BigClouT should cover with state-of-the-art technologies all the aforementioned security aspects.		All use cases	All
R2.1.6	BigClouT security and privacy parameters should be (re-) configurable.		All use cases	Smart Cities, End Users
Group 2: Scalability				
Code	**Description**	**Dependencies and Comments**	**Origin of requirement**	**Relevant Stakeholders**
R2.2.1	The BigClouT system must be able to scale with respect to more input sensors. In this way, the number of edge nodes within a BigClouT system should not be limited, such that more edge nodes can be deployed to handle more sensors.		All use cases	Infrastructure and Service Providers, Integrators
R2.2.2	The big data analytics engine should be able to scale to more input data from more edge nodes.		All use cases	Infrastructure and Service Providers, Integrators
R2.2.3	The dashboard should be able to respond to user queries from the use cases, and moreover should be able to handle multiple users of the use cases at once, such that results are obtained quickly even under load.		All use cases	Infrastructure and Service Providers, Integrators
Group 3: Performance				
Code	**Description**	**Dependencies and Comments**	**Origin of requirement**	**Relevant Stakeholders**
R2.3.1	The BigClouT system deploys various big data analytics frameworks that have demands in computational power. They should be regularly		All use cases	Infrastructure and Service Providers,

	evaluated during development, such that they are shown to be accurate with real-time data.			Integrators
R2.3.2	Statistics and reports that should be displayed through the dashboard is a process with high performance needs.	R1.1.2	All use cases	Infrastructure and Service Providers, Integrators
Group 4: Reliability and availability				
R2.4.1	The BigClouT system should have a high availability and reliability (e.g. more than 98% in regular operation during the pilots) that can be monitored, measured and audited.		All use cases	Infrastructure and Service Providers, Integrators
R2.4.2	In case of failures, measures have to be taken in order to overcome these in short notice and additional measures for preventing their occurrence.		All use cases	Infrastructure and Service Providers, Integrators
Group 5: Manageability and flexibility				
Code	**Description**	**Dependencies and Comments**	**Origin of requirement**	**Relevant Stakeholders**
R2.5.1	The BigClouT system should have a high manageability and flexibility even for users that are not considered experts.		All use cases	Infrastructure and Service Providers, Integrators
R2.5.2	Common management attributes such as add/delete/update should be intuitive and easy to be performed.	R1.1.4	All use cases	Infrastructure and Service Providers, Integrators
R2.5.3	The BigClouT modularity level should allow enough independence of all modules so as if any module needs to be replaced, this will have no consequences to the other modules.		All use cases	Infrastructure and Service Providers, Integrators
Group 6: Openness and extensibility				
Code	**Description**	**Dependencies and Comments**	**Origin of requirement**	**Relevant Stakeholders**
R2.6.1	The various components of BigClouT should be ideally portable across major operating systems.		All use cases	Service Providers, Integrators, OS Community
R2.6.2	The various components of BigClouT should be interoperable with other		All use cases	Service Providers,

	services implementing common and open standards			Integrators, OS Community
R2.6.3	The core components of the BigClouT framework should be extensible to new unforeseen types of sensors and events captured.	R1.1.11	All use cases	Service Providers, Integrators, OS Community
R2.6.4	BigClouT APIs should rely on open standards and built upon other existing open standards where possible.		All use cases	Service Providers, Integrators, OS Community
R2.6.5	BigClouT should provide programming interfaces for application developers to gather real-time and historic data	R2.6.4	All use cases.	Service Providers, Integrators, OS Community
Group 7: Design and implementation requirements				
Code	**Description**	**Dependencies and Comments**	**Origin of requirement**	**Relevant Stakeholders**
R2.7.1	BigClouT should reuse existing open source software and tools, where it is appropriate and possible according the license.	R2.6.*	All use cases	Service Providers and Integrators
R2.7.2	The architecture of BigClouT must be layered, providing separation of concerns.		All use cases	Service Providers and Integrators
R2.7.3	The components of BigClouT must be developed according accepted good programming practice.		All use cases	Service Providers and Integrators, OS Community
R2.7.4	The components should be developed using proven and trusted languages.	R2.6.4	All use cases	Service Providers and Integrators, OS Community

5 Partners' technological background and relation to BigClouT

This section provides a description of the project background per partner and other projects in which the partner is involved in relation to the technological focus that is considered for the project according to its role. Furthermore, it identifies requirements associated with the (re)use, extension and enhancement of background technology components in the scope of the BigClouT project. A detailed analysis of these assets is provided in deliverable D1.1.

5.1 ICCS

ICCS brings in the project the following assets:

CoherentPaaS: *The platform addresses the problem of Polyglot Persistence environments and leverages a novel technology able to scale out transactional processing.*

COSMOS: *Through the Eventflows Marketplace it enables developers to build IoT applications. Its Privelets functional component is a component that runs at the Thing's side and its role is, acting as a filter, to ensure that every Thing (and therefore its user) shares only the intended information and leaves out all other that is considered as private and is believed to affect his/her privacy*

The requirements the two provided ICCS's assets fulfil are:

- providing data and management collection functionalities
- providing real-time data processing functionalities
- provide tool(s) to build IoT applications

5.2 ENG

Engineering (ENG) brings in the project the following assets:

CDMI Storage: *The CDMI Storage is an elastic and scalable storage system that enables to historicize sensor data, object data (i.e. images, videos, big files, etc.) and associated metadata.*

SpagoBI: *Free software and open source business intelligence suite that offers different functionalities and a wide range of analytical tools to create reports, perform multidimensional analysis (OLAP), create charts, manage KPIs, set up interactive cockpits (aggregating different views and charts), visualize business data on maps, extract knowledge, etc.*

KNOWAGE: *Open source suite for business analytics able to combine traditional data and big data sources into valuable and meaningful information.*

Engineering was one of the partners implied in the ClouT project, on which the BigClouT one is based on. The requirements the three provided Engineering's assets fulfil are:

- ability to perform predictive analysis
- providing a dashboard in order to present results of analysis
- providing "big data" analytics functionalities
- providing stored historical data

5.3 ULANC

Lancaster University brings in the project the following assets:

Distributed Edge Processing Platform (D-NR): *IoT implementation consisting in D-NR processes running across participating devices in local networks and servers in a Cloud infrastructure.*

City Hub: *Cloud-based hubs allowing to develop IoT centric frameworks for smart cities. It offers a consistent and easy-to-use interface for emerging IoT infrastructure within the city that systems integrators and application developers can use. It supports the system-of-systems approach to smart cities whereby a cloud-based hub can integrate a number of sub-systems that collectively make up the complete smart city software infrastructures.*

The requirements the two provided ULANC's assets fulfil are:

- the access to data from sensors
- the access to data in real-time from sensors
- the ability of being integrated with existing sensor networks
- providing real-time data processing functionalities
- being able to monitor data flow in real-time
- providing data collection functionalities
- provide tool(s) to build IoT applications

5.4 TSU

TSU brings in the project the following assets:

JsSpinner: *a data stream processing framework capable of handling semi-structured (JSON) streams*.
StreamOLAP: *online analytical processing (OLAP) over streams exploiting off-the-shelf stream processing engine (SPE) combined with OLAP engine*.

The requirements the two provided TSU's assets fulfil are:

- providing real-time data processing functionalities
- providing edge processing functionalities

5.5 NII

NII brings in the project the following assets:

ECAVerifier: *It is a tool supporting effective use of the model checking technique for verification of ECA rules.*

Self-Healing*: The self-healing tool provides a function to correct the sensory faults, that being of bias, drift, dysfunction or random.*

NII was one of the partners implied in the ClouT project, on which the BigClouT one is based on. The requirements the two provided NII's assets fulfil are:

- providing real-time data processing functionalities
- provide tool(s) to build IoT applications

5.6 Keio

Keio University brings in the project the following assets:

Lokemon: *It is a brand new way of motivating citizen to participate crowd sensing without any privacy issues.*

Sensorizer: *It is a technology allowing to define arbitrary elements on a web page as EWC containers, to periodically mine current value from those containers, and to transmit data to a dedicated middleware that uses XMPP over HTTP.*

SOXFire: *It is a universal sensor network system for sharing social big sensor data to realize sensor data ecosystem in smart cities. Social big sensor data is required to be shared various level such as city elements, community-level and city-level.*

Keio University was one of the partners implied in the ClouT project, on which the BigClouT one is based on. The requirements the three provided Keio University's assets fulfil are:

- the access to data from sensors
- the access to data in real-time from sensors
- the ability of being integrated with existing sensor networks
- providing data collection functionalities

5.7 NTTRD

NTTRD brings in the project the following assets:

oneM2M: *It is one of the most promising Machine-to-Machine (M2M) standard. Eight of the world's leading regional ICT standards bodies (ARIB, ATIS, CCSA, ETSI, TIA, TSDSI, TTA, TTC) have come together to create oneM2M.*

Virtual sensor: *It is a tool aiming at noise reduction and missing value estimation. It enhances the quality of participatory sensing data, and make virtual sensors reliable and flexible.*

NTTRD was one of the partners implied in the ClouT project, on which the BigClouT one is based on. The requirements the two provided NTTRD's assets fulfil are:

- the access to data from sensors
- the access to data in real-time from sensors
- providing real-time data processing functionalities

5.8 CEA

CEA brings in the project the following assets:

sensiNact gateway: *sensiNact is a horizontal platform dedicated to IoT aiming at managing IoT protocols and devices heterogeneity, and providing synchronous (on demand) and asynchronous (periodic or event based) access to data/actions of IoT devices.*

sensiNact studio: *sensiNact studio is a software platform developed for monitoring IoT devices in physical environments and developing light IoT applications by making use of the services exposed by those devices.*

CEA was one of the partners implied in the ClouT project, on which the BigClouT one is based on. The requirements the two provided CEA's assets fulfil are:

- the access to data from sensors
- the access to data in real-time from sensors
- the ability of being integrated with existing sensor networks
- providing real-time data processing functionalities
- being able to monitor data flow in real-time
- providing data collection functionalities
- provide tool(s) to build IoT applications

6 Conclusions

Requirements analysis plays an important role for the whole lifecycle of the BigClouT project. It is the input for the BigClouT specification and overall architecture as well as for the validation of the final system and its evaluation against to the desired functionality.

In this document, we have presented the requirements analysis methodology along with the defined functional and non-functional requirements of the BigClouT system.

The analysis starts with a definition of the BigClouT concept, including an overview of the use cases and the stakeholders involved so as to understand the context of the project and identify the various stakeholders who represent a holistic value chain.

Similar projects and background from previous projects are also mentioned in order to present the state-of-the-art and the previous achievements that can be used as a starting point. In the sequel the elicitation of requirements is derived from the definition of the desired functionality of the BigClouT system given from the perspectives of the functional components and the non-functional attributes that the end system has to expose. The BigClouT system should have specified functionality to facilitate the use cases and a rich set of non-functional requirements such as scalability, reliability, availability, manageability, flexibility, modularity, openness, etc.

The document has concluded with a consolidated and coded requirements list that will be the reference for the design activities and the implementation and validation of the BigClouT system. The list has been divided into groups of requirements, indicating dependencies between the various requirements but also the relevant stakeholders that are affected.

The current deliverable will be one of the main reference documents for the design and specification of the BigClouT system. In particular, the deliverables “D1.3 First BigClouT Architecture” and “D1.4 Updated use cases, requirements and architecture” are the ones that will take this document most into account for the further development of the project in Work packages 2 and 3 as well as for the pilots validation in WP4.