WP4 Pilots, citizen involvement, integration and validation.
D4.5 Integrated use cases and final large-scale deployments and experimentation -Demonstration-

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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 describes the final demonstrators of integrated use cases and large-scale deployments and experimentation of the BigClouT project. Its objective is to present the project trials that have been an opportunity for demonstrating the integration work performed by the project partners. It includes brief descriptions of the trials as well as other relevant information such as technical information, evaluation results, lessons learned, etc. The live demonstrations will take place during the 3rd year Project review meeting.

Disclaimer

Revision history

Revision	Date	Description	Author (Organisation)
V0.1	2019-4-24	Initial ToC	KD (NTTE)
V0.2	2019-4-23	Initial ToC amended	AK (BiO)
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V0.9	2019-8-01	Amended	KD (NTTE) EC (BIO)
V0.10	2019-8-02	Final version	EC (BIO)

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1 INTRODUCTION

This deliverable describes the final demonstrators of the integrated use cases, large-scale deployments and experimentation of the BigClouT project. For each city we have provided a brief update on the main trials (based on the respective use-cases) followed by a description of the demonstrator available at the review meeting to showcase the trial.

Where possible, we have highlighted how the trials and demonstrators are scaling to fullfil our stated focus on large scale. Further, since one of the main objectives is to verify implementation of the applications using BigClouT technology in the real world, we have included a brief overview of how each trial uses the core BigClouT platform. More details are available in the companion deliverable (D4.4), which discusses how the trials use the core BigClouT platform and the WP2 and WP3 technologies that have been developed.

This deliverable is presented as explanatory material of the demonstration for the Final Review meeting planned to be held in Tokyo on the 19th September 2019.

As stated in D4.4, we have identified the following BigClouT main features;

1. BigClouT platform facilitates rapid and flexible collection of variety of city data (citizens, sensors, web pages, legacy platforms, ...)
2. BigClouT provides high level programming tools for rapid prototyping of smart city applications
3. BigClouT provides easy to use tools to extract value from the raw city data
4. BigClouT maintains a data lake with real life data useful for building and experimenting city and citizen services
5. BigClouT is based on a modular architecture that can be instantiated and customized according to specific city needs

BigClouT is composed of 13 components developed by its partners, each one contributing to provide the BigClouT features summarised above. About 20 integration links have been built between the components to achieve the goals set by the BigClouT trials. Figure 1 illustrates the BigClouT platform with the components mapped to their functional layers. Detailed information about each component has been given in Deliverable 4.4.

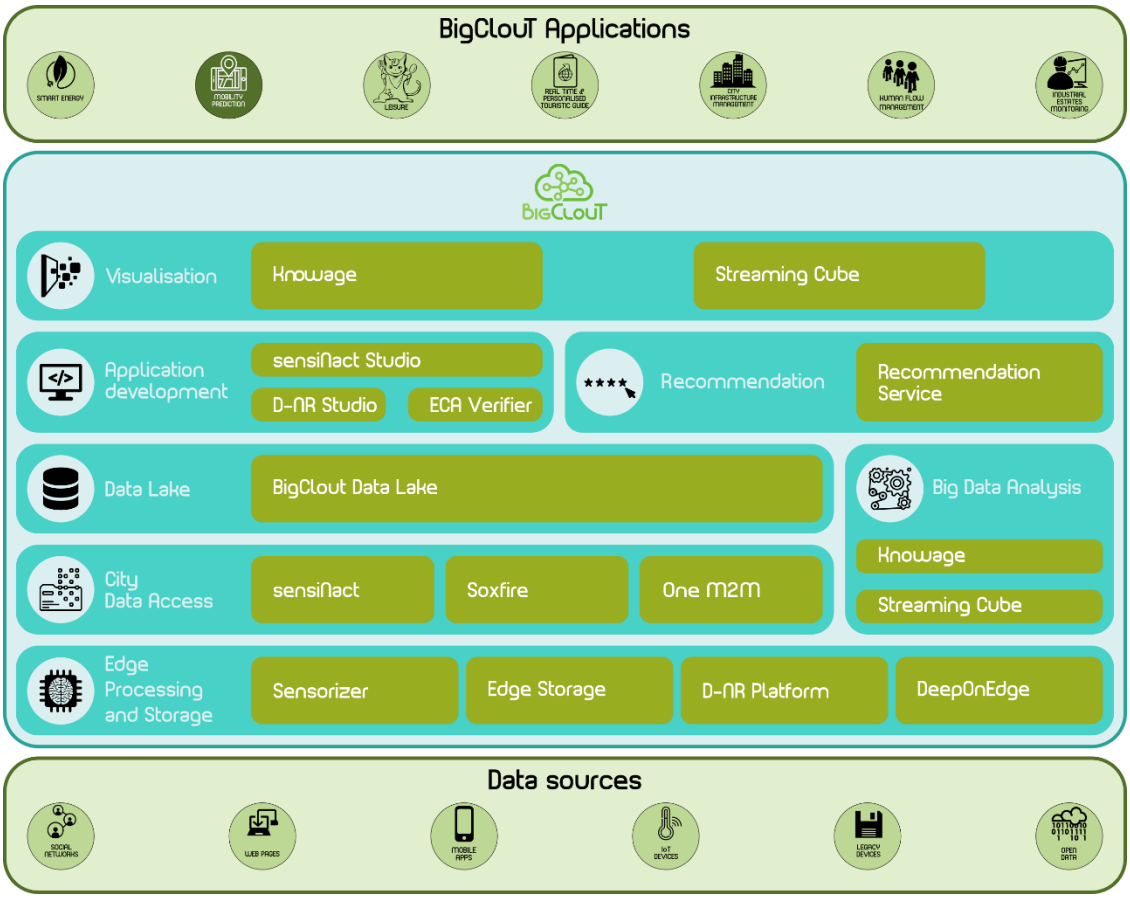

FIGURE 1. BIGCLOUT COMPONENTS ASSETS

The final trials of this project have been implemented in 4 cities in Europe and Japan to evaluate how BigClouT's components have opportunities to be used in the real world and contribute to improve citizens' life. In addition, the MinaRepo application, which was developed by KEIO and proved effective in Fujisawa city in Japan, was refurbished and implemented in Bristol city in EU as an EU-Japan joint trial. Although this deliverable is a demonstration format, an overview of each demonstration is explained in this document.

2 CITY TRIAL STATUS AND DEMONSTRATORS

All cities have reached their objectives in their trial activities with continued progress on defining, refining and deploying trials. Outlined below are results on the development of the use cases along with any important changes in use-case design as a result of experimentation and other factors. Following on from the status update of the trials, is a description of the demonstrator that will be available at the 3rd year review which serves to document and highlight progress of the city trials.

2.1 Fujisawa

Fujisawa have been focusing on two core areas for trials - city event management and city infrastructure management. Within these areas are a number of sub-projects each with its own self-contained trial.

2.1.1 Trial 1: City Event Management

2.1.1.1 City needs and goals

The objective of the use case is to enhance the local economy in terms of various events where citizens and visitors participate. The 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.

2.1.1.2 Stakeholders engaged in trials

End-users: Citizen, Tourist
Stakeholders: City, Event management companies, Transportation companies

2.1.1.3 Trial objectives

We defined the following objectives in D1.4.

(1) Collect physical and virtual information about Fujisawa city by leveraging a variety of 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 the local economy for stakeholders

To achieve the scenario and solve the problems, we accomplished two sub field trials with a focus on 1) human point of view (participatory sensing) and 2) IoT point of view (human flow sensing). In the human point of view, we focused on collecting city data from citizens while preserving privacy issues by keeping to enhance motivation of citizen. In the IoT point of view, we focused on collecting and understanding human flow from different kinds of sensors (Camera-based, WiFi-based, etc) with state-of-the-art machine learning techniques.

2.1.1.4 Engagement process with citizens and government

In the both sub trials, we executed following engagement process with citizens and government. Firstly, we had periodical meetings with BigClouT partners and Fujisawa city to identify problems and solutions for the engagement. Then, we joined several stakeholders meetings such

as event organizer (Fujisawa festival management organization) or transportation companies (Odakyu railways company and Enoden railways company).

2.1.1.5 Technical approach – BigClouT components

- Human point of view: Lokemon

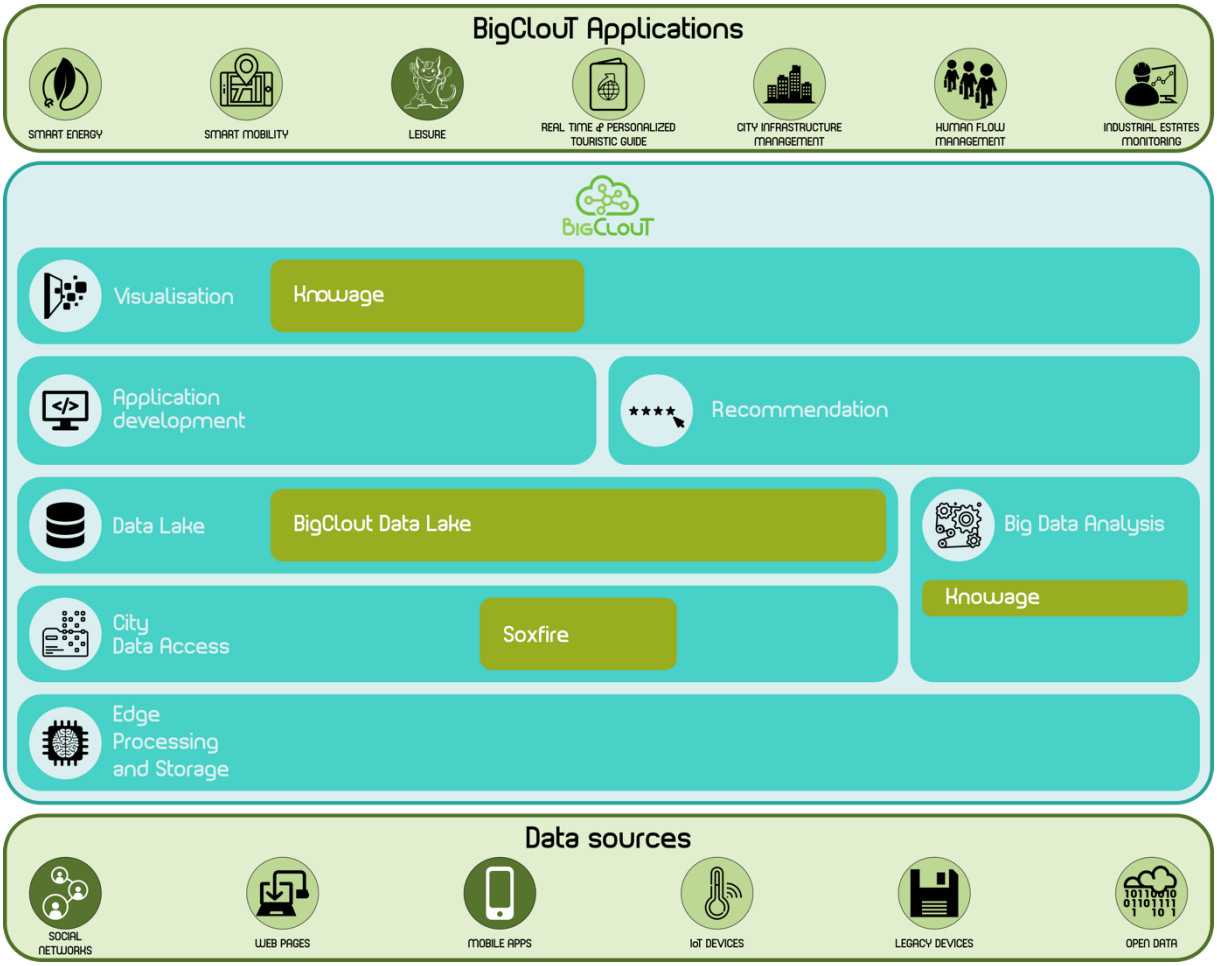

FIGURE 2. LOKEMON - BIGCLOUT COMPONENTS USED IN THE TRIAL

Participatory crowdsensing, where a large group of participants collect and share data of common interest via their portable devices like smartphones and tablets, is widely recognized as one of the major sensing technologies for collecting required information to understand the situation of a city, since it can collect both objective and subjective information leveraging human's perception. Since mobile portable devices have become ubiquitous presence in the last decade, a number of participatory crowdsensing applications with which citizens cooperatively gather and share data have been proposed in the literature in the application areas, especially city event management. The development of participatory crowdsensing mainly entails the following two issues. Firstly, it is required to provide adequate incentives to motivate people to participate. People are usually gifted something when they collect and report their data, and/or be guided to a sensing target when they are close to there.
Secondly, we need to reduce participants' concerns on possible privacy leakage such like their locations. To reduce participants' concerns on privacy leakage, it is typically possible to allow users to contribute data anonymously. However, this may decrease their sense of contributions and thus their motivation to participate. To cope with this problem, we propose a novel participatory crowdsensing approach called Lokemon, which allows participants to mimic a virtual monster associated with a specific sensing target, i.e., Point of Interest (PoI) to collect and share data of the PoI. It is expected that the use of monsters will promote users to participant in

crowdsensing inspired by the related studies of behavior change promotion using avatars and anthropomorphic design. This brings the following four merits.

Firstly, participants can be attracted and induced to visit a PoI by showing monsters on a map and providing them required information. Secondly, users can ask a question to a monster instead of asking someone with his/her username. By using known identity to interact with people, we activate and facilitate communication among users. Thirdly, by using a monster as an alias when posting information, we entertain people and motivate them to post information. It also hides users' real identity making it easier for users to post information while reducing the concern on leakage of location privacy. Finally, multiple users can share a monster when they are simultaneously present within a PoI.

A shared monster is a common identity of the users, which narrows a talking target to one. This shared identity simplifies interaction among users. In all, Lokemon monsters serve as an intermediation mechanism among cooperative people in participatory crowdsensing.

In Lokemon, each PoI is associated with a monster. In order to guarantee that only users within a PoI can report data, we define the following related areas of PoI as shown in Figure 3.

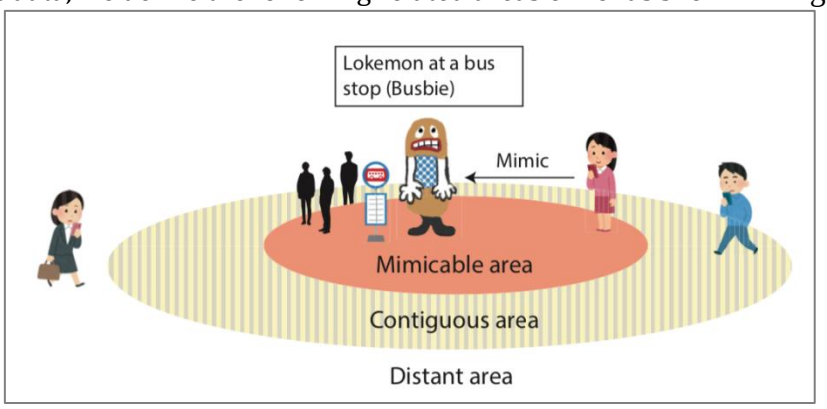

FIGURE 3. RELATIONSHIP BETWEEN A POINT OF INTEREST AND AN AREA

[Mimicable area (MA)] An area within which a user can act as a monster to conduct participatory crowdsensing.
[Contiguous area (CA)] An area adjacent to the mimicable area within which any user can get detailed information about the monsters of the mimicable area.
[Distant area (DA)] Outside the contiguous area within which a user can get detailed information about the monsters after they enter the mimicable area and add the monster to their collection.

The MA of a PoI corresponds to the area within which the desired information can be detected and is dependent on the specific PoI. For example, as shown in Figure 3, the MA of a bus stop is the area within which the congestion level can be recognized.
On the other hand, the MA of a shopping mall should be larger than that of the bus stop.
In our implementation, the MA of a PoI is configurable. Besides, the MA of PoIs can overlap. For instance, a bus stop can be located at a shopping mall. The relationship of PoIs can be categorized into three types of separated, overlapped and included as shown in Figure 4.

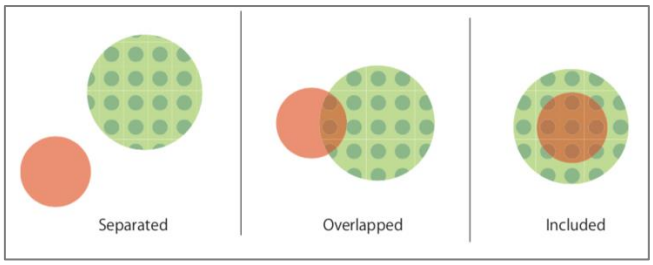

FIGURE 4. RELATIONSHIP BETWEEN POINTS OF INTEREST

The functions of Lokemon are summarized as below:
[F1. Find monsters on a map]
Monsters are displayed on a map according to the locations of associated PoIs. From the map, users can find and collect nearby monsters to get detailed information such as icons and chat logs. Through finding monsters, we let users have interest in PoIs. This function will eventually induce them to visit there so as to gather participants.

[F2. Ask monsters a question]
Users can ask a question regarding a PoI to the monster. When someone wants to know information of a PoI, he/she can initiate a sensing task on his/her required information to the monster of the PoI. For example, one can ask a Busbie a question like "How many people are waiting at the bus stop?'' In the existing participatory crowdsensing models, users typically ask a question to someone with his/her username. In the Lokemon model, users can ask to a monster whose identity is known to the Lokemon system users. Putting well-known identity among users can activate and facilitate communication.

[F3. Act as a monster to post information]
When a user enters the MA of a PoI, he or she can act as a monster, which is considered to be virtually located at the PoI, to post information pro-actively or reactively. Figure 5 shows a comparison between the typical participatory crowdsensing model and the Lokemon model. In a typical participatory crowdsensing model, users send sensing data with their user names. In the Lokemon model, by contrast, users send data in the name of the monster in the PoI. By using a monster as a sender label, users can post information without exposing their identities. This also reduces the concern on possible privacy leakage, since other users cannot know who is actually reporting the data. Moreover, multiple users who are simultaneously present within the same PoI can act as the same monster. This mechanism implements a shared identity among users and leads to a new form of online communication. In previous participatory crowdsensing model, people interact with one another directly (many-to-many communication). In Lokemon, they interact with a monster (many-to-one communication). In this way, by narrowing a talking target to one, we simplify social interaction in participatory crowdsensing.

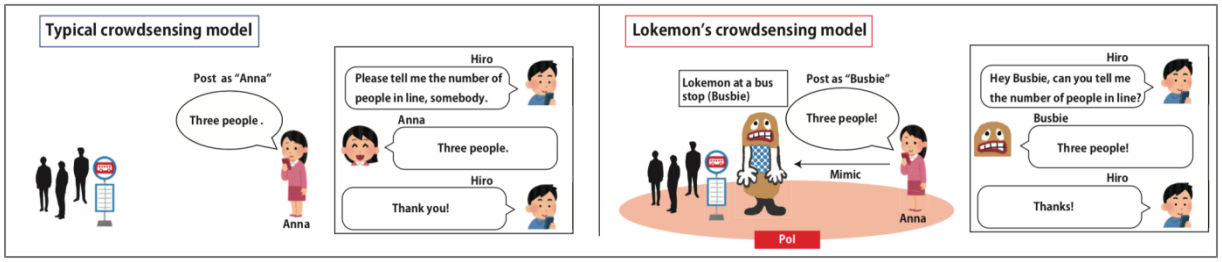

FIGURE 5. COMPARISON OF THE EXISTING PARTICIPATORY SENSING MODEL AND THE PROPOSED LOKEMON SENSING MODEL

We implemented the system with BigClouT components. We utilize SOXFire for data dissemination, and through SensiNact technology, we can also send the data into BigClouT data lake. Thanks to BigClouT architecture, our Lokemon prototype is instantly being a part of city sensing systems.

- IoT point of view: Integrated human flow sensing

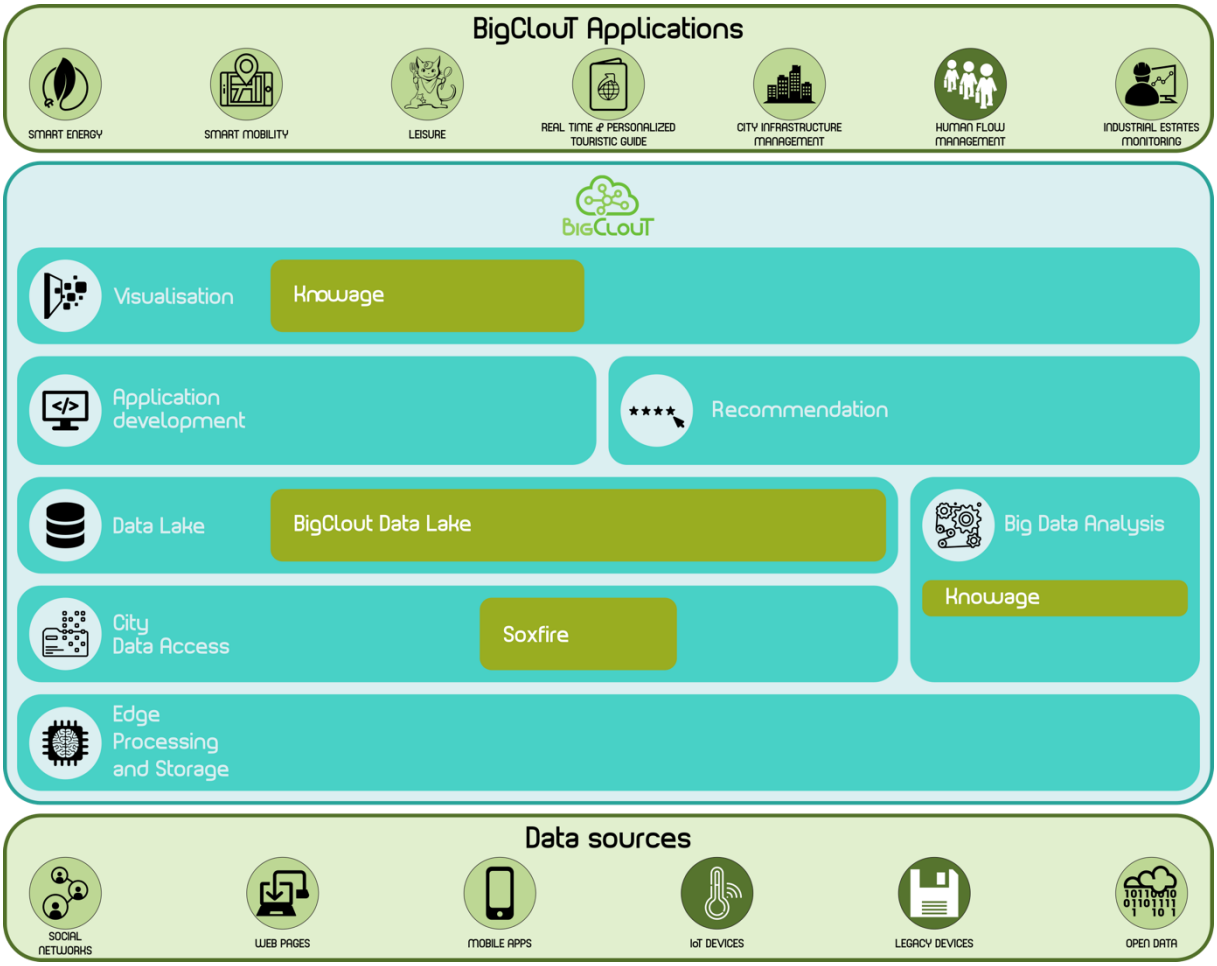

FIGURE 6. HUMAN FLOW SENSING - BIGCLOUT COMPONENTS USED IN THE TRIAL

In addition to use participatory sensing, to understand the real-time congestion of spectators in the big events, and also predict future congestion, we collect and analyse human flow information around Enoshima island by using IoT devices. Usually, event includes several wide area such as event main area, stations for the transportation, restaurant etc. Therefore, we have to collect human flow information from different places. In each places have appropriate sensing method, we focused to create integrated human flow sensing based on several IoT devices such as camera, WiFi sensor etc. Firstly, we deployed high-resolution camera in Enoshima tower to capture human flow in beach area of Enoshima island by cooperating with Enoden company. Secondly, we collect the data from WiFi sensor which was deployed by Odakyu railway company. As following, we present each trials with its technical overview.

・Crowd density recognition by using high-resolution camera

Estimating crowd density can provide very useful information in visualizing city information. For example, if it is possible to visualize the crowdedness of the theme park by estimating the crowd density, it becomes possible to analyze which time zone is crowded in which time zone, and by providing it to the theme park users, the user can choose better behavior. There are many other use cases for crowd density estimation, such as surveys of pedestrians at intersections and measurement of the number of customers at tourist spots. For the estimation of crowd density with many use cases, many methods using deep learning have been proposed. An example method is proposed in CrowdNet. This method divides the image into small patch images and uses deep learning to estimate the crowd density map from the patch images. The images analyzed so far in crowd density estimation are mainly images in which people are crowded in relatively narrow areas such as intersections and avenues (see target image example in left of Figure 7). On the other hand, the resolution of cameras is increasing at present such as 4K and 8K, and by making it possible to estimate crowd density from images captured in a wider area from now on, the wider area will be larger than the narrow area previously used (see example image in right of Figure 7). It is possible to capture the situation of the crowd. Images captured over a wide area tend to be represented by an extremely small number of pixels, and the distribution of crowd density is greater depending on the area, compared to conventional images. Therefore, in the method of dividing into patch images such as CrowdNet for prediction, a large number of patch images without human beings are generated, resulting in data imbalance.
Therefore, in this research, in order to obtain more information from one image, the purpose is to propose a method to estimate crowd density with higher accuracy than the existing method from an image capturing a wide area such as a tourist spot. As mentioned above, the image which captured the wide area is a wide area, so the distribution of crowd density in each area is large. Therefore, in order to consider the characteristics of each area, we propose a model that can predict wide-area and high-resolution images end-to-end without dividing images into patches. In addition, a more accurate crowd density map is predicted by preparing a subtask that predicts the degree of congestion for each area and estimating the crowd density using it as an attention. In order to show the effectiveness of the proposed method, in order to estimate the crowd density over a wide area, it was experimentally verified whether attention due to classification of multiple scales is due to the accuracy of crowd density estimation. As a result, it was shown that the accuracy could be improved by learning the classification map as a subtask, performing multitask learning, and performing classification map with multiple scales.

FIGURE 7. COMPARISON OF TWO IMAGES. LEFT: EXISTING TARGET. RIGHT: OUR TARGET

In this research, we propose Multi-Attention Network that estimates density directly from wide area image to obtain high precision density map even for wide area image. First, in order to consider global features, the image is input without being divided into patches. The input image is input to the feature extraction mechanism, and the feature obtained by this mechanism is input to the classification mechanism. The classification

result obtained by this mechanism and the feature quantity obtained by the feature extraction mechanism are combined, input to the combination mechanism, and the density map is output. This method is roughly divided into three mechanisms. The first is a feature extraction mechanism, the second is a classification mechanism, and the third is a combination mechanism. By learning these mechanisms end-to-end, we obtain high-precision density maps directly from high-resolution images.
As the result, we built a system which recognize more than 1000 people count within 10 secounds with +-50 people counting error.

2.1.1.6 Personal data protection

In line with the BigClouT ethics guidance - and national requirements - we anonymized collected data by setting anonymity-level to ensure no personal data is used, before the data are sent to the BigClouT Data Lake.

In Japan, protection of personal data is mandated under Act on the Protection of Personal Information. This requires any entity, which collects any form and amount of data that enable personal identification, to pay a special commitment. In that, the data collected through this trial are not capable of identifying a person, due to the following reasons.

- The trial does not collect any information that contains a unique ID, such as a MAC address and a phone number.
- The images collected by the human flow sensing contain human faces which are too tiny to identify a person.
- The location information collected by Lokemon cannot be associated with any identifier.

In addition to these, all the data collected through the trial have been stored in a database maintained by KEIO which is configured not to be reached from the Internet directly. This avoids accidental information leakage.

2.1.1.7 KPIs and Evaluation

We set following KPIs in deliverable 1.4.

TABLE 1. FUJISAWA KPIS - CITY EVENT MANAGEMENT

KPI or Metric	Target
Users	250
Critical mass of users	300 in first year
Daily active users	50
Average length of time spent using app	10 minutes
Frequency of use	Everyday
Time until trouble in city event resolved	1 hour

As the result of our several field trials, we achieved the majority of the KPIs.
- **Users**
  We involved more than 350 users in Lokemon field trial.
- **Critical mass of users**
  As above indicate, we obtained critical mass of users more than 300.
- **Daily active users**
  When we execute field trials, we obtained more than 100 active users.
- **Average length of time spent using app**

We cannot count actual length of time spent using app, but some users post city information more than 10 times per day. Thus, it could be regarded as more than 10 minutes use at maximum.

- **Frequency of use**

When we execute the field trial, we continuously operate the trial system everyday.

- **Time until trouble in city event resolved**

When we executed the initial field trial, we had no chance to evaluate the time. However, in a second trial, we encountered actual trouble such as illegal garbage thrown in the city. In that case, our system achieved to solve the problem more quickly than usual. Thus, as overall of the field trial in Fujisawa city, we achieved the KPI.

2.1.1.8 Summary – lessons learned, sustainability

In the city event management field trial, we mainly executed two field trials in the viewpoint of human perspective and IoT perspective. We succeeded to involve more than 300 citizen in the trial, and also involve several new stakeholders such as railway companies, etc. Through the field trial, we also explored new and important city problems to be solved, and solve the problem with BigClouT technologies.

2.1.2 Trial 2: City Infrastructure Management

2.1.2.1 City needs and goals

Fujisawa city have highlighted a concern with the road network that they manage. Road infrastructure in Japan is getting older, with many roads and others public equipment built as part of a significant infrastructure build out 30-40 years ago. As this infrastructure ages, it is necessary to understand the road conditions of the whole city to develop a comprehensive plan for maintenance and repair. However, management such infrastructure consumes a lot of costs both of human and budget. Therefore, in the trial2, we provide deployable and effective city infrastructure management.

2.1.2.2 Stakeholders engaged in trials

Road management section in Fujisawa city

Garbage management section in Fujisawa city

2.1.2.3 Trial objectives

The objectives of the trial is following - 1) we provide effective system to manage road infrastructure with considering sustainable way which can be adapted to any cities in Japan, and 2) we design, implement and evaluation the system with leveraging BigClouT components provided by several partners .

2.1.2.4 Engagement process with citizens anf governments

As we mentioned in Deliverable4.1, we engaged citizens and city sections in the loop of discussion-development-testing-feedback loop. We also provided term report which shows how our trial reduces city costs for city management to keep motivation of stakeholders.

2.1.2.5 *Technical approach – BigClouT components*

This trial is combined of two trials implemented in Fujisawa city, which are Minarepo as a human point of view, CityInspector as IoT point of view, to visualize the city activities. Please see the details of each trial in D4.2 and D4.3.

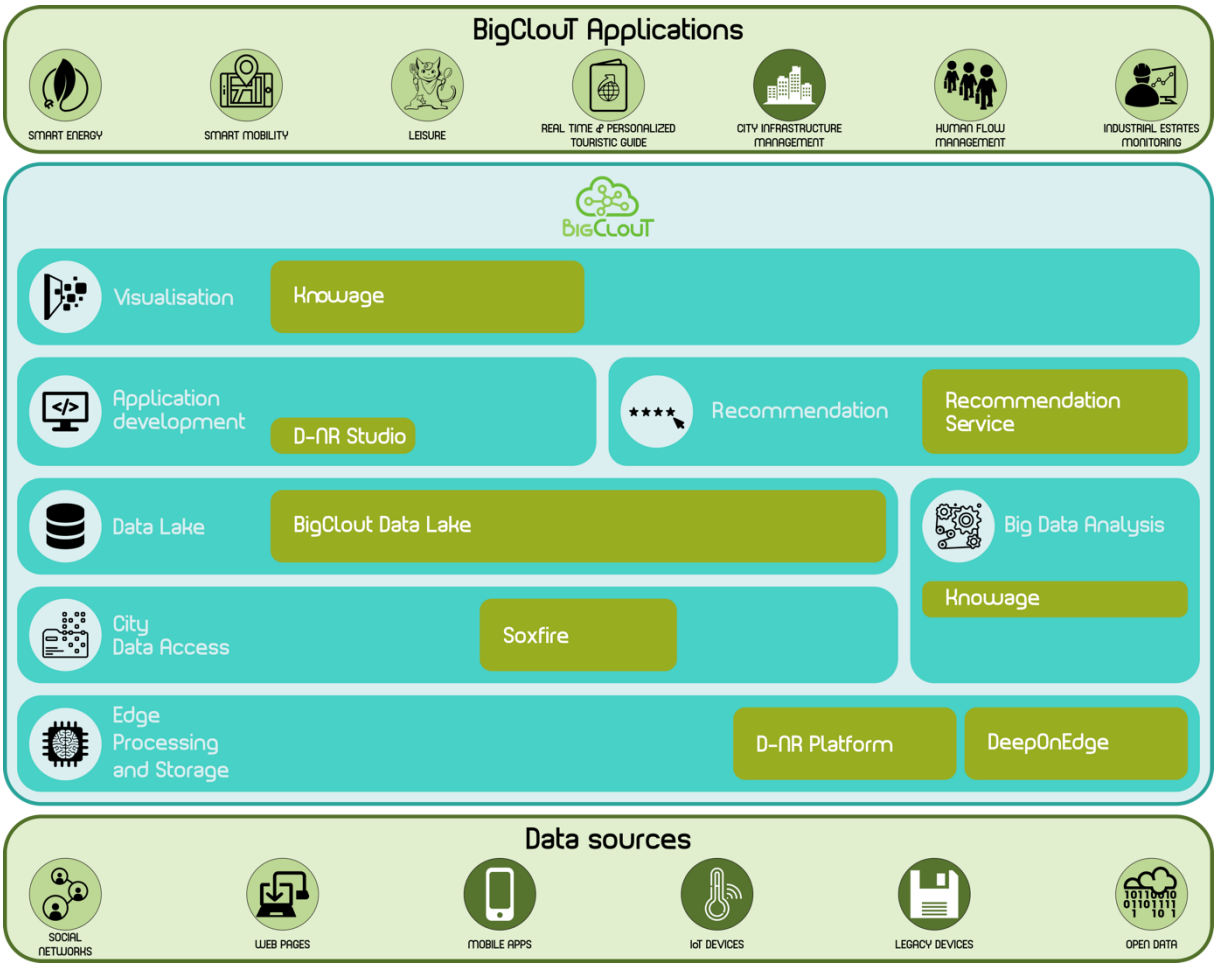

FIGURE 8. CITY INFRASTRUCTURE MANAGEMENT - BIGCLOUT COMPONENENTS USED IN THE TRIAL

- Human point of view: MinaRepo

We present that adapting crowdsensing technique to daily city infrastructure management by civil officers can collect spatial and time covered rich urban data with enhancing efficiency of their daily works. Municipalities take responsibilty on various city problems such as road management, waste management, park management, social welfare and so on. Through the city management, civil officers have to find and collect various urban information from entire of city which provide great opportunities for urban science, however, in most of cities (at least in Japan), such information is collected, shared and managed in analog and legacy way - telephone, facsimile or paper documents. By digitalizing city management with crowdsensing technique, we present that spatial and time covered rich urban data can be collected compared with citizen crowdsensing, and it contributes to make unknown fact of cities clear by analyzing the data.
We designed and implemented a crowdsensing tool called MinaRepo which fits daily city management by civil officers. Figure 9 shows overview of MinaRepo. When a civil officers find urban information to be reported, he/she select the types of report (e.g., illegal garbage, graffiti, damaged mirror etc.) and make a report with MinaRepo application which uses smartphone's camera and GPS sensor. Then, the report is published via city sensing platform based on SOXFire[hoge]. Published report is stored in WEB server and it's database. Finally, other civil officers can confirm reported problem in WEB browser with list and map interface. As the

viewpoint of crowdsensing tool, MinaRepo itself looks like standard implementation. However, we also provide several functions to support civil officers' daily work such as report notification according to emergency level, visualizing region of self-governing association as layer to map, and discussion forum to record action history to the reported problem. The necessity of these functions is obtained through continuous discussion among us and civil officers for naturally fitting MinaRepo to existing and ongoing daily works in the city.

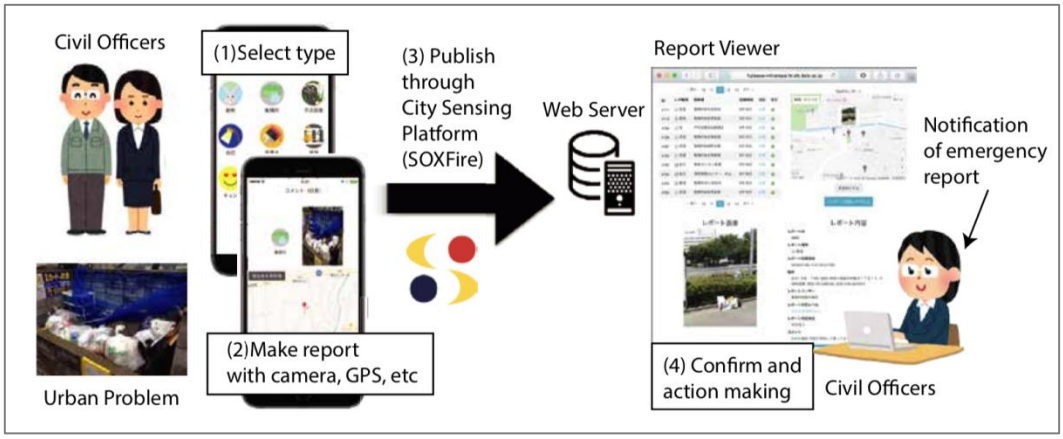

FIGURE 9. OVERVIEW OF MINAREPO WORKFLOW

To confirm effectiveness of MinaRepo, we conducted long- term experiment with garbage section in Fujisawa city, Japan. In the garbage section, civil officers have to manage garbage-related information such as illegal garbage, uncollectible garbage against the rule, forgotten garbage to be collected, etc. In addition, they also collect various urban problems such as graffiti, corpse of animals, road damage etc. We started the experiment from October, 2016. 65 of civil officers who is in charge of garbage-related works uses MinaRepo application in their daily works.

To understand feature of collected data from civil officers' crowdsensing, we compare it with data of ChibaRepo crowd- sensing. ChibaRepo, which is used in Chiba city Japan, is a crowdsensing service which allow citizens to report various city problems. Table 2 compares MinaRepo and ChibaRepo in terms of its number of users, number of collected report, etc. Figure 9 also shows simple plotted data and its visualization based on kernel density estimation. From these comparisons, we confirmed that integration of crowdsensing with civil officers can provide larger amount of data with high spatial coverage compared to citizen-based crowdsensing. In addition, we also confirmed that our system improve efficiency of daily works by conducting questionnaire survey to civil officers.

TABLE 2. MINAREPO AND CHIBAREPO DATASET

	MinaRepo	ChibaRepo
Area	Fujisawa City (69.57 km^2)	Chiba City (271.8 km^2)
Target User	Civil Officers	Citizens
Types of Report	Garbage, Graffiti, etc.	Road, Park, Garbage, etc.
Period	Oct 6, 2016 - Mar 20,2018	Aug 28, 2014 - Feb 27, 2016
Num. of Users	65	3615
Num. of Report	3667	1873
Num. of Report per User	56.41	0.51

-IoT point of view: CityInspector

The road is one of the most important infrastructures of a city in planning and development.

For instance, people usually use them for going somewhere or for planning land utilization to enrich their livelihoods. However, many roads need repairing since most of them are built in periods of rapid economic growth and have been deteriorating since. Thus, to inspect their condition for road repair, the city administration needs to employ people for constant inspection.
Yet manual road inspection is expensive and takes a lot of time; for instance, in order to detect the damage or blur of road markings, people have to check by eye, whose ability has certain limits. In addition, in certain regions such as Japan, public funds for road inspection have been reduced due to current societal conditions. In short, manual road inspection and repair is not enough for sufficient maintenance. Most previous work has therefore focused on making the cost of road inspection cheaper to increase sustainability. Some works have focused on road flatteness, potholes, and cracks. In contrast, we aim to detect the damage or blur of white lines. To our knowledge, only our previous work addresses this problem. Detecting the damage of white lines is difficult to do using smartphone accelerometers. Thus, we use a camera to take pictures/videos. If we use participatory sensing and collect the images, however, the cost issue still remains due to the cost of platform introduction and labor.

To tackle this issue, we focus on city vehicles, especially garbage trucks. Garbage trucks run their services every day and cover a whole area of the city. For example, at Fujisawa city in Japan, the garbage trucks cover about 65% of 100m mesh grids if they runs in the city about three days. Therefore, if the garbage truck equips a camera and takes pictures of roads, we can obtain road images from the whole area. Furthermore, we do not have to pay additional costs for labor or facilities. However, the number of running garbage trucks is so large (e.g., hundreds of trucks) that it is troublesome to storage and manage image data in a centralized way. Simultaneously, if we upload an image every time a camera takes pictures, it would take great communication costs and bandwidth. In summary, our goal is proposing a system that can be attached to garbage trucks and detect white line damage on the spot.

Therefore, we spotlight city vehicles, especially garbage trucks for taking pictures and collecting the images. Since the garbage trucks run their services every day and cover a whole area of the city (the red area of map in Figure 10), we can gather the road images from whole area when the garbage truck equips a camera.
However, the number of running garbage trucks is so large (e.g., hundreds of trucks per day) that it is troublesome to storage and manage image data in a centralized way.
Simultaneously, if the camera on the garbage trucks upload images each time it takes pictures, it would take great communication costs and bandwidth.
To treat these problems, we proposed the road damage decision system, deep on edge (DoE) that execute on the edge computer, such as Raspberry Pi 3.
The model working on DoE is a very small convolutional neural network and classify the given image of lane marking into two classes; damaged or non-damaged.
While DoE succeeded classification with very high accuracy, DoE is not useful enough to be deployed to garbage trucks because of their requirement that the camera has to be set so as to take pictures towards grounds.

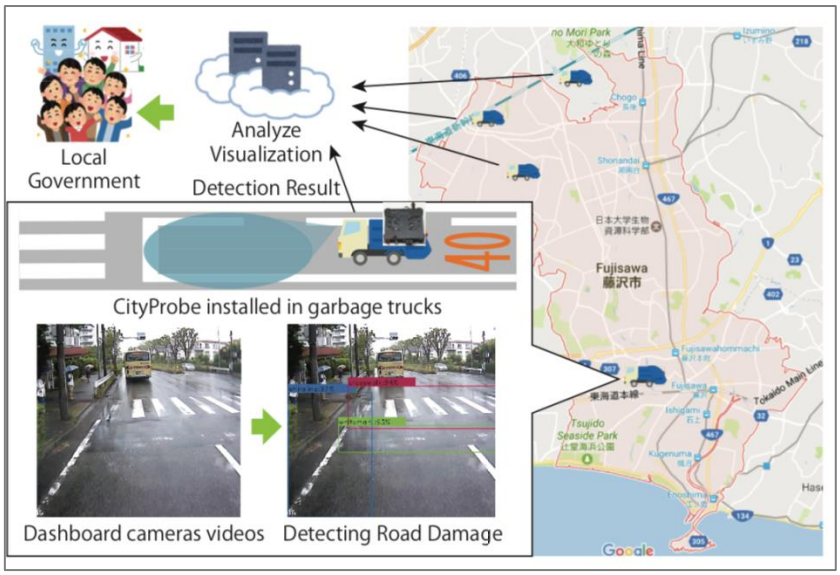

FIGURE 10. CITYINSPECTOR - SYSTEM OVERVIEW

Each garbage truck running in the city detects road markings blur. The cloud computer aggregates and analyzes the detect results. Finally, the system feedbacks them to citizens and administrators.

In order to give priority to deploy to garbage trucks, we choose to use drive recorder cameras that are already set to almost all of garbage trucks. The example of an image taken from the drive recorder is shown in Figure 10. In Figure 10, we can see not only the lane markings but also other markings, for instance, crosswalk marking. Therefore, we adopt the real-time object detection approach to treat these marks altogether. While there is enormous approach to detect objects, we use vanilla you only look once (YOLO) model for the first trial which are based on neural networks. To train the model, we collect the image data from drive recorder of sanitation engineer. Then we annotate the images: surrounding the area of road marking blur with a bounding box. In our experiments with this dataset, we verify whether YOLO models detect the road markings blur. As a result, while YOLO models are not good at mean average precision (mAP) score, the result of blur detection seems to be good with visualization. Therefore, our results may help the administration to know which road to repair in the city.

Requirements

In this section, we indicate requirements of CityInspector in order to facilitate the road damage inspection by piggybacking the garbage trucks.

R1) Road Damage Detection: CityInspector needs to inspect the road to find the damage from the camera installed in garbage trucks. In order to satisfy this requirement, image processing technology is suitable. One of the image processing technology, a deep neural network is very useful because of its high performance. While deep neural networks can discriminate the images into 1000 classes, which contain various object images, there is no study that discriminates the status of objects (i.e. our target task, road damage) to our knowledge. Therefore, firstly, we need to investigate whether the deep neural networks can discriminate the status of objects. After the investigation, then, CityInspector adopt the deep neural networks to inspect the road damage.

R2)Detection Environment and Data Management: The second requirement is the edge computer environment to detect road damage. In general, a lot of application that analyzes the

images or videos send them to cloud servers because the computational cost of image processing is very high. However, since the dozens of garbage trucks travel through a city, the amount of video data becomes enormous and the communication cost of sending the data to cloud servers is huge. Thus, it is not reasonable to send all video data. Contrary to this, there is a way that preserves the video data in local storage such as SD cards or USB memory. If the video data is preserved in the local storage, it is very troublesome to collect the data. This is because the additional workflow to deliver the storage to somewhere and salvage the data from it, or new network environment, such as Wi-Fi routers, is required. Additionally, there is another problem related to the data. The information that is very related to the individuals, such as faces and registration numbers, is often in the videos from dashboard cameras. Hence, it is difficult for local government or city administrative to preserve these videos due to the privacy protection ordinance. To address these issues, CityInspector is required to conduct the road damage inspection on a local environment, a so-called edge computer, and not to preserve the video data. Simultaneously, the data to be sent is only the result of the detected damaged road. When the CityInspector conduct the road inspection, it is also required that there is no omission of the road inspection. Therefore, the CityInspector needs to conduct the road inspection within a short time. If we assume that garbage trucks usually runs by 30 km/h (= 8.3 m/s) and the range of the road being in a video frame is 5 m -10 m, the CityInspector needs to process with in 1 second.

R3) Power Management: Given the previous requirement, edge environment, CityInspector needs to be supplied an electric power from the garbage truck. In order not to add a new workflow, the power management should be done by CityInspector self. Therefore, CityInspector needs to start the road inspection with the engine of garbage trucks simultaneously, since the electric power is not supplied before the engine starts. In addition, it is revealed that city officers sometimes take a rest in a daily work and stop the engine for few minutes. It is very inefficient that turning off the CityInspector at the every time of the engine being stopped. To remedy this, CityInspector needs to be turned off in few minutes after the engine stopped.

Implementation

Hardware: For the environment to recognize and/or detect the road marking damage, we adopt the NVIDIA Jetson TX2, which is operated on Linux based OS (i.e Ubuntu).
Otherwise, there is a RaspberryPi that is also operated on Linux based OS as well.
However, utilizing the RaspberryPi, the road damage recognition and/or detection is taken on CPU. On the other hand, the Jetson TX2 can conduct the road damage recognition and/or detection on their GPU, which is installed into the JetsonTX2. Of course, while the price of the Jetson TX2 is much higher than that of the RaspberryPi, we prioritize the performance of road damage inspection and we use JetsonTX2. The system configuration of the hardware part of our CityInspector is depicted in Figure 11.The 24V voltage is applied on the cigarette lighter port in a garbage truck when the engine of it is started. We use Arduino to monitor whether the voltage is being applied or not.While the voltage is being applied on the cigarette lighter port, an electric current flows into the JetsonTX2 and a built-in battery to charge it. We call this status as active. When the engine of the garbage truck is stopped, Arduino detect it and start the countdown timer and the electric current flows from the built-in battery instead. This countdown timer is used for a temporal engine stop that the city officers take a rest. This status is called countdown. If the engine is restarted during the countdown, the status change from countdown to active. If not, the status change from countdown to inactive, which is that the JetsonTX2 get a shutdown signal from Arduino. CityInspector provide us an LCD monitor to confirm the status as shown in **Erreur ! Source du renvoi introuvable.**. The completed prototype of CityInspector is depicted in Figure 13.

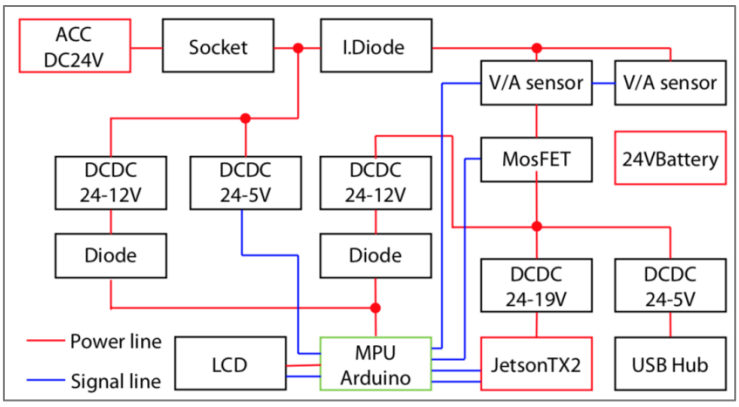

FIGURE 11. SYSTEM CONFIGURATION OF THE HARDWARE PART OF CITYINSPECTOR

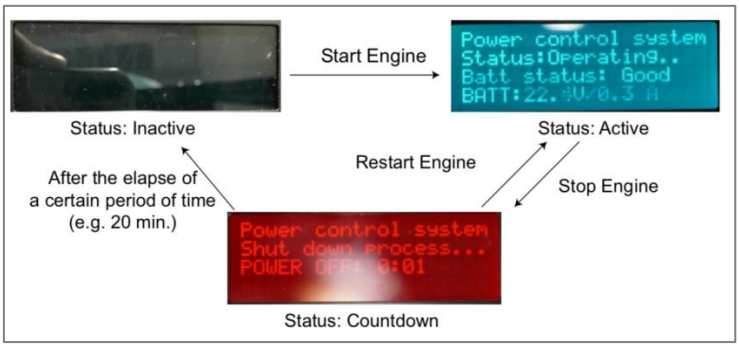

FIGURE 12. STATE TRANSITION DIAGRAM WITH THE ACTUAL MONITOR OF CITYINSPECTOR

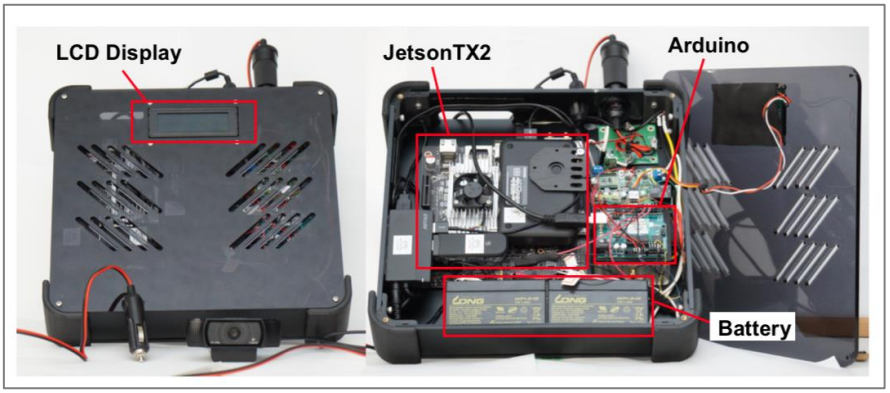

FIGURE 13. PROTOTYPE OF CITYINSPECTOR

Regarding the software side, there are several modules constructing CityInspector as shown in Figure 14. First, the main module, that is road damage detection, gets the images from an equipped USB camera and processes them to detect the road damage. At the same time, the geolocation acquiring module outputs the geolocation: longitude and latitude.
Then the detection result sending module aggregates the results and send them. In addition to this basic software, we designed all functionality of CityInspector by using BigClouT's other components, such as GANonymizer, SensiNact gateway, BigClouT data lake and KNOWAGE that are orchestrated by Distributed Node-RED (see Figure 15).

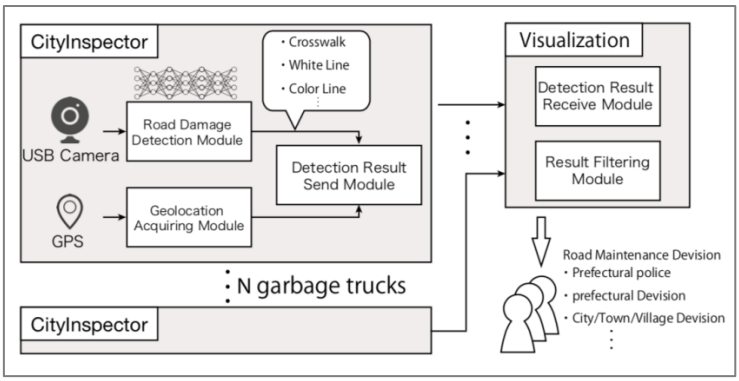

FIGURE 14. CORE ROAD DAMAGE DETECTION SOFTWARE IN CITYINSPECTOR

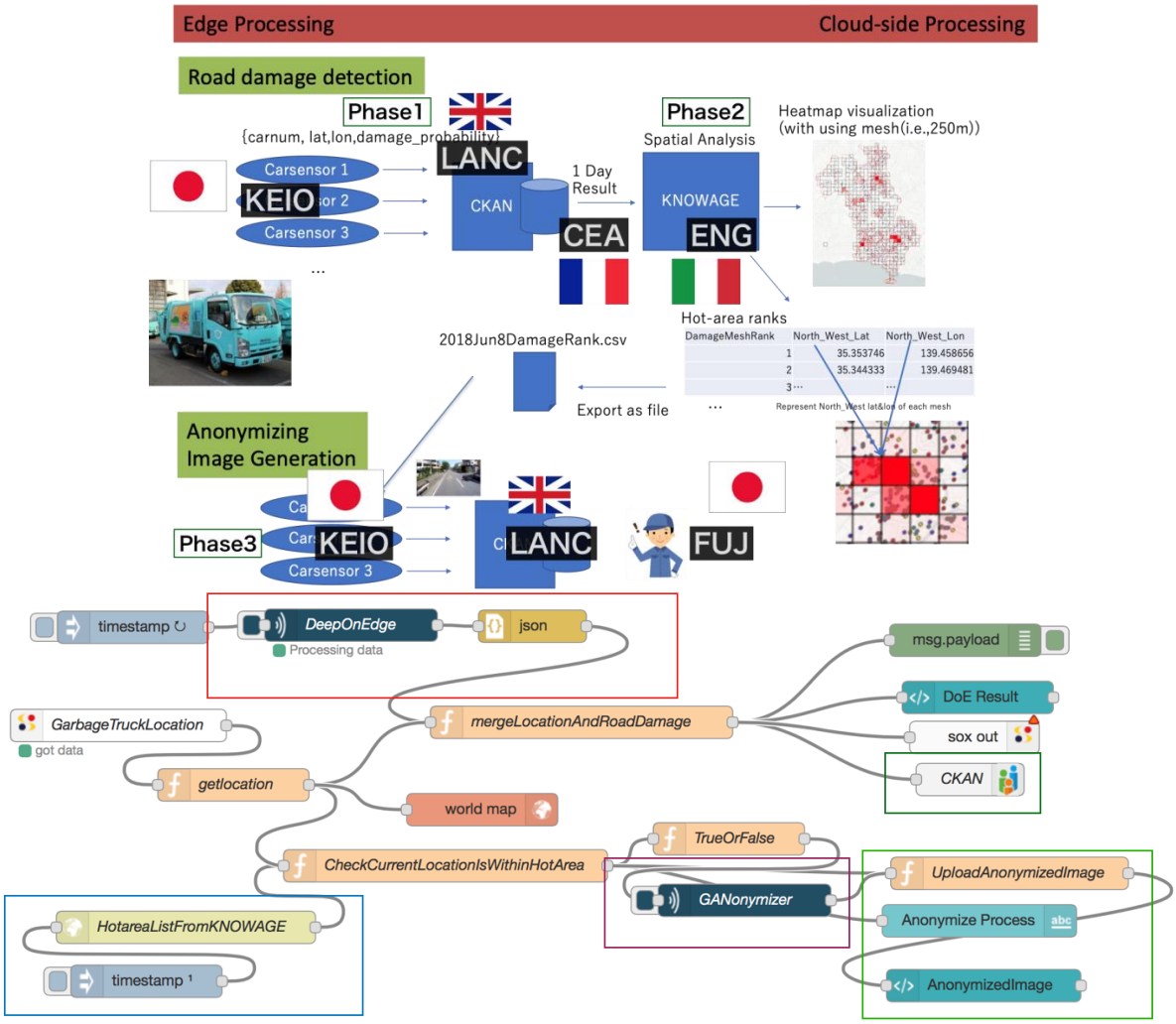

FIGURE 15. OVERALL FLOW FOR CITYINSPECTOR USING BIGCLOUT COMPONENTS (ABOVE) ORCHESTRATED BY DISTRIBUTED NODE-RED(BOTTOM).

2.1.2.6 Personal data protection

To share the data collected in Fujisawa securely with protecting privacy, we defined rigid access role in each data and sent to BigClouT Data Lake. In terms of video image taken from dashcam, we proposed GANonymizer which anonymizes privacy-related objects.

In Japan, protection of personal data is mandated under Act on the Protection of Personal Information. This requires any entity, which collects any form and amount of data that enable personal identification, to pay a special commitment. In that, the data collected through this trial are not capable of identifying a person, due to the following reasons.

- The trial does not collect any information that contains a unique ID, such as a MAC address and a phone number.
- The images collected by Minarepo contain human faces, but they are not associated with any other personal data.
- The images collected by Minarepo also and City Inspector are processed by GANonymizer. It automatically removes personal objects, such as cars, bikes, persons, etc., from the images.

In addition to these, all the data collected through the trial have been stored in a database maintained by KEIO which is configured not to be reached from the Internet directly. This avoids accidental information leakage.

2.1.2.7 KPIs and Evaluation

We defined following KPIs in deliverable 1.4.

TABLE 3. FUJISAWA KPIS - CITY INFRASTRUCTURE MANAGEMENT

KPI or Metric	Target
Garbage trucks used	Min 50
Critical mass of data	5GB per day
Frequency of use	Every working day
Cost reduced for city infrastructure management	1,000,000 yen per year

Through our field trials, we concluded to achieve these original KPIs.
- **Garbage trucks used**
We deployed our system more than 75 trucks
- **Critical mass of data**
When 75 trucks are used in same time, total data volume is more than 5GB per day.
- **Frequency of use**
MinaRepo system is used in every working day.
- **Cost reduced for city infrastructure management**
We interviewed garbage management section in Fujisawa city. According to the interview, they succeeded to reduce two hours from daily working time. Thus, we can calculate total reduced cost could be regarded as more than 1,000,000 yen.

Moreover, we confirmed that our trial provided new value for city infrastructure management. For example, through MinaRepo trial, we found several new insight about city such as relationship between city demographic and garbages. These values are very useful for city management.

2.1.2.8 Summary – lessons learned, sustainability

We developed several technologies for city infrastructure management in the viewpoint of human and IoT perspective. One of the systems is composed by several BigClouT components orchestrated by Distributed Node-RED. Through the field trials, we confirmed that we achived

our defined KPIs and moreover we recognized that additional values can be provided by the system.

2.2 Bristol

2.2.1 Trial 1: Smart Mobility - Walkability and Air Quality

Bristol has been targeting two fundamental areas for its trials: air quality with the Smart Mobility trial, and energy consumption with the Smart Energy trial.

Terms used within the document relating to healthier options, healthiest routes are made as generalist layman terms and should not be quoted as offering any form of medical advice. The sensor data gathered, data computed and the algorithms in these experiments have not been reviewed or advised by anyone from the medical profession.

2.2.1.1 City needs and goals

Air pollution is one of the most serious problems in all cities - including Bristol. Exposure to poor air quality can cause long-term and short-term health effects, such as respiratory and cardiovascular disease. The World Health Organization has counted that approximately 4.2 million people die prematurely every year because of exposure to polluted urban environments.

One of the major causes of urban pollution is fuel combustion from motor vehicles (e.g. cars and heavy-duty vehicles). This process produces nitrogen dioxide (NO2), which can cause inflammation of the airways. Concentrations of NO2, measured over a year, must not be more than 40 µg/m3 (microgrammes per metre cubed). Yet, a large part of Bristol is affected by an excess of NO2 compared to the UK and EU standards, in particular in the central area of Bristol where approximately 100,000 people live and through which many more walk and cycle.

FIGURE 16. SMART MOBILITY - BRISTOL SITES EXCEEDING 40 MGM-3 (LEGAL LIMIT) IN 2018.

Although public pressure is growing to address the underlying causes of pollution, for example by introducing 'clean air zones', many citizens are still not aware of the poor air quality levels in Bristol to which they are exposed every day.

Therefore it seems essential to increase the awareness of Bristol's population towards air quality and to suggest routes that may reduce their exposure to polluted areas. These represent the main driving points for Bristol's first trial.

2.2.1.2 Stakeholders engaged in trials

For this trial, our end users are a diverse group of citizens who regularly walk in Bristol. The use case will also target all the age ranges. However, Bristol has a relatively young age profile, so we expect that there will be a large uptake of people in the range 18 - 40 years old.

Stakeholders have been identified within the City Council. Bristol City Council has a statutory duty to develop an Air Quality Action Plan to reduce the impact on human health and to achieve compliance with government legislation. Therefore, BiO has been engaging with the City Council to understand more about the strategic decision making on air quality improvements, and future implementations to facilitate behaviour change in the city. With this trial, by reducing citizens' exposure to pollution, BiO will contribute to the City Council's plans to reduce the impact of pollution on Bristol population's health. On the other hand, Bristol City Council will make a great contribution to the trial by providing real-time air quality data through its Open Data platform.

2.2.1.3 Trial objectives

The initial concept of the use case was to increase citizen awareness about pollution by utilising LED screens deployed in the city centre. However, Bristol has had to make some adjustments to this use case based on the viability and cost of installing the LED screens.

As a result of these changes, Bristol has developed a mobile-friendly website that offers users a tool to help them avoid polluted areas. This is done by suggesting a range of walking routes of different lengths and pollution levels. Armed with this information, users can decide whether to take a lower pollution option, even if it is longer (though this will not always be the case). Choosing a less polluted route rather than their usual route, users will decrease their exposure to pollution with a potential for considerable impact on their health.

Using the web-app, users can also monitor the air quality levels for different sites in Bristol and get real-time analytics. This, we expect, will raise awareness of pollution and incentivise users to take further actions to tackle the poor air quality problem in Bristol.

From a technical point of view, we created a web-app that could be used with different operating systems and browsers. Although focusing on mobile devices implied a reduction of the demographic variety of the users involved (for instance, people without phones will not be able to utilise the service), our goal was to create a tool that could be easily used by people walking. Webpage usage data (site pages visited, routes requested, etc) are collected in order to make improvements and offer users a better tool in the future. Moreover, in order to not discourage people from using the app, we have taken great care to not collect any personal and sensitive info about the users.

2.2.1.4 Engagement process with citizens and government

Citizen engagement has been carried on through social media (Facebook, Twitter and LinkedIn), during the last week of May. Users were directed to the Bristol is Open website where they could register their interest for the trial and try out the web-app for a month. At the end of the trial, 100 randomly chosen participants will be rewarded with a £20 Amazon e-voucher. Only the name and their email address have been collected for the purposes of issuing Amazon vouchers - these data will be deleted once the vouchers will be issued.

All the registered participants, before trying the web-app, have received a questionnaire, aimed at collecting data about their walking habits (how often do they walk in a week, what affects the choice of a route, etc). For statistical purposes, only questions about gender and age have been collected. As stated above, we have opted not to ask sensitive questions (for example, about ethnicity) or collect personal information, to not discourage people from signing-up for the trial.

The implementation of the BigClouT components in the web-app has gone through some technical issues. This has caused a delay to the release of the web-app. However, during the time between the participants' registration and the release, we have made sure to keep the user engagement active. This was done by sending information emails about the status of the trial, and by allowing a dozen registered users to try out the web-app and provide feedback on the user experience side before the official start.

Note that the trial has started on May 31st but the web-app has officially released on July, 12th, therefore the trial is currently ongoing at the time of this writing.

At the end of the trial, we will send out a post-trial questionnaire, with the intention of gathering feedback on the web-app, and understanding how the trial has affected the users' awareness and changed their habits.

An engagement process has also been carried out with the City Council. Through several meetings, we have engaged with the City Council to better understand their air quality action plans.

2.2.1.5 Technical approach – BigClouT components

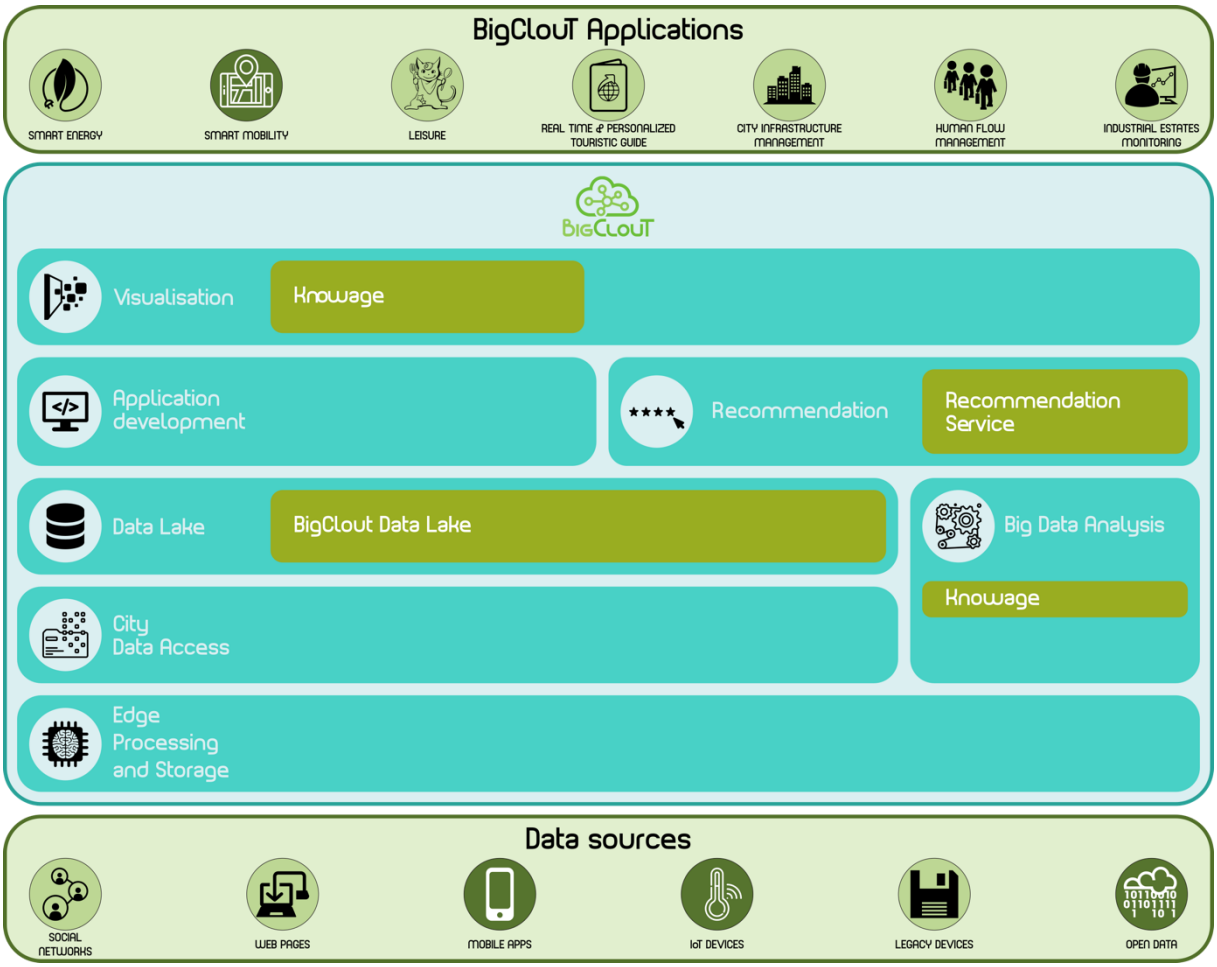

FIGURE 17. SMART MOBILITY - BIGCLOUT COMPONENENTS USED IN THE TRIAL

The web-app can be found at the following address:
https://bigclout.cloud.bristolisopen.com/#/mobility

FIGURE 18. SMART MOBILITY - WEBSITE SCREENSHOTS

From the home page, users can access the 'Route Finder' where they can get recommendations on less polluted walking routes, the 'Analysis' page showing real-time air quality from different sites in Bristol, and the 'FAQs' page where users can learn more about the BigClouT project, the trial and Bristol is Open.

The picture below shows how the BigClouT technical components have been implemented together for this use case.

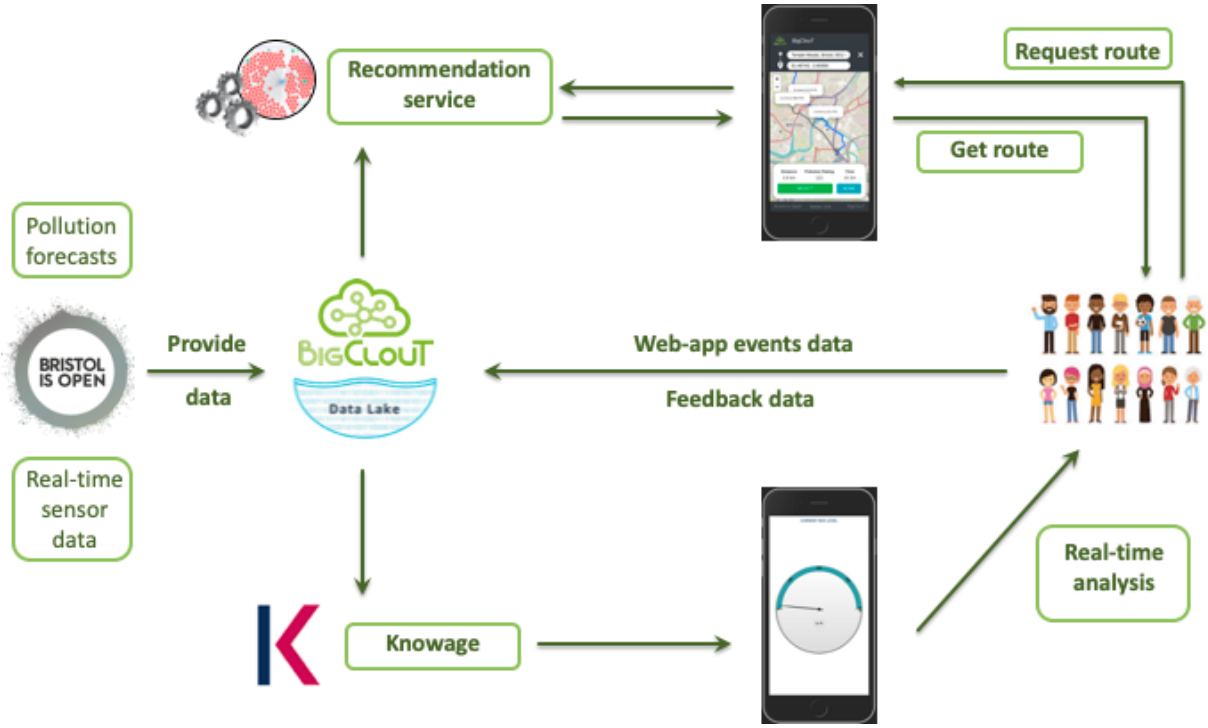

FIGURE 19. SMART MOBILITY - BIGCLOUT COMPONENTS

For the Smart Mobility trial, Bristol has made use of real-time air quality data coming from 7 sensors around Bristol. The data represent hourly levels of NO2 measured by sensors deployed

by DEFRA (UK Government agency)(2 sensors) and Bristol City Council (5 sensors). Before sending the data to the BigClouT data lake, Bristol is Open performs some cleaning and data wrangling on the collected data. The real-time data are sent every hour for a total of 168 data-points per day.

It is clear that 7 sensors do not measure the air quality levels for the entire Bristol area, therefore Bristol is Open has developed a Machine Learning predictive model that using the real-time data from the sensors, weather forecasts and urban metrics data (distance from major roads, distance from industrial areas, elevation, etc), which is capable of producing hourly NO2 forecasts for the whole city of Bristol. For the model, we divide Bristol into a grid of 33,277 squares and we make hourly predictions for each of these squared areas, as shown below:

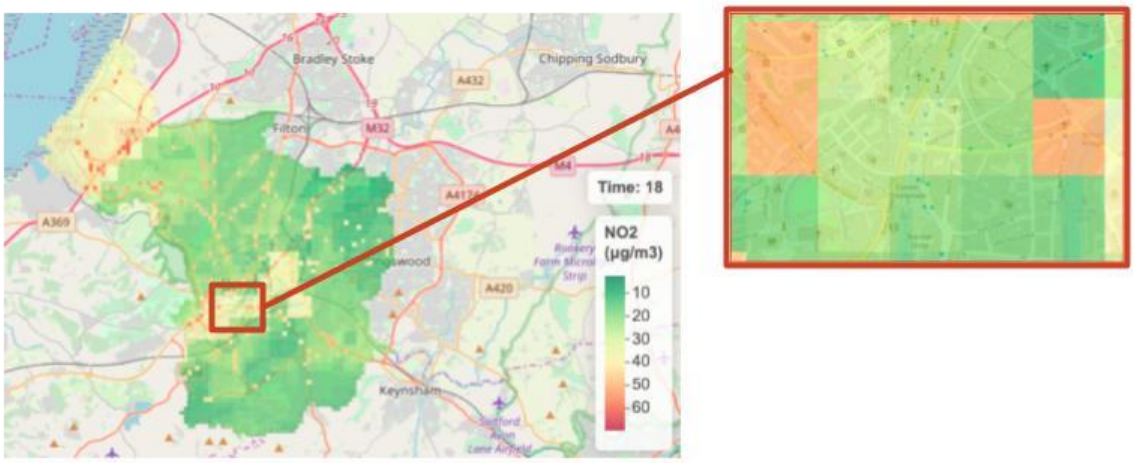

FIGURE 20. SMART MOBILITY - GRID COVERING BRISTOL AND RELATIVE HOURLY POLLUTION FORECAST

Every day, the model produces hourly forecasts for each of the 33,277 squares, a total of 798,648 records per day sent to the BigClout data lake.

The real-time and forecasted pollution data are used by Knowage and the Recommendation service, respectively.

One of the main driving points of our trial was to raise awareness among the citizens about the low air quality in Bristol. To achieve this, we have used Knowage to create some charts that could visualize in real-time the pollution situation in the city. From the home page, the user can access the 'Analysis' page where four Knowage charts are available.

FIGURE 21. SMART MOBILITY SCREENSHOTS - KNOWAGE CHARTS

The Knowage charts created are:

1. Two gauges, one to view the current NO2 level measured by each of the 7 sensors across Bristol, and one gauge for the current pollution index for each of the sensors.
2. A map, to see the location of the sensors and their last NO2 value measured.
3. A bar chart to show real-time hourly analytics for each of the 7 sites where the sensors are deployed.

Users can interact with each chart and filter the data to get more precise info for each of the sensors.

The other driving point for this trial was about helping citizens to decrease their exposure to pollutants by offering them a tool to avoid polluted areas. For this, we have worked closely with the ICCS team to use the Recommendation Service to suggest citizens healthier routes.

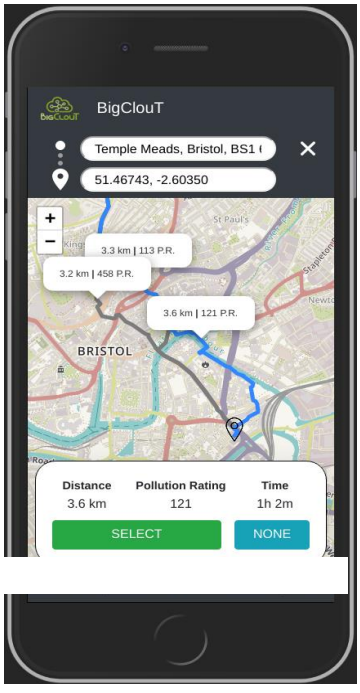

FIGURE 22. SMART MOBILITY SCREENSHOT - ROUTE FINDER MAP

From the Home Page, users can get access to the 'Route Finder' map. Here users can select their start and destination locations. Via a REST API service, the selection is sent to the Recommendation Service that fetches the routes and associates with them a pollution rating (P.R.), a value used to compare the pollution that users would be exposed to on the different routes. The rating is computed by taking into account the varying levels of pollution along the route using the hourly pollution forecasts (see Figure 20) and the time users are expected to be exposed to that pollution. A higher relative rating means greater exposure to air pollution. From the routes returned by the API, we select and show to the users 3 routes: the least polluted one (the route with the lowest P.R.), the shortest one, and one route for which 'distance' and 'P.R.' have middle values between the healthiest and the shortest routes. In the case in which the healthiest route is also the shortest, we show the two routes with the next lowest P.R. Armed with this information, users can decide whether to take a lower pollution option, even if it is longer (though this will not always be the case). To select a route, users will just need to click on the chosen route and the 'Select' button, this will leave on the screen only the selected route so that they can easily walk along it.

However, users might find that none of the 3 displayed options suits them. If this is the case, they can select 'None' on the screen. They will be prompted with a message asking them for feedback.

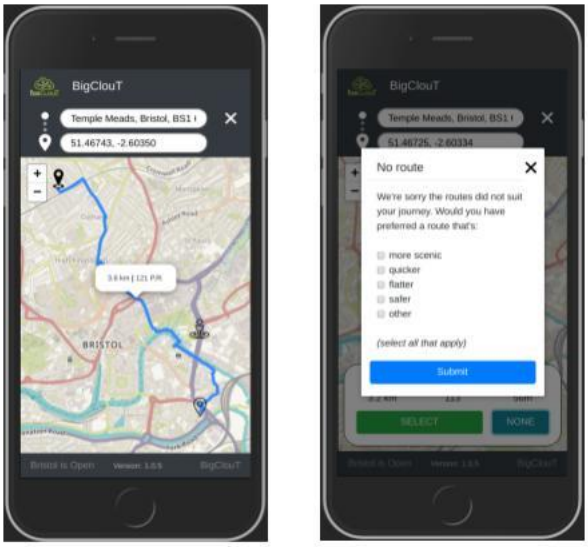

FIGURE 23. SMART MOBILITY SCREENSHOT - ROUTE FINDER SELECTION/FEEDBACK

All the data generated by the usage of the app, such as pages visited, route selected, feedback from not have chosen a route, etc, are sent to the BigClouT data lake. At the end of the trial, we will consider whether to make improvements to the app and better understand how the app has contributed to change the participants' behaviour.

2.2.1.6 Personal data protection

The following are the data used by the trial:

- Real-time Air Quality sensors data from DEFRA UK and Bristol City Council. These data are free to use under an OGL v3 license. After some data wrangling, the data is uploaded every hour to the BigClouT data lake. Roughly 7 data entries per hour (subject to sensors working properly) for a total of ~168 data-points in a day.
- Weather forecast data for the 7 Bristol Air Quality sensors. These data come from darksky.net and they are daily uploaded into the BigClouT data lake. For each of the sensors, we collect 24h weather forecast, for a total of 168 data-points in a day.
- Pollution forecasts data generated by applying Machine Learning algorithm to the above-cited data and urban metrics (distance from roads, elevation, etc). The model generates hourly forecasts for 33,277 locations in Bristol, for a total of 798,648 records per day sent to the BigClout data lake (54.9 MB).

As a result of the use of the website, we generate the following data:

- Website usage events, including pages visited and potential errors generated by the website. These data do not contain users' personal information.
- Route requested (start end destination points), routes recommended, and route chosen (with related feedback if no route has been selected). These data do not contain users' personal information, since to use the web-app no login is required, and we do not track users' position.

The above data are all sent to the BigClouT data lake in real time.

2.2.1.7 KPIs and Evaluation

Note: The Smart Mobility web-app has been released on July, 12th and, at the time of this writing, the trial is still ongoing.

The followings are the KPIs that had been set for the Smart Mobility trial in 2018.

TABLE 4. BRISTOL OLD KPI - SMART MOBILITY

KPI or Metric	Target
Target user number	150
Critical mass of users	300 in first year
Daily active users	150
Demographics	Representative of general Bristol city
User engagement	Min 25% users respond to questionnaire

As explained in the sections above, the Smart Mobility trial has gone through some changes since its inception. Moreover, some technical issues during the implementation of the BigClouT components have caused a delay in the start of the trial. This means that not all the KPIs have been met, as explained below:

- **Target user number**: initially the trial was supposed to make use of LED screens in one of the main squares in Bristol, engaging in this way with a larger number of people. Focusing on mobile devices meant that fewer users could get involved. At the start of the trial, we have 80 people registered through the online form to try the web-app.
- **Critical mass of users**: As noted above, we are unable to engage with such a large audience. Moreover, we will run the trial for only one month. In the current situation, 50 daily active users would represent for us a critical mass of users.
- **Daily active users**: As for the two KPIs above, the changes to the trial use case meant that the target for this metric cannot be reached
- **Demographics:** The trial was open to everybody. However, the choice of not asking sensitive questions, such as about ethnicity or religion, that could have led the users to drop out of the trial meant that we are unable to say whether the target has been reached or not. Nonetheless, from the pre-trial questionnaire's answers to gender and age, we can say that it is well-balanced and inclusive, the majority of respondents are in the range 30-59.
- **User engagement**: ~60% of participants have responded to the pre-trial questionnaire.

Because the above KPIs were designed for the original trial which has now changed significantly, we have decided to set metrics that could reflect the new focus of the Smart Mobility trial.

TABLE 5. BRISTOL NEW KPI - SMART MOBILITY

KPI or Metric	Target
Behaviour change	40% post-trial respondents changed their habits
Frequency of use the app	2 – 3 times per week
Time spent using the app	5min + time to follow the route
Data collection	2000 web-app events info generated by the end of the trial and sent to the data lake

Through the post-trial questionnaire, we aim to evaluate the first three metrics, while the 'Data collection' KPIs will be assessed by analysing the web-app data collected and sent to the BigClouT data lake.

The new KPIs will be evaluated at the end of the trial and their evaluation will be shown during the 3rd review meeting in September.

2.2.1.8 Summary – lessons learned, sustainability

Pollution is a significant problem in all cities, including Bristol. The purpose of the 'Smart Mobility' use case is to offer the user a tool to avoid polluted areas. This is done by suggesting a range of walking routes of different lengths and pollution levels, through a mobile-friendly app. Armed with this information, users can decide whether to take a lower pollution option, even if it is longer (though this will not always be the case). The user can also monitor through the app the air quality levels for different sites in Bristol and get real-time analytics.

The type and the amount of air quality data available have played a major role in defining and shaping the use case during the last period of the project. The delays caused by technical issues has taught us how important it is to have a user engagement plan in place to not lose the participant interest. As the trial is still ongoing, we are still awaiting the result of the users' feedback to see what other lessons can be learnt.

For the future, we are working with stakeholders and other organizations in Bristol to see how to extend the tool further.

2.2.2 Trial 2: Smart Energy - Smart homes energy consumption

2.2.2.1 City needs and goals

Energy consumption affects us every day. It does not only have an impact on our personal finances - it has been calculated that ~13% of UK households expenditure is on energy - but also on the planet. In fact, electricity is very often generated by the combustion of hydrocarbons (oil, coal, gas) or other substance, which release substantial amounts of carbon dioxide, a major cause of global warming, and other pollutants such as sulphur dioxide, which produces acid rain.

A major phenomenon that contributes to the energy consumption is the so-called "phantom load", the electricity consumed by electrical appliances while they are switched off (but still plugged into an outlet) or in standby mode. It has been calculated that 10% of home energy consumption bill comes from "phantom load". Unfortunately, not many households are conscious that this phenomenon affects their bills.

Energy peak demands are another phenomenon that households are not aware of. Peak demand is the highest amount of power consumed at a specific moment. Sometimes, electricity peak demands may exceed the maximum power levels that electrical power industry can supply. This would cause power outages and electrical power shutdowns. For example, this is a common situation during heat waves when use of air conditioners raises the electrical demand. Spreading, when possible, the energy demand during the day, it would help to avoid creating peak demands.

Therefore, it seems necessary to make households aware of the "phantom load" and help them spread their energy consumption during the day. This not only would contribute to improving their quality of life as they make monetary savings but at the same time it would help them to take care of the planet. These are the reasons behind the Bristol Smart Energy use case.

2.2.2.2 Stakeholders engaged in trials

For the Smart energy trial, the end users have been identified into the Bristol residents that have signed up for the *REPLICATE* project. For this project, 150 residential buildings in Easton and Lawrence Hill Neighbourhood, two of the most deprived areas of Bristol, have been equipped with WiFi-enabled home automation units. On the demographic information provided by the city council, we can estimate that the end users age range is as below:

- Age from 0 to 15: 25%
- Age from 16 to 64: 67%
- Age from 65 or older: 8%

In terms of gender distribution there appears to be no bias. This sample of Bristol's population is typical of the demographic of Bristol City Council's local authority area. Bristol has a relatively young age profile, with more children under the age of 15 than citizens of pensionable age. The areas selected in the use case have a large population of working age adults which is typical of the wards surrounding the city centre.

The followings are the stakeholders for the Smart Energy trial:

- Bristol City Council, in particular through their "Warm Up Bristol", a project dedicated to tackling cold homes and reducing fuel poverty.
- Knowle West Media Centre (KWMC), a charity centre that uses technology and art to make positive changes in the lives of people from disadvantaged backgrounds.

These stakeholders have worked to make up the Bristol pilot for REPLICATE and, with their inside knowledge of Bristol deprived areas, they have provided feedback to the development of the BigClouT Smart Energy use case. On the other hand, the smart energy use case will provide them insights on home energy consumption.

2.2.2.3 Trial objectives

For this use case, Bristol has developed a mobile-friendly website. Using the web-app, householders can monitor their home electricity consumption in real-time and get analytics on their daily/weekly energy consumptions. This, we expect, will raise awareness about the "phantom load" phenomenon and incentivise users to unplug unused appliances to avoid energy wastage and cut down on their electricity bills. Within the app, users will also get offered suggestions on when to use their appliances during the day to avoid creating energy peak demands. Also, the website can also be used by our stakeholders to monitor the homes energy usage.

From a technical point of view, to reach such objectives, one of the main goals was to make sure that the data from the home sensors would have been available to use. For this reason, Bristol has developed a platform to store and distribute the data collected from the home units.

2.2.2.4 Engagement process with citizens and government

As explained above, we have reused the data coming from the REPLICATE project. The participants that have signed up to such a scheme have been recruited by Bristol City Council (through "Warm Up Bristol") and the KWMC. The council and the KWMC charity have surveyed the properties and calculated the cost of installation for the sensors. Once the sensors have been deployed in the selected homes, no more interactions have been needed except for sensor maintenance, because the REPLICATE Bristol pilot has been designed to be a non-intrusive pilot.

We believe that it would be constructive to the BigClouT project if we were to engage with the citizens throughout the process, however, due to the restrictions in engagement on the REPLICATE project, we are unable to directly interact with the households. Nonetheless, we have engaged with the Bristol City Council to act as a proxy for the citizen engagement, to ensure that we do receive as well as share constructive feedback on the trial. Therefore, the City Council will provide the link to the mobile-friendly website to the households and provide us with feedback on the website. Moreover, website usage data (site pages visited, recommendation requested, etc) are collected in order to make improvements and offer users a better tool in the future.

An engagement process has also been carried out with the stakeholders leading the project during the initial phase of sensor deployment.

2.2.2.5 Technical approach – BigClouT components

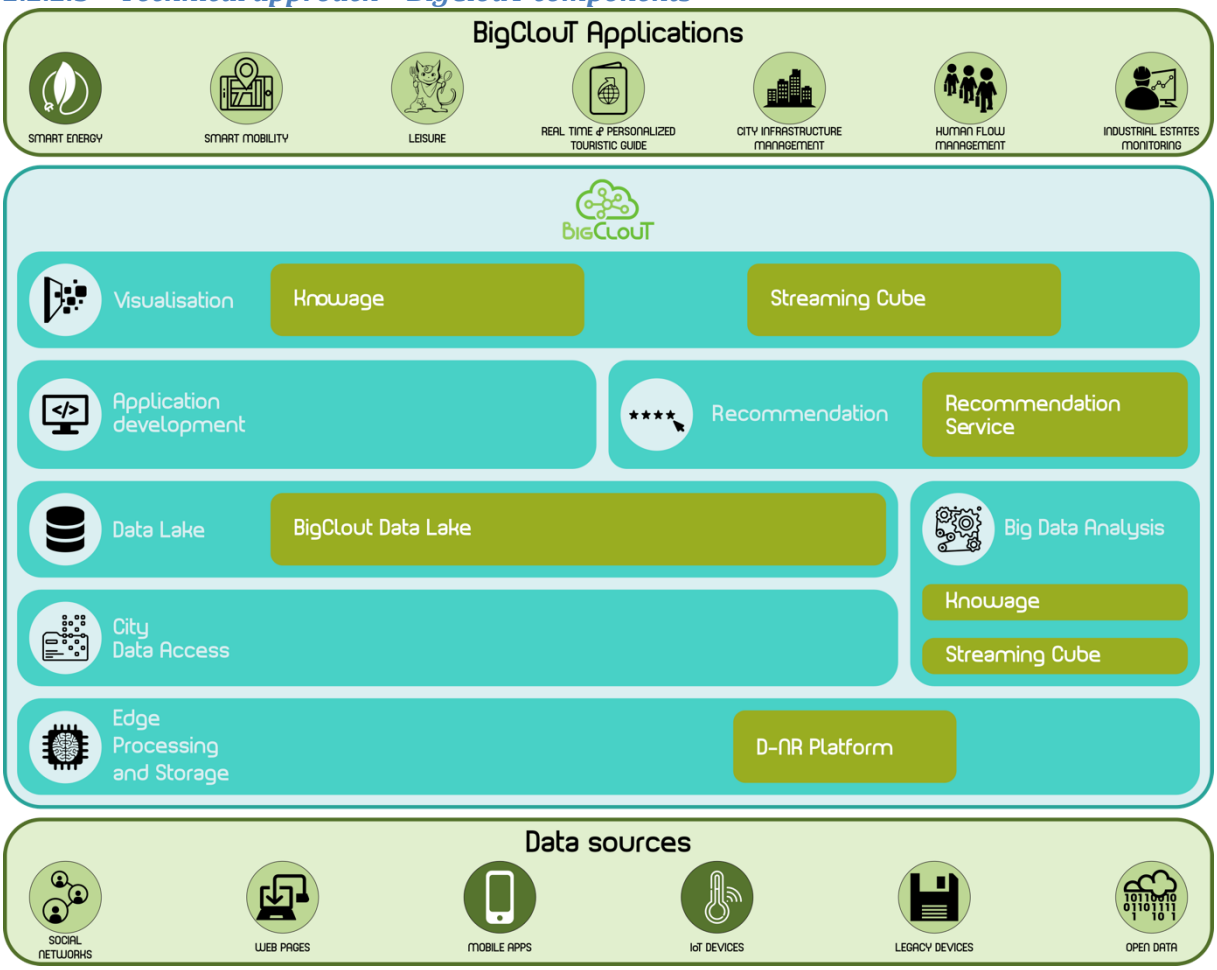

FIGURE 24. SMART ENERGY - BIGCLOUT COMPONENTS USED IN THE TRIAL

The web-app can be found at the following address:

https://bigclout.cloud.bristolisopen.com/#/energy

FIGURE 25. SMART ENERGY - WEBSITE SCREENSHOTS

From the home page, it is possible to access the 'Suggestions' page where households can get daily personalised recommendations on managing energy usage. From the homepage, users can also access the analysis page to monitor the current energy usage and see daily/weekly energy consumption analysis.

The picture below shows the data flow for this use case:

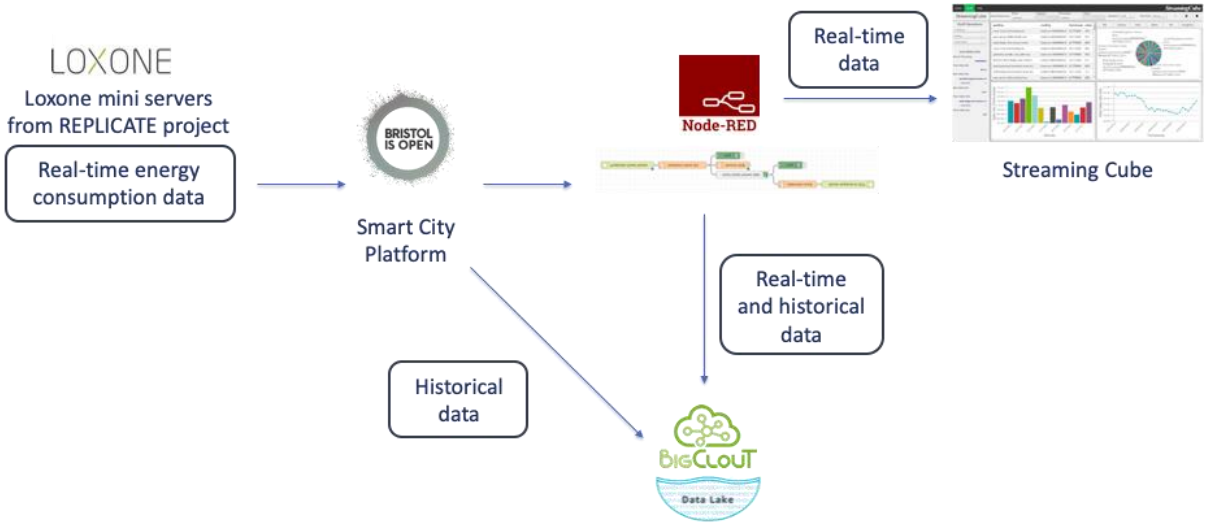

FIGURE 26. SMART ENERGY - DATA FLOW

As said above, we have reused the data from the REPLICATE project. The sensors collect data about power consumption of some white goods (dishwashers, washing-machine, tumble-dryer, etc) and the whole home energy consumption. Such data get sent to the Smart City platform that Bristol is Open has developed. Some old historical data have been added manually to the BigClouT data lake. On the other hand, for the real-time energy consumption data, we make use of a Node-Red flow to send it into the data lake. Through Node-Red and a Web API, the data get sent to Streaming Cube. Through the Streaming Cube dashboard it is possible to visualize in real-time the energy consumption for all the homes in the project. This dashboard is meant to be used by the City Council to monitor the energy demand from the homes in the project.

The figure below describes how we have arranged the BigClouT components for the web-app portion of this trial:

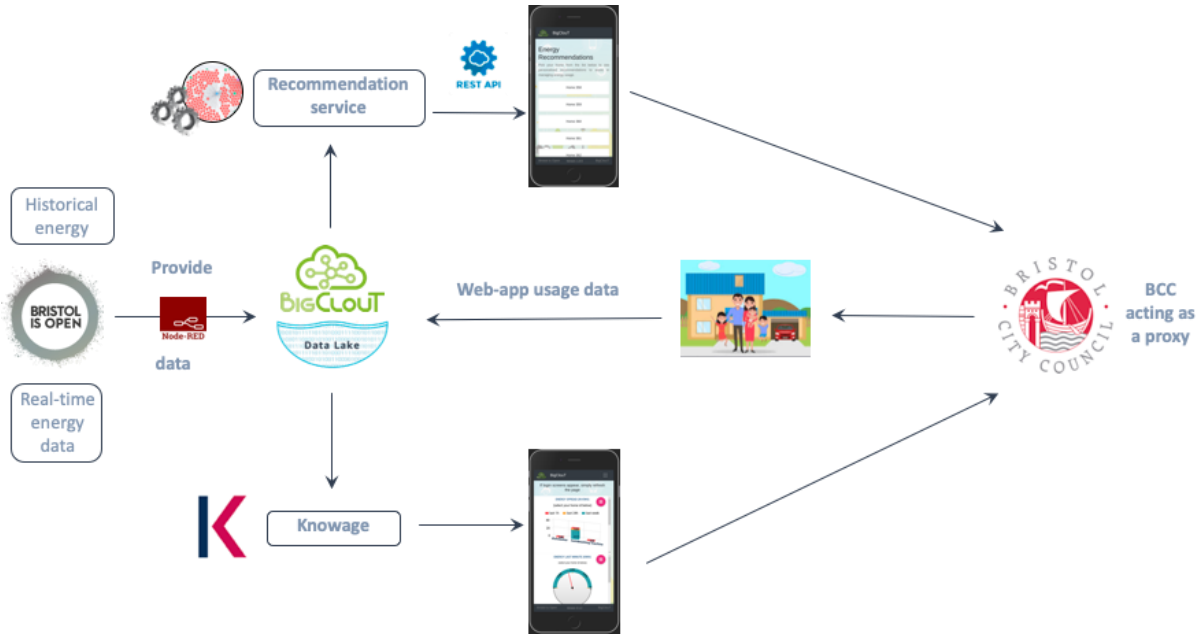

FIGURE 27. SMART ENERGY - BIGCLOUT COMPONENTS

All the data get sent to the BigClout data lake via Node-Red. The data are then used by Knowage and the Recommendation service.

One of the main reasons behind the Smart Energy use case is to help households to manage their energy consumption by using appliances at different times to when they would normally use them. This should help them avoid creating peak energy demands.

Using Machine Learning techniques on the households data, the Recommendation service is able to create personalized suggestions for each household. From the home page, users can access the 'Suggestions' page where they can click on their home id and get daily personalized recommendations. The suggestions are meant to suggest to the users better times to use their appliances, hence to help them to spread the energy usage during the day. We hope that by following these suggestions, users will generate fewer energy peaks and therefore save on their electricity bills.

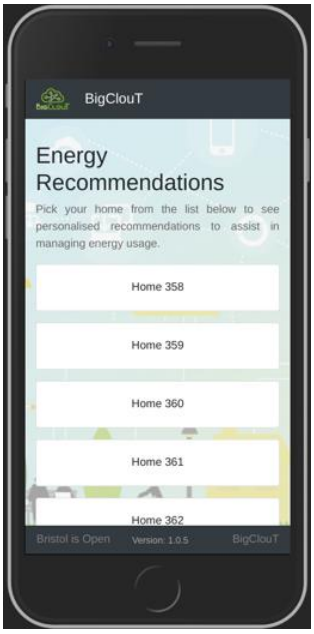

FIGURE 28. SMART ENERGY SCREENSHOT - RECOMMENDATIONS

The other main reason behind this trial was to raise awareness among the households about the "phantom load" phenomenon. To achieve this, we have used Knowage to create some charts that could help homeowners to see their current home electricity usage, and get analytics on their daily/weekly energy consumptions. From the home page, the user can access the 'Analysis' page where the following four Knowage charts are available:

- A gauge showing the current average energy usage from all homes. The users can also select a home id to see the current electricity consumption.

- A 3D bar chart showing the last 1h, 24h and week average energy consumption for all homes and the single appliances. Also for this chart, individuals will be able to select a home id to see the analytics.
- A line chart comparing all the home energy usage in the last week against the National grid energy demand. This will help not only households but also the council to see how the energy demand from the project homes compares with the national demand.
- A line chart showing the fluctuation of the energy usage along the day. The idea is to make such line as flat as possible, by helping people spread the energy consumption during the day thanks to the personalized suggestions from the recommendation service.

All the data generated by the usage of the app, such as pages visited, errors generated, etc, are sent to the BigClouT data lake. We aim to use these data, together with the feedback collected from Bristol City Council, to improve the web-app on a later stage.

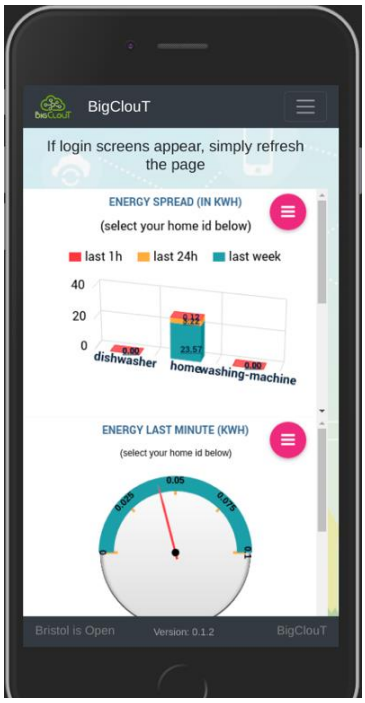

FIGURE 29. SMART ENERGY SCREENSHOT - KNOWAGE CHARTS

2.2.2.6 Personal data protections

For this trial, we have reused the data from the REPLICATE project. The data collected are about the power and last-minute energy consumption of some white goods, and the last-minute and total energy consumption of the whole home.

At the time of this writing, consultations with the Bristol City Council are taking place to assign an appropriate open data license to such data. Therefore, these data cannot be made public for the time being. However, the Bristol City Council and the REPLICATE stakeholders agreed on sharing these data with the BigClouT partners for the purposes of the Smart Energy trial. Therefore, the data will be uploaded into the BigClouT data lake as private datasets - the data can be used, viewed and downloaded by BigClouT partners, they can be used to create analytics and recommendations, but they will not be downloadable by the general public. The datasets will be made public once an agreement on the type of license is reached.

Both historical and real-time data will be sent to the BigClouT data lake. The historical data have been collected since summer 2018 and comprise of 17 million records, each of size 156 bytes. For the real-time data, Bristol is Open will use Node-Red to send ~900records per minute (50KB/min) into the data lake.

The data collected from the REPLICATE project do not contain personal or identifiable information about the households. Each home is identified by a numeric home id that has been appropriately changed in order to not make possible, once the data will be publicly available, to go back to any information related to the households. However, we will make households aware of such change so that they will still be able to recognize their own data and analytics.

Also the data generated by the use of the website will not contain user identifiable information, being only about the page visited and the possible errors generated by the web-app.

2.2.2.7 KPIs and Evaluation

Note: The Smart Energy trial is still ongoing. Some issues with the deployment of the home sensors have delayed the upload of the data to the BigClouT data lake and the use of such in the trial. Therefore, at the time of this writing, we are still working on the implementation of the BigClouT components in the web-app. We expect to complete the implementation by end of July, and engage with the households through the City Council after this date.

The following are the KPIs that had been set for the Smart Energy use case in 2018.

TABLE 6. BRISTOL OLD KPIS - SMART ENERGY

KPI or Metric	Target
Number of households involved in trial	150 min
Representative demographics	Trial participants should represent household demographics of Bristol city area
Daily active users	150

At this stage of the trial we can say the following about the KPIs' targets

- **Number of households involved in the trial**: it was originally planned that the REPLICATE project would have deployed sensors in 150 homes. However, due to third-party hardware issues, this target is now not reachable. Currently, only 90 sensor locations are sending data every minute. Unfortunately, we believe that the remaining 60 sensor locations will not be up and working by the end of the BigClouT project.
- **Representative demographics**: as explained in the section above, the participants represent the typical Bristol demographics.
- **Daily active users**: as for the households target number, this KPI's target cannot be reached. Moreover, because we are not directly engaging with the households, we are unable to quantify exactly how many participants will make use of the app.

As not all the above KPIs have been reached and the trial is still ongoing, we have decided to set new metrics that could reflect the current status of the project:

TABLE 7. BRISTOL NEW KPIS - SMART ENERGY

KPI or Metric	Target
Frequency of use the app	Every working day
Time spent using the app	15 – 20 mins
Data collection	300 webapp events info generated by end of trial and sent to the data lake

Through the web-app events data collected and the feedback from the City Council, we aim to be able to evaluate the above KPIs, and show such an evaluation during the 3rd review meeting in September.

2.2.2.8 Summary – lessons learned, sustainability

What and how much energy we use affects us every day. A high use of energy not only has a bad outcome on our pocket, but it is also harmful to our planet. The purpose of the Smart energy use case is to raise awareness about energy wastage, such as the "phantom load", and avoid creating peak energy demands. Through the project, householders are able to monitor their home electricity consumption in real-time and get analytics on their daily/weekly energy consumptions. They also get offered suggestions on when to use their appliances during the day to avoid creating energy peak demands.

Engagement with the project stakeholders has been fundamental to define and give form to the use case. Relying on third-party hardware has meant however being powerless when technical issues have happened. This has caused some delays meaning that the trial is still ongoing. Therefore we are still waiting for the City Council feedback to see what lessons can be learned from this project.

We are continuing to work with the REPLICATE stakeholders to identify what other data and outcomes would be useful to them in the future.

2.3 Tsukuba

2.3.1 Trial 1& 2: Provide tourism, traffic and environmental information in real time to visitors & Grasp status about foreign visitors to Tsukuba and provide concierge service to them

As already reported in previous deliverables, in Tsukuba city, we originally planned two trials based on the following use cases:

- Use Case 1: Provide tourism, traffic and environmental information in real time to visitors
- Use Case 2: Grasp status about foreign visitors to Tsukuba and provide concierge service to them

Based on the sequel discussion, we noticed that these use cases are similar, and we decided to merge the trials for these use cases. This subsection is to report the outcomes from the unified trial carried out in Tsukuba city.

2.3.1.1 City needs and goals

Tsukuba city is known to be a scientific city where hundreds of public and private research institutes as well as universities are located. Besides, the city has many sightseeing places, including Mt. Tsukuba. For this reason, the city has a significant number of domestic and foreign visitors, and the number is considered to be growing. To further increase the number of visitors, it is essential to improve the visitors' experiences during their stay in the city.

Besides, in Tsukuba city, the city officials have a problem that they do not have comprehensive information regarding foreign visitors, such as the number, gender, country, popular visiting places, etc. Also, they do not know the problems experienced by foreign visitors.

2.3.1.2 Stakeholders engaged in trials

Based on the above needs and problems, we have identified the following users and stakeholders:

- Users
  - (Foreign) visitors in Tsukuba city
- Stakeholders
  - Tsukuba city official
  - Tsukuba Tourism and Convention Association
  - Tsukuba City Bussankai
  - Tsukuba International Congress Center
  - Tsukuba Science Tour Office
  - Metropolitan Intercity Railway Company
  - Tsukuba Scenic Railway Co., Ltd.
  - Kanto Railway Co., Ltd.

2.3.1.3 Trial objectives

To cope with this problem, in this trial, we have developed a participatory sensing system for foreign visitors called "HukuRepo." HukuRepo post is a smartphone app for foreign visitors, and it has the following features: 1) when users experience some problems/troubles during their stay in Tsukuba city, the app allows them to make a post reporting the troubles/problems with a photo; 2) the users can get responses to the post from city volunteers; 3) the users can see the posts made by other users to get useful information; and 4) based on the current location of the user, he/she can get recommendation of nearby spots including restaurants, shops, hotels, etc. From a different perspective, for Tsukuba city officials, they can get from the posts (and related

data as well) useful information regarding foreign visitors in Tsukuba city, e.g., their behavioral information during their stay in the city, troubles/problems that they experienced, etc.
The technical problems of this trial lies in the following: 1) how to make responses to users' submissions as quick as possible; and 2) how to exploit different BigClouT components to make analysis of the collected data for subsequent uses. As a result, decided to use KNOWAGE and StreamingCube to make analysis of the data as depicted in Figure 30. In addition, we could use the Recommendation Engine to enable recommendation of spots. However, we did not use it. Instead, we internally implemented distance-based recommendation to make spot recommendation possible.

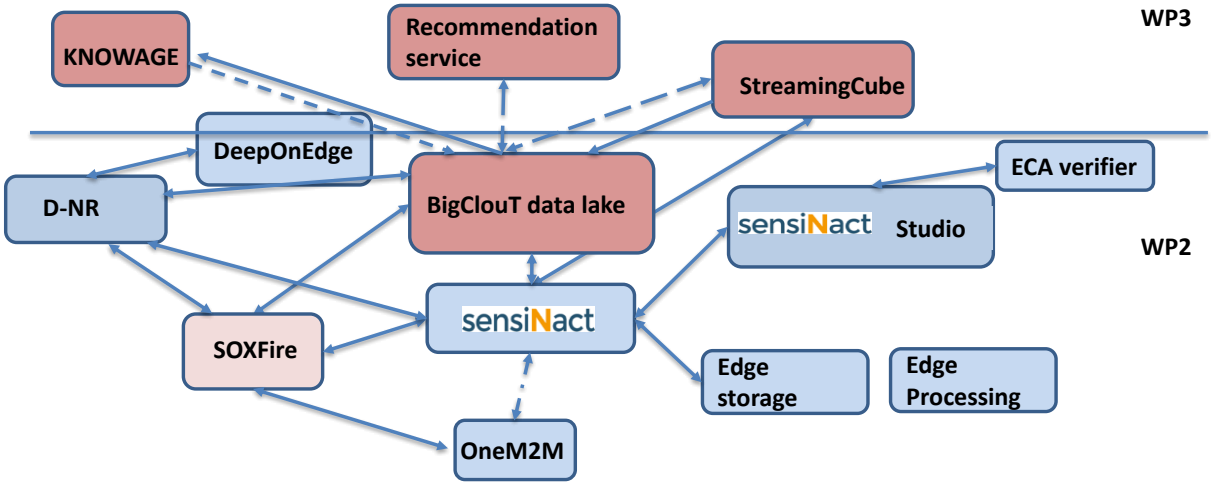

FIGURE 30. INTEGRATION LINKS FOR THE BIGCLOUT COMPONENTS IN THE HUKUREPO TRIAL

2.3.1.4 Engagement process with citizens and government

At the beginning of trial, we started discussion with Tsukuba city official (division of information and policy) about the planning of trial, and identified the objective, trial plan, and stakeholders. NTTE took the role of negotiation with the stakeholders with the help of Tsukuba city official, and came up with the following engagement channels:

- Flyers and posters: we designed fliers and poster of HukuRepo trial. Flyers were distributed at different stakeholders, such as tourist information center, stations of Tsukuba Express, 19 hotels in Tsukuba city, bus station, etc. Posters were put at the terminal station of Tsukuba Express, University of Tsukuba, Tsukuba international convention hall, etc.
- Advertisement at events in Tsukuba city: we tried to advertise HukuRepo trial at different events in Tsukuba city, e.g., Matsuri Tsukuba (festival), a conference held at the international congress center, and Digital City Tsukuba (symposium).

Social networks: in addition, we tried to advertise the trial using different social media including Twitter and Facebook. More precisely, for Facebook, we advertised the trial to the community of foreign inhabitants in Tsukuba city.

FIGURE 31. HUKUREPO FLIER

2.3.1.5 *Technical approach – BigClouT components*

Overview. Figure 32 shows an overview of the system.

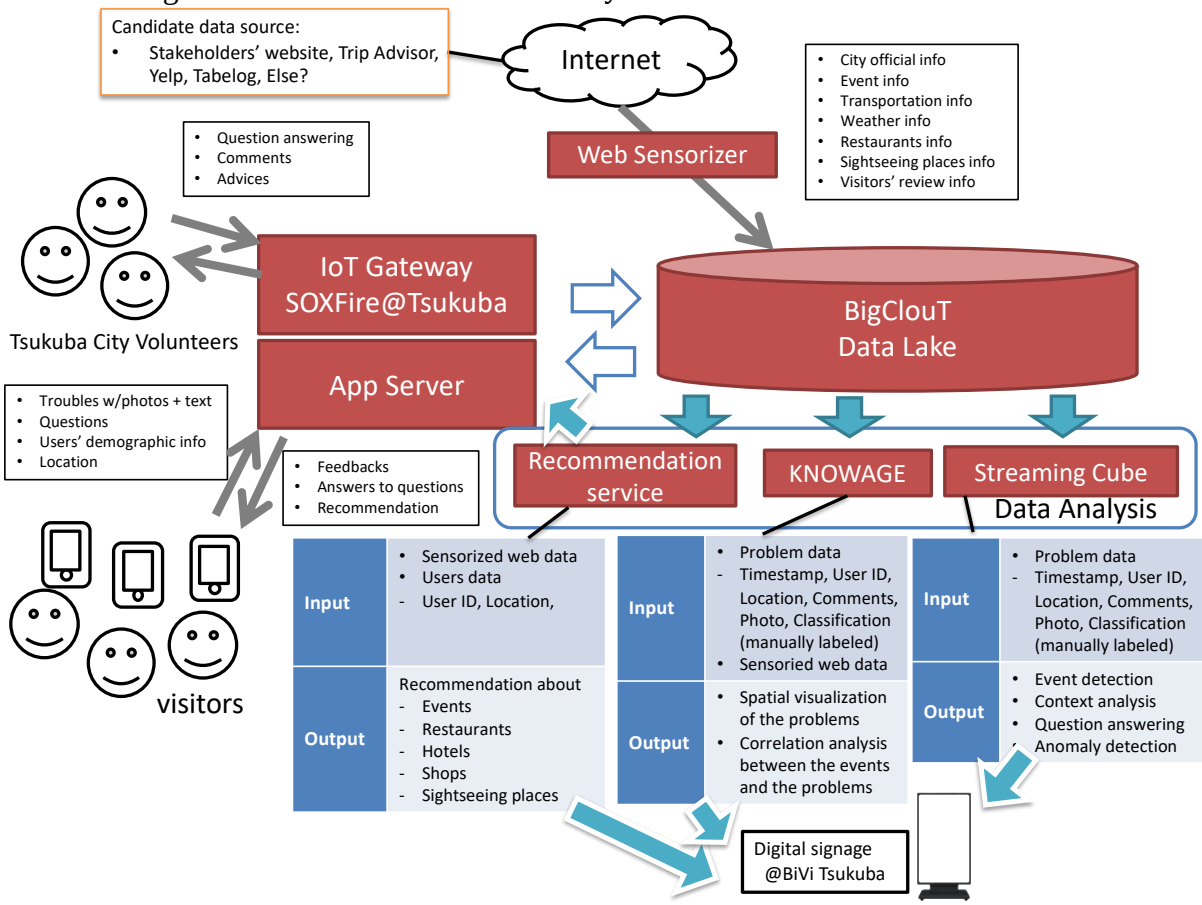

FIGURE 32. HUKUREPO SYSTEM OVERVIEW

Foreign visitors use a smartphone app HukuRepo post (Figure 33) to make posts and/or to get responses from city volunteers and recommendations, while city volunteers use another app HukuRepo response (Figure 34) to make responses to the users' posts. All posts made by end users and city volunteers are sent to the BigClouT data lake. Also, we constructed a knowledge base containing major spots in Tsukuba city, and it is also stored in the data lake. To get useful information from the collected data, we exploit different BigClouT components.

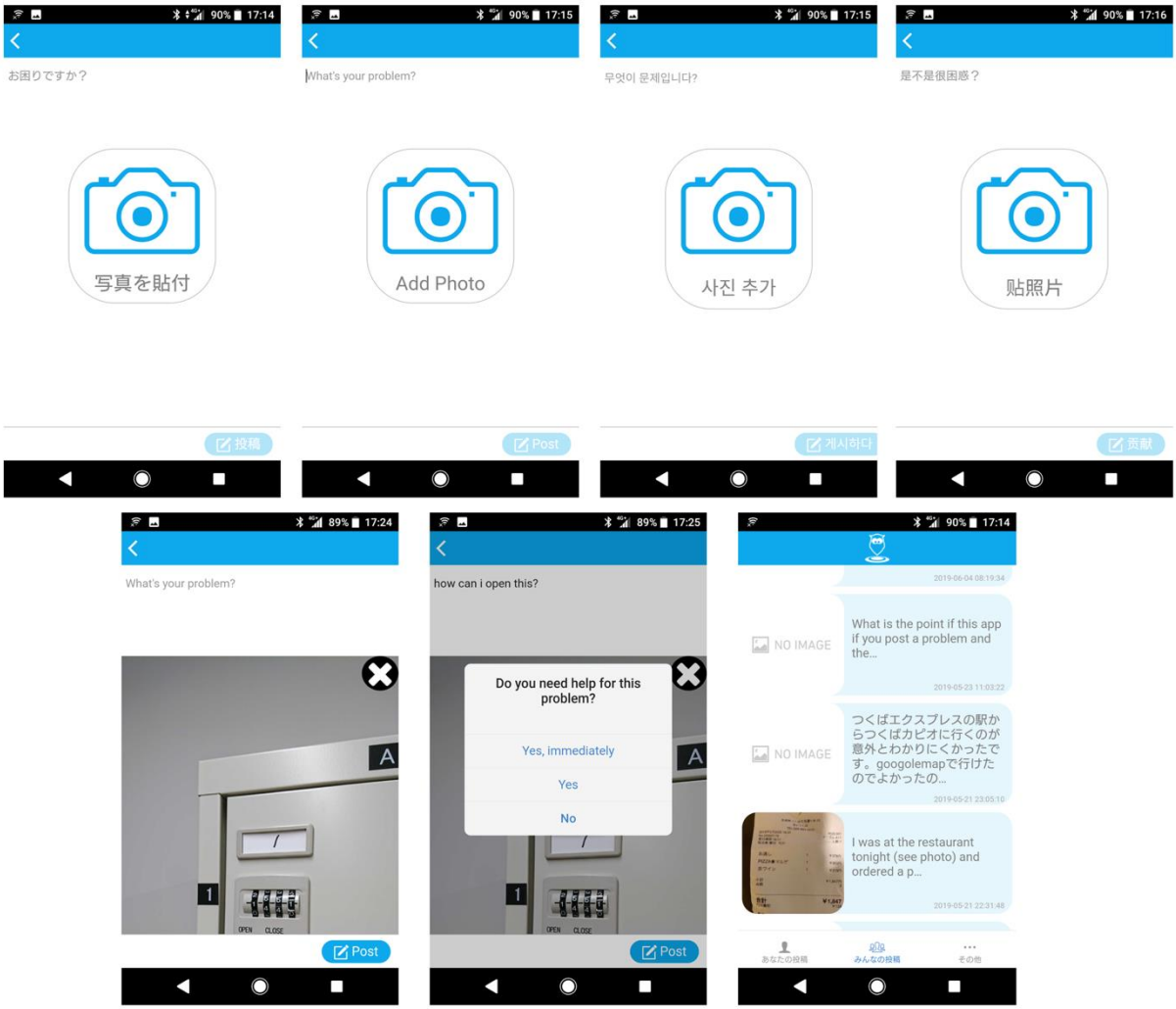

FIGURE 33. HUKUREPO POST

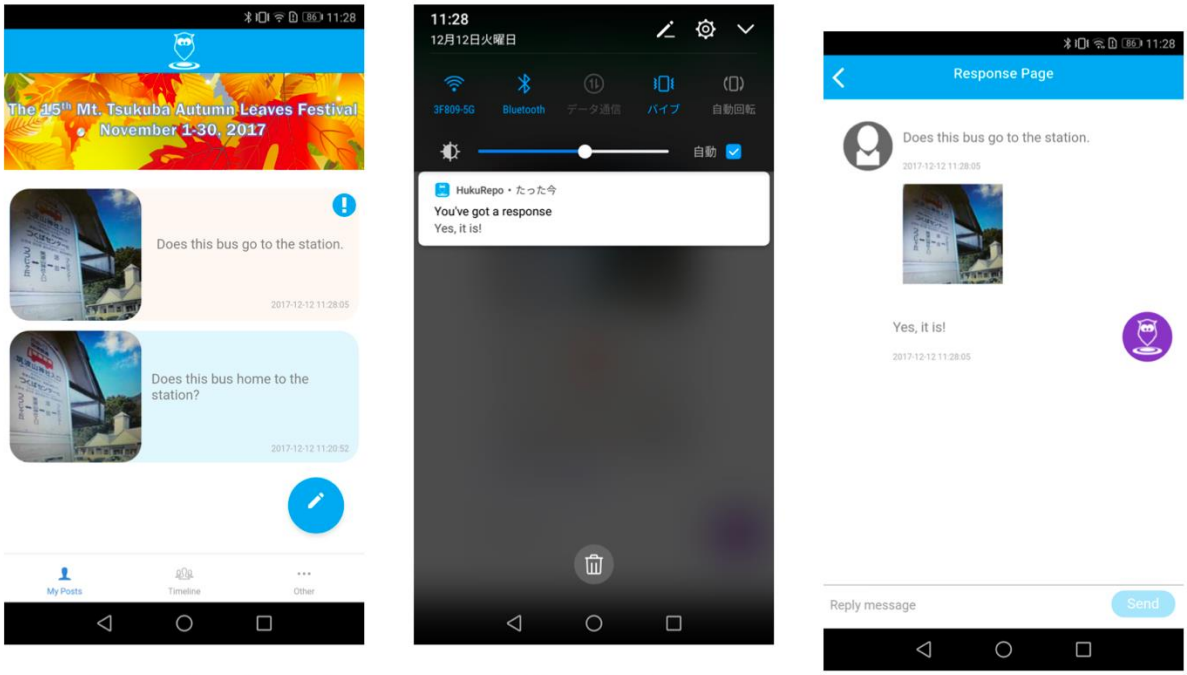

FIGURE 34. HUKUREPO RESPONSE

BigClouT components. To get useful information from collected data, we exploited different BigClouT components (Figure 35). Specifically, we used StreamingCube to make real-time multidimensional spatial analysis over users' posts containing geospatial information (Figure 36). Besides, KNOWAGE was used to make static analysis over stored data in BigClouT data lake (Figure 37). It allows us to get statistical summary over the posts and Tsukuba spot data. Also, it allows geospatial analysis over data containing location data. Notice that the analysis that can be performed by KNOWAGE is different from that can be done by StreamingCube in the sense that KNOWAGE assumes that the data being analyzed is static, while StreamingCube takes as input real-time streams of data. Also, the BigClouT recommendation engine can be used to make recommendation for users.

As for Recommendation Service, we considered to implement spot recommendation using it. However, we could not make it ready by the trial. Instead, we have implemented distance-based spot recommendation, whereby nearby spots are recommended to the user according to his/her current location, as a part of HukuRepo post app.

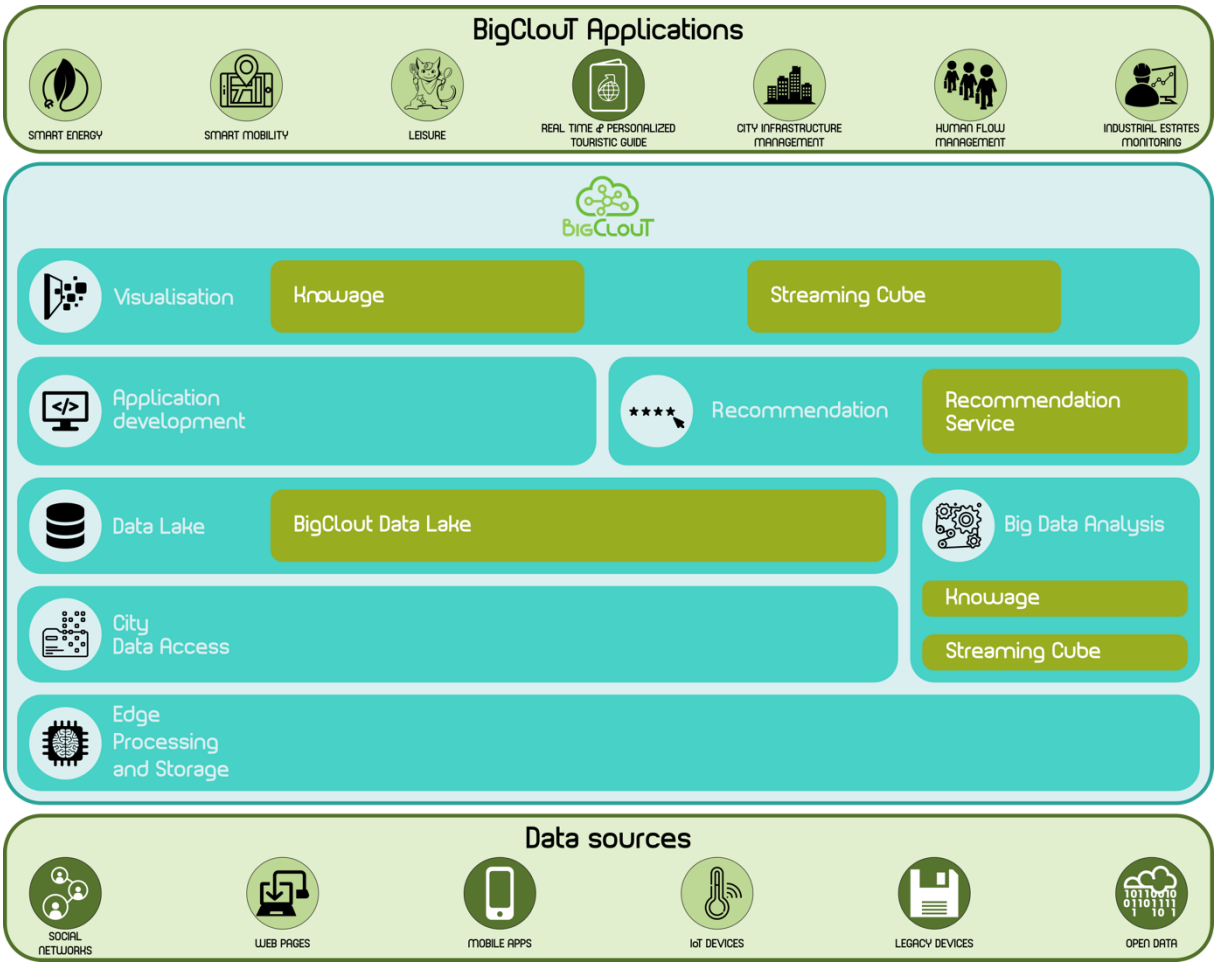

FIGURE 35. HUKUREPO - BIGCLOUT COMPONENTS USED IN THE TRIAL

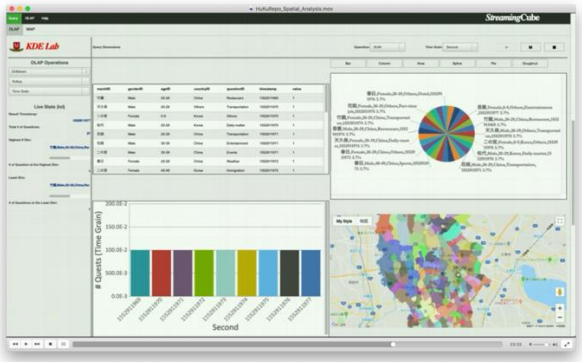

FIGURE 36. DATA ANALYSIS BY STREAMING CUBE

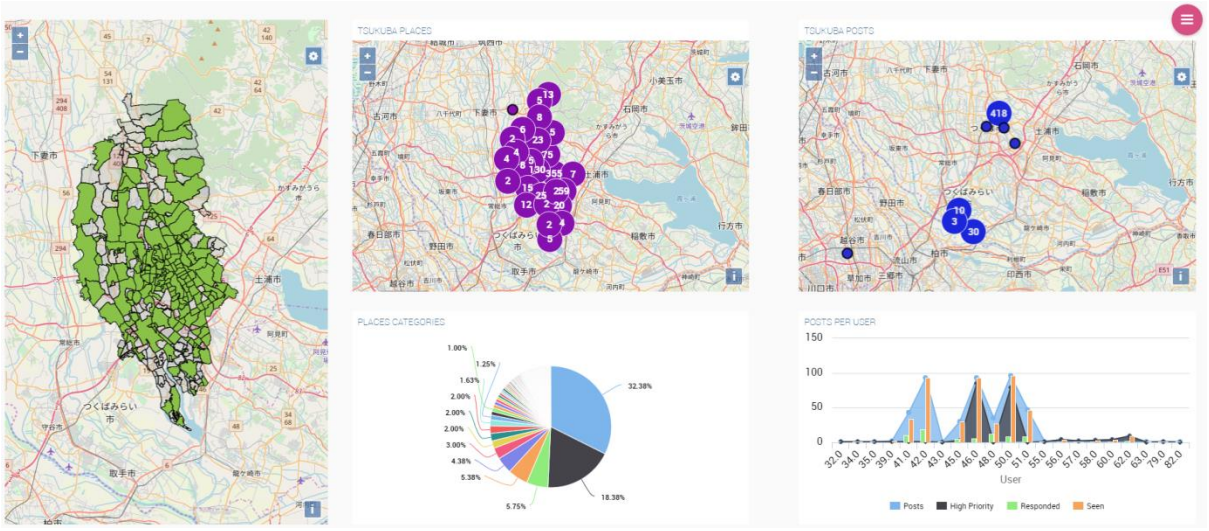

FIGURE 37. DATA ANALYSIS BY KNOWAGE

2.3.1.6 Personal data protection

For protecting personal data, we have followed the guideline provided by NICT. More precisely, in prior to the trial, we have submitted the trial plan to the ethics committee by at NICT and the one at the Center for Computational Sciences, University of Tsukuba.

For the trial, we have collected the following data from the users:

- Profile: name, email, gender, age, and country of residence
- Post: text, image (optional), and geolocation (latitude and longitude)

In HukuRepo apps, we did not use their personal data (i.e., profile), and used their unique IDs to be displayed. Similarly, we did not include profile data when analyzing collected data in order to prevent exposure of private data.

2.3.1.7 KPIs and Evaluation

The following table summarizes the KPIs identified in the Tsukuba trial and the results:

TABLE 8. TSUKUBA OLD KPIS

KPI	Target	Results
Number of downloads	50 / first month 600 / first year	100 in total
Number of users	600 / first year	23
Number of active users	10	23
Average time of use	10 mins	-
Frequency of use	Everyday	

The initial KPIs have been revised in order to better reflect the focus of the trial which was the number of posts and satisfaction rather than the number of users.

TABLE 9. TSUKUBA NEW KPIS

KPI or Metrics	Target	Results
Degree of satisfaction of Tsukuba city officials regarding collected data (by questionnaire)	70/100	(TBD)
Number of posts	100/month	475 / 3 months
Response time by auto-reply	1 - 2 minutes (avg)	< 1 sec
Response time by manual	Daytime: 30 min / nighttime: 1 hour (avg)	(TBD)

2.3.1.8 Summary – lessons learned, sustainability

In this trial, we have developed a participatory sensing system HukuRepo where foreign visitors can post and share troubles/problems and can get feedback from city volunteers and recommendations of spots in Tsukuba city. The system allowed the city officials to get information about foreign visitors through BigClouT analytical components, i.e., StreamingCube and KNOWAGE.

From the results, we have learned the following lessons:

It was quite hard to engage end-users. According to our original KPI, we expected 600 downloads and users, while the actual downloads and users were far less than that. One of the reasons for this would be the fact that most of the smartphone users in Japan use iPhone (iOS), but there was a long delay in delivering the iOS version of HukuRepo app due to the application reviewing problem. Also, many foreign visitors do not have local SIM-card, and they are only able to install/use smartphone apps when a Wi-Fi connection is available. To cope with this problem, we may develop a Web-application version of HukuRepo so that users can use it without installing any dedicated app.

From the city official's perspective, some information generated from the data collected by HukuRepo turned out to be useful for their work. It may be possible to get further insights from the data by applying different big data analysis.

2.4 Grenoble

2.4.1 Trial 1: Management of industrial estates

2.4.1.1 City needs and goals

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 example, is there a need for improved public transport? Is there a need to put in place a canteen?) and also to create a connections between the employers to jointly participate events, encourage car-sharing solutions, etc.

The ultimate goal is to be able to better attribute public resources, to improve the working conditions on these zones and the quality of experience of the employees and finally the environmental impact of the activities in the zone.

2.4.1.2 Stakeholders engaged in trials

After several exchanges with different potential stakeholders, as the most organized industrial estate in the city area, it has been decided to use the Inovallée area as the pilot area for the BigClouT project. With 380 enterprises (almost half being startups), 12000 jobs, 900 researchers, Inovallée is an important technological pole in France and even at the European level.

FIGURE 38. GRENOBLE: INNOVALLE BUSINESS PARK

Following the guidelines provided by the Deliverable 4.1, we have organised several meetings with the Inovallée association which is in charge of organizing the activities of the zone. We have decided to build an Inovallée app for the zone, which would bring together all different questions relating to users of the zone - transport options, dining options, information about the different actors present on the zone, information about business events and various sport clubs etc.

Several different use cases have been identified with Inovallée:

- 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

2.4.1.3 Trial objectives

The goal of the trial is to deploy a useful application to be used by the employees in the Inovallée industrial zone. It is important for the app to have as many features and as much information as possible from its initial deployment in order to ensure optimum uptake from users. The overall goal of this trial is to provide a better service to users of the Inovallée industrial estate and in the long term to attract companies to set up their business in the area. Furthermore, we hope to reduce the environmental impact of the zone by encouraging and rewarding environmentally-friendly behaviour. It is also planned to enlarge this app development and adapt it to other industrial estates in the city.

Main technical objectives are three-fold:

- Provide high reliability and availablility of the application
- Monitor the usage of the application to gather information on how the users interact with the app, which parts they use most, etc, in order to propose enhancements in the future.
- Provide customized recommendations to the users for their comfort and quality of experience from various aspects (mobility, restauration, events, etc.)

Section 2.4.1.5 provides the technical approach adopted in the project to address those objectives.

2.4.1.4 Engagement process with citizens and government

In March 2018, a survey carried out with the users of the site (employees in the zone) in order to validate the contents of the Inovallée app. The idea of the app was validated through a survey carried out with the users of the Inovallée zone who were overwhelmingly positive about the creation of an app. You can find more information about the survey results in D4.1.

Once the application launched, many different measures to ensure optimum uptake of the app have been taken:

- Press conference on March 26 (4 media present) - Press kit sends to 20 journalists (see Figure 39)
- Animations in each of the 3 restaurants during the lunch with distribution of flyers, demos of the app (see Figure 40)
- Dissemination of flyers within companies via referring persons
- Presentation of Myino during inovallée highlights (General Assembly, workshops, etc.)
- Relays in 2 newsletters:
    - The eco newsletter (6000 recipients)
    - The employee newsletter (3500 recipients)
- Two blog articles:
    - https://www.inovallee.com/inovallee-lance-la-v1-de-son-appli-myino-dans-le-cadre-dun-experimentation-internationale-unique-europe-japon-bigclout-copilotee-par-grenoble-alpes-metropole-et-le-cea/

- https://www.inovallee.com/lappli-myino-facilite-la-vie-des-usagers-de-la-technopole-autour-dune-vision-forte-tech-for-human/

- Headband and banners on the site of Inovallée and in email signatures (see Figure 41)
- Relay to the web app from the directory and site restoration pages
- Posts Facebook, Linkedin and twitter
- Zoom press on social networks following media coverage (April and May)

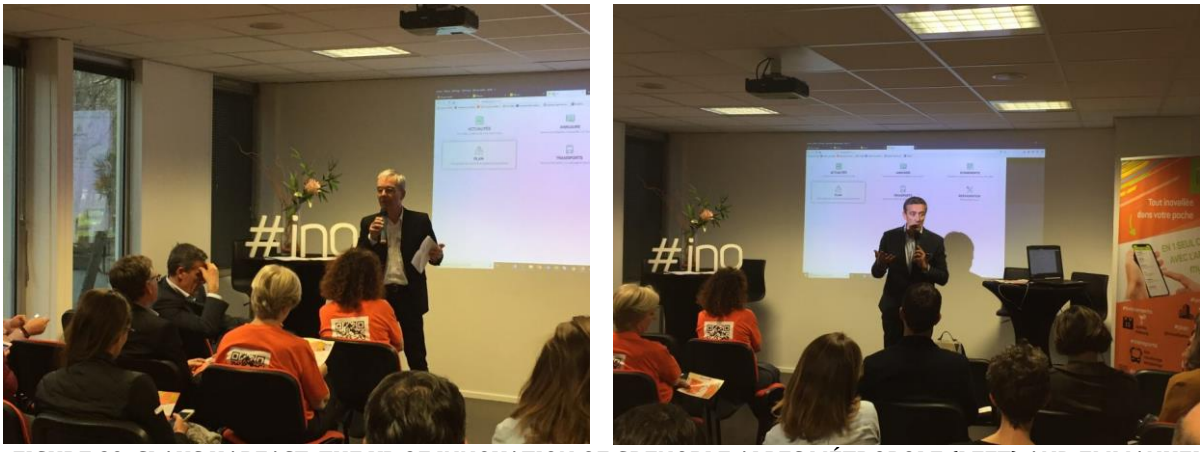

FIGURE 39. CLAUS HABFAST, THE VP OF INNOVATION OF GRENOBLE ALPES MÉTROPOLE (LEFT) AND EMMANUEL SABONADDIER THE CEO OF CEA-LETI (RIGT) PRESENTING THE APP DURING A PRESS CONFERENCE.

FIGURE 40. INOVALLÉE ASSOCIATION PROMOTING THE APP DURING THE LUNCH TIME AT DIFFERENT RESTAURANTS

FIGURE 41. BANNERS IN THE INNOVALLÉE WEBSITE PROMOTING THE MYINO APP.

Different articles in the press have been published to announce the launch of the app as well:

- **Frenchweb:** https://www.frenchweb.fr/made-in-grenoble-zoom-sur-le-projet-bigclout-et-la-global-challenges-science-week/361184
- **Télégrenoble:** http://www.telegrenoble.net/replay/reportage_59/reportage-myino-une-appli-pour-les-salaries-d-inovallee_x753r2x.html (see Figure 42)
- **Présences:** https://www.presences-grenoble.fr/actualites-ils-font-l-actu-grenoble/inovallee-site-pilote-pour-le-projet-bigclout.htm
- **Dauphiné Libéré:** https://c.ledauphine.com/isere-sud/2019/04/01/avec-l-appli-myino-inovallee-prepare-la-ville-de-demain


MEYLAN/MONTBONNOT-ST-MARTIN Cette application a été développée dans le cadre d'une expérimentation européenne

Avec l'appli Myino, Inovallée prépare la ville de demain

LE DAUPHINÉ LIBÉRÉ LUNDI 1er AVRIL 2019

La technopole Inovallée a, depuis quelques jours, sa propre application pour smartphone. Objectif : faciliter le quotidien des salariés mais aussi réfléchir à une utilisation efficiente des nouvelles technologies au bénéfice de tous.

C'est face, c'est une nouvelle application pour smartphone. C'est pile, c'est un projet pilote, une expérimentation réunissant l'Europe et le Japon avec, au milieu, le CEA-Leti, la métropole grenobloise et Inovallée.

Le côté face c'est donc une application, Myino, disponible pour tous les smartphones. « Elle est destinée à faciliter le quotidien de tous les usagers de la technopole, explique Claire Chanterelle, animatrice du projet au sein d'Inovallée. Elle les informe gratuitement de tout ce qui se passe autour d'eux : transports, restauration, actualité des entreprises, de la technopole… Toutes les données utilisateurs sont anonymisées. » Quant au contenu disponible dans Myino, il était jusque là disponible sur différents sites, sur d'autres applis, « jamais au même endroit ». Le tour de force a été d'agréger toutes les données, de les rassembler dans une seule et même offre, lisible, accessible à tous gratuitement. C'est là que le CEA-Leti est intervenu avec sa plateforme d'agrégation de données baptisée "SensiNact".

"…Au profit des villes intelligentes et de la qualité de vie des citoyens"

Et c'est ici qu'on change de face, qu'on passe du côté pile du projet, baptisé BigClouT. Financé à hauteur de 3 millions d'euros par la Commission européenne et le Japon, il est porté, chez nous, par la Métro, Inovallée et le CEA-Leti. Son objectif est de tirer le meilleur parti des objets connectés (IoT) et des solutions cloud, au profit des villes intelligentes et de la qualité de vie des citoyens, pas des entreprises privées, "pour bâtir un monde durable tout en préservant le dynamisme économique des territoires". C'est en tout cas la volonté des organismes engagés dans cette expérimentation qui doit durer trois ans. Elle est menée dans quatre villes, Tsukuba et Fujisawa au Japon, Bristol et Grenoble en Europe.

« Toutes les entreprises font leur transformation numérique aujourd'hui, explique Claus Hablast, vice-président de Grenoble Alpes Métropole. Les collectivités sont, elles, parfois un peu en retard. Pourtant, si on veut favoriser le vivre ensemble, il y a urgence à maîtriser les données du quotidien afin qu'elles ne deviennent pas celles d'entreprises privées. Il faut, avec vitesse et force, lancer la transformation numérique de nos territoires. Myino est un des outils qui doit permettre à ce que nos citoyens vivent mieux grâce à une utilisation des données par des structures qui sont ici, sous maîtrise, contrôlées par les citoyens. »

Matthieu ESTRANGIN

Annie Soufi, directrice d'Inovallée, Claus Hablast, vice-président de Grenoble Alpes Métropole, Emmanuel Sabonnadière, directeur du CEA-Leti et Claire Chanterelle, animatrice du projet au sein d'Inovallée. Photo Le DL/Matthieu ESTRANGIN

FIGURE 42. A VIDEO INTERVIEW ABOUT THE TRIAL (LEFT) AND ARTICLE APPEARED IN THE LOCAL PRESS (RIGHT)

2.4.1.5 Technical approach – BigClouT components

Following consultations with the future users of the app (employees on the Inovallée zone) and all stakeholders, it was decided to focus on several key services:
- map of the area with information about bus stops, companies, restaurants etc
- contact information for all structures in the area
- news about the site and companies based on the site
- information about events and the possibility to sign up for events (sports, business, culture...)
- traffic information - bus, tram, car-sharing, problems...
- restaurant information - canteens, menus, pricing, opening times

With these services, users of the app will have the most pertinent information about the Inovallée zone in one place, at their fingertips.

MyIno App has therefore been developped taking into account the above mentioned features defined by the potential users. Screenshots from the application are given in Figure 43. MyIno App is available on both Apple Store1 and Play Store2. A lighter web version is also available online[3].

[1] https://itunes.apple.com/us/app/myino/id1457219488?mt=8
[2] https://play.google.com/store/apps/details?id=app.myino
[3] https://myino.app/

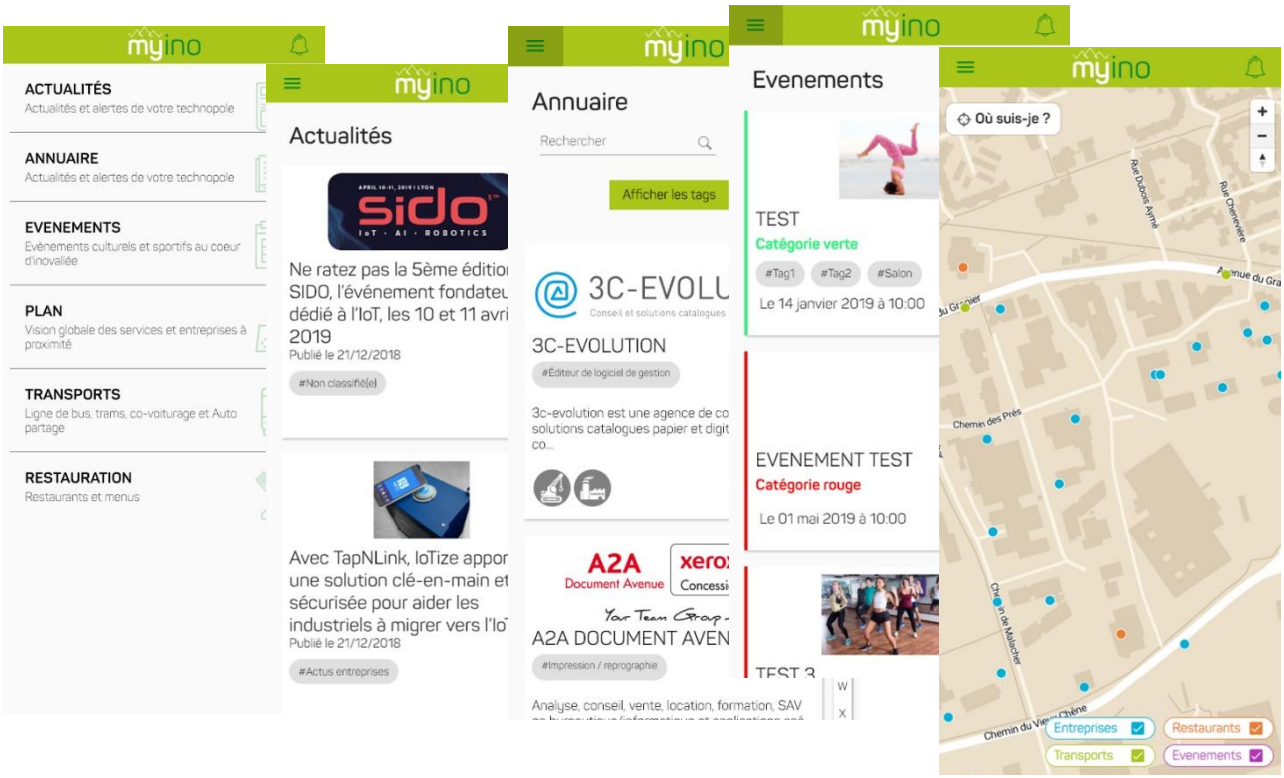

FIGURE 43 SCREENSHOTS FROM THE MYINO APP

The next version of the application will also contain recommendations based on the profile and interests of the user. E.g., recommendations on restaurants serving user's favourite meal, events that are potentially of interest to the user, reporting incidents or recommendations on the mobility of the user with public transport, car sharing, etc.

Grenoble trial has been using various components from the BigClouT platform. The overall picture of the trial and used components is illustrated in the Figure 44 (taken from the BigClouT website).

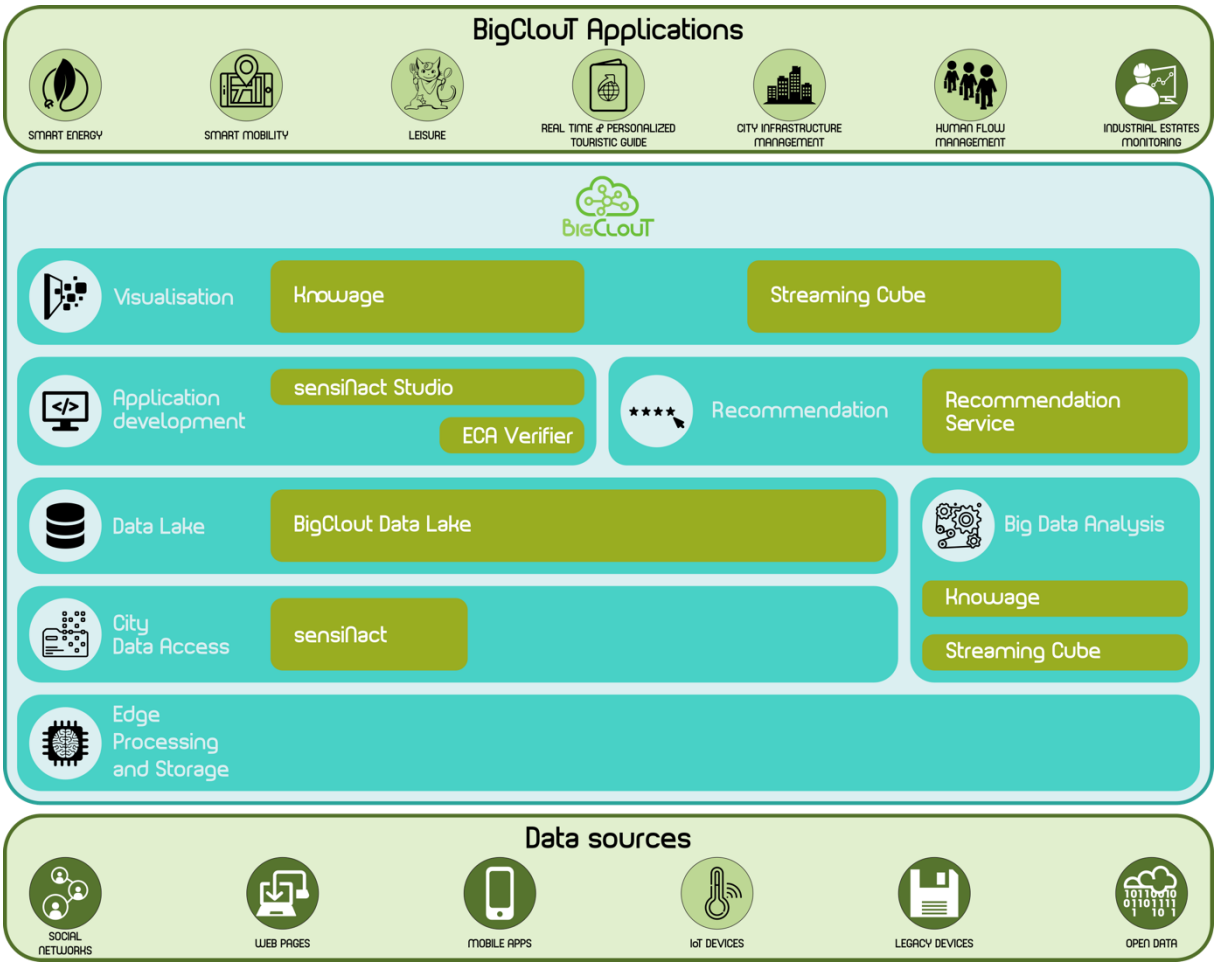

FIGURE 44. MYINO - BIGCLOUT COMPONENTS USED IN THE TRIAL

The core data collection and redistribution is managed by sensiNact, which is in charge of unifying heterogeneous data sources such as mobility, restaurants and events information in the Inovallée zone. The objective is to allow the application developers focusing on their application logic and not dealing with the technical details (communication protocols, data models, etc.) of each individual set of data sources. The MyIno app then gathers data and uses for the presentation to the users.
Similarly, data from the application usage is gathered by sensiNact and transferred to the data lake for offline analysis purposes by KNOWAGE, StreamingCube and Recommendation Service (Figure 45).

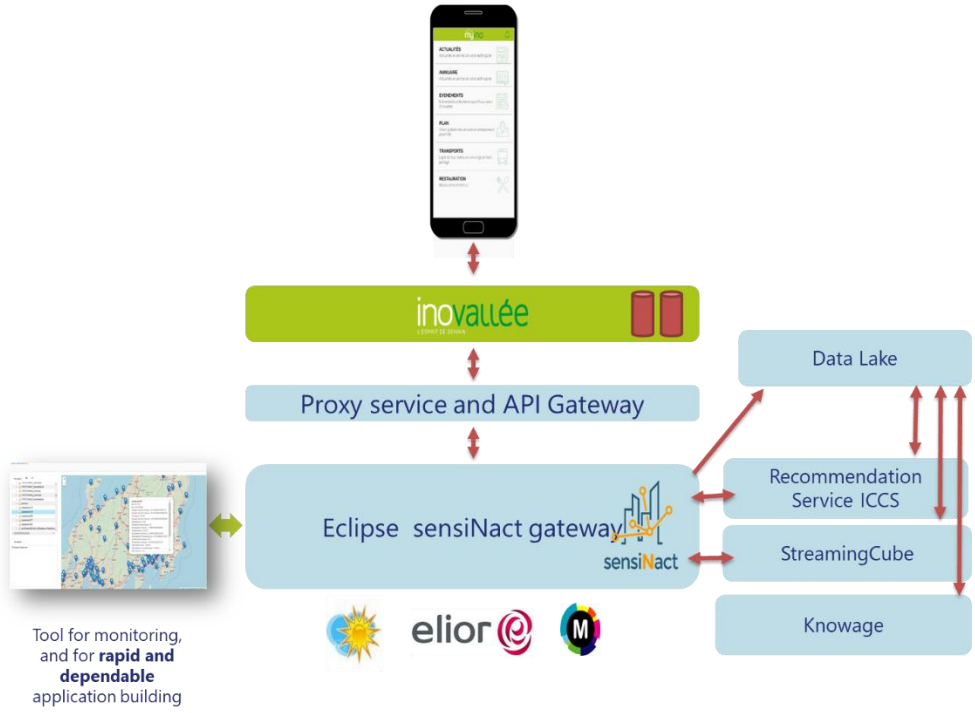

FIGURE 45 SENSINACT AND DATA PROCESSING/VISUALISATION TOOLS IN GRENOBLE TRIAL

For example, KNOWAGE is being used to better understand the behaviour of the users and their interests. Thanks to various visual widgets from the KNOWAGE, Inovallée can gather several insights about the zone, to respond for instance to various questions such as, which event attracts more attention, which restaurants are more looked for, at what time of the day users use the app, which bus stations they use more, etc. Various visualisation graphs have been provided to Inovallée for the purpose of understanding the behaviours of the Inovallée employees.

Figure 46 below provides some screenshots from the provided dashboards, which is also accessible at the following link: https://knowage.opsi-lab.it/knowage/public/servlet/AdapterHTTP?ACTION_NAME=EXECUTE_DOCUMENT_ACTION&OBJECT_LABEL=Gre_Usage&TOOLBAR_VISIBLE=true&ORGANIZATION=BigClouT&NEW_SESSION=true&PARAMETERS=day=&day_field_visible_description=

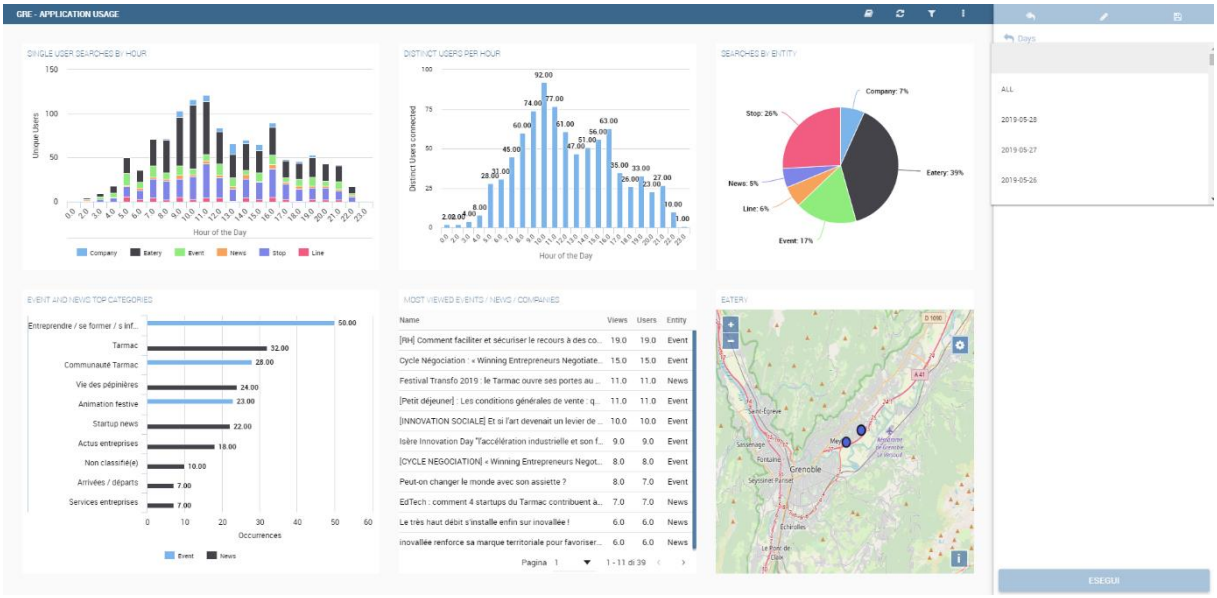

FIGURE 46. KNOWAGE DASHBOARDS FROM INOVALLÉE DATA SENT BY SENSINACT

2.4.1.6 Personal data protection

Grenoble trial pays a particular attention to the personal data protection issues. It has been done a deep analysis on potential issues concerning the personal data management, in particular in how data collected and processed.

i) Data collected / application of personal data regulation

The "MyIno" app has been launched, for trial purposes, on March 26th 2019.
The first version of the app (v.1) does not require its users to create any personal account. Thus, the only data collected are: the user's device Id (Unique Device Identifier – UDID), the user's logs (which pages have been visited, at what time) and, when the GPS is activated, geolocalization data (upon requests for public transportation networks or catering facilities for instance).
In a later version, users shall be required to create a user account, and to fill in more detailed personal information, such as name and first name, email address, or telephone number (not mandatory). **Focusing on v.1 of the application**, the question arose whether those "non-nominative" data collected should be considered nevertheless as "personal data" under GDPR and, therefore, whether Inovallée, as data controller and editor of the application, should respect GDPR requirements on user information and consent.

It may be recalled that, under Section 4 (1) of GDPR:
'personal data' means any information relating to an identified or identifiable natural person ('data subject'); an identifiable natural person is one who can be identified, directly or indirectly, in particular by reference to an identifier such as a name, an identification number, location data, an online identifier or to one or more factors specific to the physical, physiological, genetic, mental, economic, cultural or social identity of that natural person;
Since the UDID identifies a device, and not a natural person, it may be argued that it is not, as such, a personal data. However, it should be considered as an indirect means of identification, since it may be easily linked to the natural person who subscribed the Internet/telephone service operated on the device (when the device has been sold by the operator, for instance), but also linked to an email address when the UDID is used to connect the user on Appstores or Android Stores. Finally, such data is undoubtedly personal when linked with localization data (such as GPS signal).
The French Data Supervisory Authority (CNIL) has recently ruled that the advertising identifier, which application editors are required to use (in lieu of the UDID) for any advertising purposes, should be considered as personal data[4]. Since the UDID is a permanent identifying number, it identifies a "user", and thus a natural person, even though its legal identity is not known from the editor of the application.
Moreover, such data is due to be linked with user logs, which will enable to refine the user's profile. Finally, the application will collect (and process – *see further*) direct (through GPS signal when activated by user) and indirect location data, such as all requests for bus or tramway

[4] "*The advertising identifier is a unique identifier generated by the smartphone's operating system making it possible to identify the user's terminal in a stable manner over time. It is available to all mobile applications installed on it and is also accessible to the various SDKs installed in mobile applications.*
This advertising identifier is permanently stored in the smartphone of the user and therefore identifies the user indirectly. It is intended to identify the user in order to associate an advertising profile made from its geolocation data. It thus makes it possible to identify the user during his later use of other mobile applications on his phone in order to associate his advertising profile and to display advertisements specifically chosen according to his travel habits". (CNIL, décision n° MED 2018-022 25th June 2018 TEEMO ; see also, on the same date : déc. N°MED 2018-023 Fidzup; déc. N)MED 2018-043 Singlespot; déc. N°2018-3042 Oct 30th 2018 Vectaury***).***

timetables at a specific stop, or for a restaurant in a given area. Thus, and even when no precise GPS data is collected, the data recipient may infer the preferential user's locations such as its home area, its workplace or its favourite catering places.
Therefore, it should be considered that the "MyIno" application, even in its first version, collects and processes personal data under Section 4 (1) of GDPR.

ii) Data processing

Data collected through "MyIno", whether personal or not, will be used to elaborate statistical data on use of public transportation networks, alternative transportation systems (such as car sharing, carpooling), use of catering facilities, traffic disruptions in the area, use of sports equipment, attendance to cultural events (via the Sortie Sport application); etc.
Statistical treatment of the user's personal data may however entail categorisation of such users (by age, gender, means of transportation, catering habits, etc).
Consequently, from a legal and ethical point of view, it should be assessed whether such processing may be considered as profiling, under Section 4 (4) of GDPR:
'profiling' means any form of automated processing of personal data consisting of the use of personal data to evaluate certain personal aspects relating to a natural person, in particular to analyse or predict aspects concerning that natural person's performance at work, economic situation, health, personal preferences, interests, reliability, behaviour, location or movements;
Profiling is prohibited only in the case of "***decisions*** *based solely on automated processing, including profiling,* ***which produces legal effects****", concerning him or her or similarly significantly affects him or her* (art.22.1 GDPR). Even though, such prohibition may be circumvented if the data subject gives an explicit consent to such profiling (art.22.2 c) GDPR) which in our case may be given in the terms and conditions, or by clicking a separate item when downloading the Application.
In our case, it could be argued that the personal data collected through the application, and processed by CEA on behalf of Inovallée, are being "analysed" through automated processing. In so far as the data concerns *personal preferences* (requests on restaurants, for instance), *interests* (cultural events), *location* (which could be inferred from transportation preferred requests) or *movements* (transportation requests, car sharing uses), it should be concluded that the processing of such data may be considered as "non-decisional" profiling under article 4.4 of GDPR.
Whereas such profiling is much less intrusive than commercial or marketing profiling, users of the application should however be informed of their specific rights mentioned above, as well as the eventual purposes of such data processing.
Therefore, it should be concluded that "MyIno" processes data for profiling purposes, although non commercial ones, but that such profiling does not induce any decision for users, whether automated or non automated based.
The application's privacy policy has been updated so as to comply with specific requirements related to such kind of profiling.

2.4.1.7 KPIs and Evaluation

Following table summarizes some of the KPIs defined. The evaluation is ongoing. The final results will be provided at the review meeting.

TABLE 10. GRENOBLE KPIS

KPI or metric	Target	Means of measure	Result
Critical mass of downloads	500 users in first 6 months, 750 in first year	App store, Play Store	In 4 months: 270 downloads from Play Store, 250 downloads from Apple Store + online users
Critical mass of users	300 in first year	sensiNact + KNOWAGE	About 300
Daily active users	150	sensiNact + KNOWAGE	About 140
Average length of time spent using app	10 minutes		Under evaluation
Time of day app used	morning	sensiNact + KNOWAGE	Mainly morning (between 09:00 - 11:00)
Different pages visited	3	sensiNact +KNOWAGE	Top ranking of the visited pages: 1) Restaurants: 39% 2) Transportation: 25% 3) Events: 18%
Satisfaction with app	average 4 stars	Play Store	Few feedbacks to conclude

The table below shows the impact of the organized events to the download of the application during about two and a half months.

TABLE 11 IMPACT OF USER ENGAGEMENT EVENTS ON THE NUMBER OF DOWNLOADS OF THE APP

Date	Actions	Used social networks	Nb downloads
26-mar	Launch of the app: Press conference	Twitter + Linkedin	
04-apr	Animation in restaurant RIE Ô Chêne / Meylan	Twitter + Linkedin	on April 5th Android: 60 Apple: 45 Total: 105
11-apr	Animation in restaurant RIE Champ de l'Etoile / Montbonnot	Twitter + Linkedin + Facebook	

17-apr	Zoom presse // article DL // via social networks	Twitter + Linkedin + Facebook	
19-apr	Minutes of the General Assembly with the announcement of the results of downloads		
29-apr	Internal information to some companies		
02-jan	Presentation of Myino to the works council of companies in the zone		
06-may	"En Une" of Myino News		
16-may	Animation in restaurant RIE Chantignole / Meylan	Twitter + Linkedin	on 21/05 Android 110 Apple 102 Total 212
17-may	Flyers in take away bags of restaurant "class croute"		
29-may	Mailing list // INFO MYINO		
03-june	Meeting about car sharing // info app with distributed flyers		on June 3rd Android 133 Aple 124 Total 257
13-june	Presentation Myino to HR divisions of the companies in the zone		
			on 13/06 Android 156 Apple 145 Total 301

The overall evaluation is ongoing and will be updated during the project final review meeting in September.

2.4.1.8 Summary – lessons learned, sustainability

Concerning the Big ClouT field trial that was carried out in the Grenoble City Area, the trial has met its objectives in terms of improving the services in the zone. This is important for improving the lives of the users of the zone and also better using the existing management resources (human resources and financial resources) in turn, this also also had the goal of making the area more attractive to businesses looking to set-up in the zone. First feedbacks from the Inovallée have been very encouraging and follow-up projects will certainly occur in similar topics.
It is currently too early to fully measure the full extent of the results of the trial in terms of long-term goals - new companies setting up in the zone, better managed resources, better information… but we can already say that the trial has been successful and that the CIty Area and the Inovallée industrial estate are fully committed in maintaining the application developed during the trial and in deploying it in other industrial zones within the City Area.
Furthermore, the trial focusing on the management of the City Area's industrial estates has allowed for better collaboration between the City Area and the CEA research centre on research projects. This is an important outcome of the project since it has paved the way for future collaborations, notably in the smart cities area.
Grenoble-Alpes Métropole has consolidated its position as a "smart city" and has made very interesting new contacts with cities and research centres for future collaborative projects and innovation. Furthermore, the project has led to the creation of the "Urban Technology Alliance" which the City Area is committed to participating in actively. This alliance further enlarges the City Area's network of cities, industrial actors and research centres across the world which

allows for more visibility for Grenoble's smart city projects, which in turn makes the are more attractive to foreign investors and talent. Moreover, the alliance fosters collaboration and the sharing of best-practices between cities which, in general, are often caught between the paradox of needing to innovate and to improve city services but at the same time to operate within ever more limited budgets. The sharing of best practices and lessons learned, coupled with the technologically-neutral expert advice from other members of the alliance renders the UTA a very useful tool for the future development of the Greater Grenoble City Area.

3 REPLICATION OF MINAREPO TRIAL IN BRISTOL

The Deliverabe 4.4 presented the integrated BigClouT platform, which is the fruit of a strong collaboration between European and Japanese partners. Through section 2, we have illustrated the technical integration work for each trial work between EU and JP partners.

As part of WP4, we have also been exploring the possibilities of scaling up the city trials via a joint EU-JP trial. While there are a number of possible approaches to this, via discussions with cities, we have settled on a strategy that combines the possibility of reusing applications developed within the project in other partner cities and of sharing data between cities. To that end the partner cities have proposed to *replicate the MinaRepo trial developed for Fujisawa to Bristol. W*e have set up the MinaRepo system, via cloud infrastructure, and tailored the interface and report types based on input from the two cities.

The goals remained consistent with those defined in the Fujisawa report as, for example, enhancing efficiency of civil officers daily works by adapting crowdsensing techniques. Moreover, Bristol aims also to use MinaRepo as a community engagement tool in order to make citizens more responsible for the area they live in.

The end users for this trial have been identified as the participants of the Smart Mobility trial. These are citizens who regularly walk in Bristol. Other stakeholders are:

- **Bristol Operative Centre**
  Controls traffic lights, emergency response and welfare services in Bristol
- **Knowle West Media Centre (KWMC)**
  A charity centre that uses technology and art to make positive changes in the lives of people from disadvantaged backgrounds.

Through a discussion event with citizens, KWMC has helped to shape the MinaRepo trial for Bristol as described in the discussion below. Bristol has worked with its stakeholders to identify the best uses for the app. The result of this engagement has been that the MinaRepo can be used as either a municipal government reporting tool, community engagement method, or event coordination tool.

Events that were organized by stakeholders have highlighted the desire for citizens to use MinaRepo as a reporting tool. It would allow individuals to help others avoid dangers, and to share positive experiences.

After one week from the start of the Smart Mobility trial, participants have been asked to use the MinaRepo app while walking in Bristol. At the end of the trial, they will receive a questionnaire aimed at collecting feedback on the use of MinaRepo.

Prior to this, Bristol has engaged with KWMC to organize a discussion event where citizens could have expressed their opinion on how MinaRepo could be used in Bristol. In total, 47 people attended the event. The participants have expressed the desire to use the app not only to report incidents such as illegal garbage, roads damaged, etc, but also to share positive experiences around the city such as cool graffiti, street artists, etc.

Bristol has also engaged with the City Council Operations centre. Initially they were asked to use the app in a similar context as the Japanese deployment scenario, however, this is not possible due to the fact that they cannot commit to a Service Level Agreement. Therefore, a proposal has

been put to them to try the MinaRepo app, perhaps to respond to some of the incidents reported and contribute with feedback on the usage.

MinaRepo system is currently deployed on cloud environment. Overall system architecture is shown below:

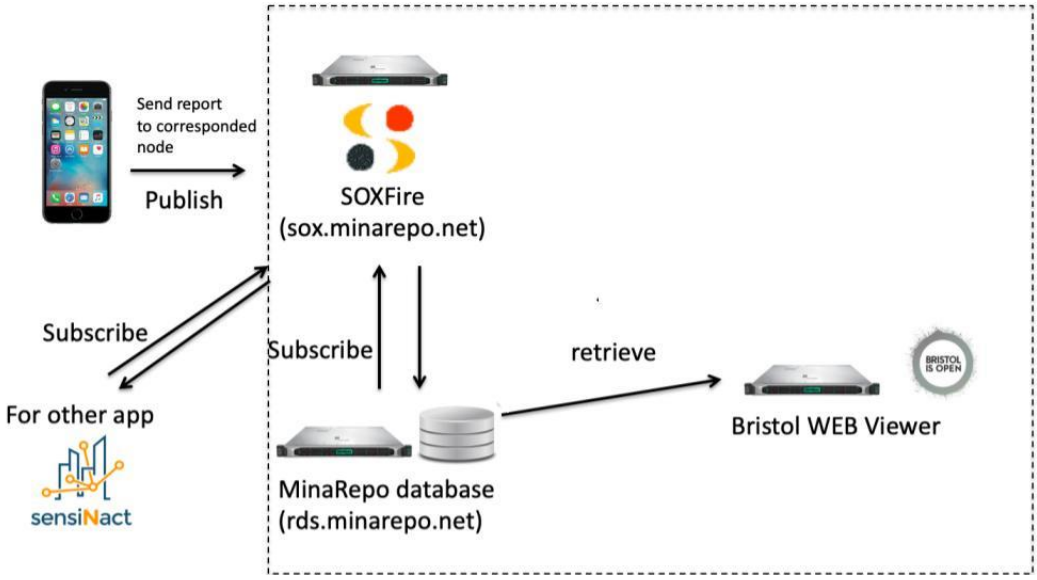

FIGURE 47. MINAREPO BRISTOL - SYSTEM ARCHITECTURE

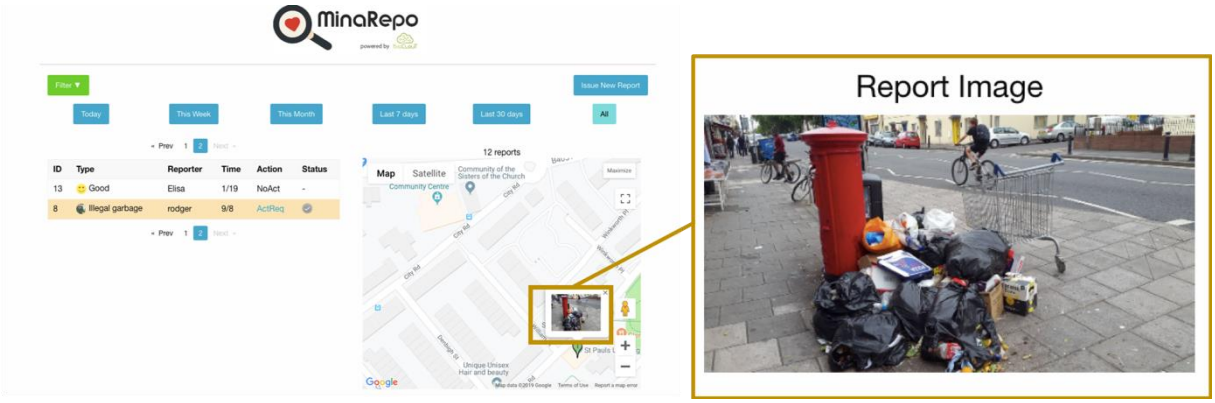

FIGURE 48. MINAREPO SCREENSHOT - ILLEGAL GARBAGE REPORT

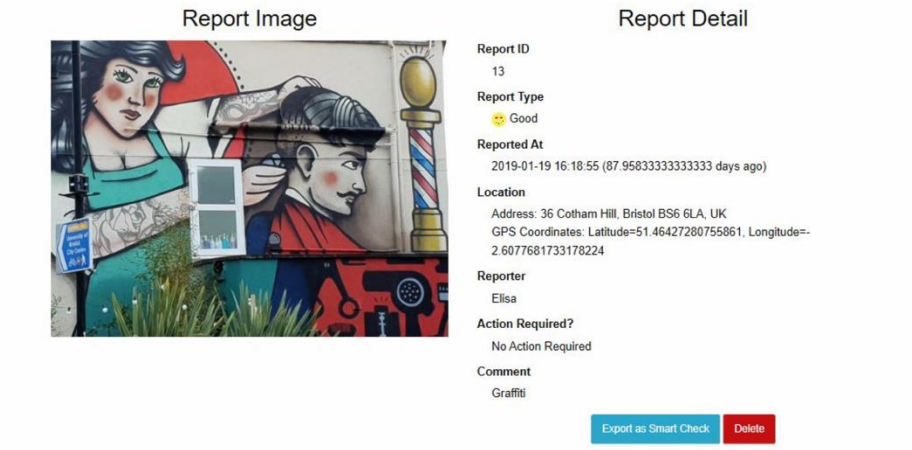

FIGURE 49. MINAREPO SCREENSHOT - NICE FINDINGS REPORT

Using the app, no personal information is collected. To add reports within the app, the users will need to insert a name. However, they are not obliged to insert their full or real name. Moreover, the login is common for all the users and no personal credentials are required.

MinaRepo viewer for Bristol can be found at the following address
https://bristol.minarepo.net/

Note: The MinaRepo app has been released one week after the release of the Smart Mobility app, on July, 18th. Therefore, at the time of this writing, the trial is still ongoing.

The following are the KPIs that we have set for the replication of the MinaRepo trial in Bristol:

TABLE 12. BRISTOL MINAREPO KPIS

KPI or Metric	Target
Target user number	50
No. of reports	10 reports per month
Average time spent using the app	10 - 15 mins
User engagement	Min 25% users respond to questionnaire

These KPIs will be evaluated at the end of the trial and their evaluation will be shown during the 3rd review meeting in September.

Through citizen engagement events we have learned that citizens prefer a tool to not only report incidents but also to share nice discoveries around Bristol. Because the trial is still ongoing, we are waiting for the citizen and city council feedback to see what we can learn from this trial.

4 SUMMARY

In this deliverable document we have shown how the BigClouT components have been used towards a broad range of applications, from personalized touristic guides to home energy monitoring, from estate managing to help people engage with their city. We have shown the strong collaboration among the European and Japanese partners and the integration work performed for each trial case, thus joining forces to overcome the challenges of today's and tomorrow's cities.

These trials succesfully overcome the 5 main Big Data challenges:

- **Variety:** with all trials handling a large heterogeneous set of data coming from live sources and sensors,
- **Volume:** even in small trial cases of the project, we could handle for instance, daily peaks of more than 5GB of data, We have shown with tests that the platform and tools can scale to the increase of users and data sources.
- **Value**: improving the experience of users (employees in the Inovallee business park in Grenobe, tourists in Tsukuba, citizens of Bristol, city staff of Fujisawa, etc.)
- **Velocity**: the platform supports frequent data (1 message per second from Fujisawa trucks, 900 energy records per minute in Bristol (50KB/min), etc.
- **Veracity**: with a fine grained security mechansim and trustful sources of information such as Tsukuba gathering data from different sources to help visitors.

Each trial involved a variety of stakeholders depending on the use cases. Engaging with them and end users helped shape the trials and ensure a positive reception. This is also shown by the KPIs that have been reached for the trials that have finished at the time of the writing. For those trials that are still ongoing, KPIs evaluation will be reported during the 3rd review meeting in Tokyo.