D2.2 Technical requirements and high-level specifications v2

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Acronyms

API	Application Programming Interface
AQI	Air Quality Index
ATMS	Advanced Traffic Management System
m2mGPS	Global Positioning System
GUI	Graphical User Interface
HR	Heart Rate
HRV	Heart Rate Variation
HVAC	Heating, Ventilation and Air Conditioning
IAQ	Indoor Air Quality
ICT	Information and communication Technology
IoT	Internet of Things
ITS	Intelligent Transportations System
KPI	Key Performance Indicator
LoRaWAN	Long Range Low Power Wide Area Network
M2M	Machine-to-machine
OAQ	Outdoor Air Quality
OSS	Open Source Software
PM	Particle Matter
RF	Radio Frequency
RTU	Remote Telemetry Unit
SQL	Structured Query Language
TCP	Transmission Control Protocol
TVOC	Total Volatile Organic Compounds
UI	User Interface

VLCi	Valencia smart City Platform
VOC	Volatile Organic Compounds

1. Introduction

This document (deliverable D2.2 *Technical requirements and high-level specifications v2*) presents the technical requirements and specifications for the use cases of ESTABLISH project. The major goal of this work package (WP) 2 is to provide definitions, requirements and specifications needed for the implementation of the ESTABLISH system. WP2 will collect and analyze the use case specific requirements to understand the motivation, interests, priorities and abilities of various stakeholders, establishing a context and concrete reference framework for the design and development of the technical solutions of the project. User needs and expectations towards defined use cases are explored via usability studies. Besides the requirements analysis, WP2 will codify the requirements in high-level technical specifications for the WPs 3-6. In those WPs, the requirements and specifications will be specified more in detail.

The work was started together with the partners in the kick-off meeting held in March 2017. There we brainstormed the use cases in groups. The ideas were discussed and prioritized together and the owners were chosen for the use cases. The use cases were developed further in smaller groups with the companies participating the certain use case. Use case definitions and user requirements together with state-of-the-art description has previously been reported in D2.1. The first version of D2.2 specified the use cases and concentrated on technical specifications of them. In that version, the descriptions were mainly based on the plans related to different use cases. Now, in this version 2, the use cases are going on and the descriptions and the requirements are more detailed and concrete. ESTABLISH project includes three use cases with six pilots. The pilot *Tracking of professional / non-profesional athletes with wearable sensors* is described for the first time in this deliverable due to the later funding decision of the Turkish partners.

This deliverable describes the technical requirements and high-level specifications related to the use cases. The deliverable is divided in four sections. After Introduction, the ESTABLISH use cases and pilots have been shortly described in Section 2. Technical requirements related to these pilots have been defined in Section 3. Section 4 includes the conclusions and the next steps for WP2. Use case specific technical specifications and general use case requirements are presented in Appendixes.

2. ESTABLISH use cases and pilots

In this deliverable, three use cases of ESTABLISH project with five pilots are shortly described:

- Use case 1: Optimized City and Mobility Planning
  - Optimized City Mobility Planning
- Use case 2: Developing smart HVAC systems that ensure a healthy indoor environment
  - Smart HVAC systems that ensure a healthy indoor environment
  - Intelligent air quality management system
- Use case 3: Promoting independence of specific vulnerable groups
  - Rehabilitation decision support,
  - Indoor air quality improvement at school, and
  - Tracking of Professional / non-profesional athletes with wearable sensors.

More specific use case and pilot descriptions can be found from D2.1 State-of-the-art, detailed use case definitions and user requirements. *Tracking of athletes with wearable sensors* pilot lead by Turkish partners has been described for the first time in this deliverable due to the later funding decision. Each pilot has its own company owner. The owner is in responsible for the progress of the pilot; planning, implementing and reporting in co-operation with other partners. Table 1 summarizes the roles of the partners in the pilots.

Table 1. Summary of ESTABLISH use cases with partner roles.

Pilot	**Owner**	**Partners**
Optimized City Mobility Planning	Prodevelop	Hi-Iberia, Tecnalia
Smart HVAC systems that ensure a healthy indoor environment	IMA	DEKPROJEKT, CUNI
Intelligent air quality management system	ETRI	Coway
Rehabilitation decision support	Siveco	BEIA, Prodevelop
Indoor air quality improvement at school	VTT	CGI (formerly Bigdatapump), Inspector Sec, Uniq Air, DEKPROJEKT, CUNI
Tracking of professional / non-profesional athletes with wearable sensors	Turkgen	Semantik

2.1 Optimized City Mobility Planning

Description and goal

Planning of urban development and traffic greatly affects air quality and consequently living conditions of a city. Based on environmental sensor data, complemented with other data sources (e.g., building footprints, demographics, traffic information, etc.) and geo-data analysis techniques, locations and/or routes will be profiled in terms of their environmental conditions and their impact on a healthy living environment.

Implementing smart transportation is a more durable way of raising the air quality in urban areas. Three key parameters will define smart mobility in urban areas:

- advanced traffic management system (ATMS),
- parking management, and
- intelligent transportations system (ITS) enabled transportation pricing systems.

In the use case on *Optimized City Mobility Planning*, the partners will build an advanced application for providing planning services and mobility information both for citizens and for city authorities considering relevant information such as contamination or traffic conditions (see Figure 1). This pilot will also enable gamification methodologies to motivate people to improve efficiency of the transport system and promote sustainable habits in the context of transport mobility.

The use case includes the development of a dashboard that displays the status of metrics and key performance indicators (KPIs) related with it. The essential features of the dashboard include a customizable interface and the ability to pull real-time data. The dashboard will have two perspectives, the first for the authorities and the second for the citizens.

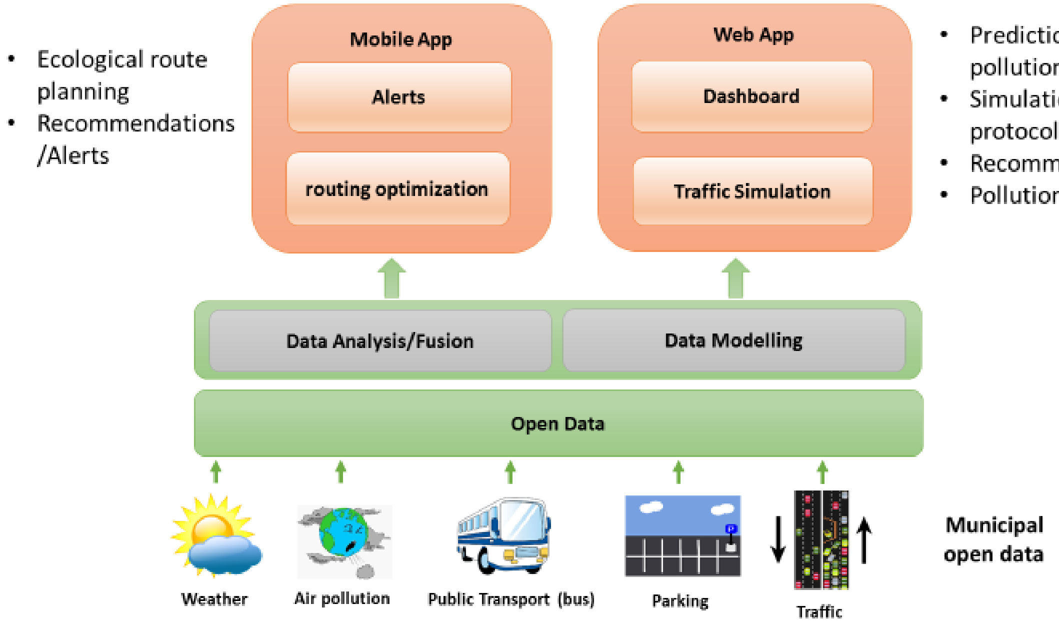

Figure 1. The idea of Optimized City and Mobility Planning use case.

The *Optimized City and Mobility Planning* will consider multi-modal mobility taking into account public and private transportation, awareness of energy usage, environmental conditions, pollution levels, travel costs and durations. The application will consider personalized preferences and constraints, the user may specify mobility problems, respiratory problems and allergies related to pollen suspended in the air, and these data will used to optimize the route to be calculated. Multi-Modal Mobility will not only improve the quality of life of individuals and, as a result, their health, but it will improve also the environment for society by reducing the air pollution produced by vehicle emissions.

Pilot

The pilot will be developed in Valencia (Spain), which is the third biggest city in Spain with 800,000 inhabitants. Valencia is investing many resources in its smart city platform and participates actively in many R&D projects and city networks (for example, Spanish Network for Smart Cities and The European Innovation Partnership on Smart Cities and Communities). Valencia is the first European city with a platform full FI-WARE compliant. Valencia Smart City Platform (VLCi) [1] contains nowadays more than 100 open data sources. These data sources are freely available for anybody, without copyright, patent or any other restriction. Valencia city council is not a partner of the Establish project but it is committed to collaborate with the pilot from the beginning and will provide support in the use of VLCi, access to new sources that will be incorporated into its platform in the future and validation of the use case. The partners involved in the use case will regularly review the new datasets and evaluate the possibility of incorporating them into the pilot.

Impact

The implementation of the use case will provide a series of benefits that will affect the increase in the quality of life of the citizens of Valencia and reducing the global pollution of the city. Thanks to the use of the application, the users will get several benefits such as reduction in average travel time in intra-urban movements, optimal routes personalized taking into account their preferences, mobility problems and health problems. The application will promote the use of greener and healthier means of transport, reducing energy consumption and pollution in cities. In order to carry out this system, it will use user information and data provided by different real-time data sources as well as weather forecasts. Through complex algorithms and forecasting models, the system will be able to predict future traffic congestion and elevated levels of pollution.

In addition, the system will provide feedback for cities and citizens. The application will show indicators on the use of different means of transport and roads. This information will be useful to detect needs of public services and to provide continuous improvement in these services.

The services for profiling geographic areas and routes in terms of their environmental conditions for city and route planning purposes will have the following impact:

- travel time reduction for individuals,
- energy savings on a city level,
- CO_2/NO_2 pollution decrease on a city level,
- reduction in overall queue lengths at public services, and
- increase proportion of people using Multi-Modal Mobility services.

2.2 Smart HVAC systems that ensure a healthy indoor environment

Description and goal

In the deliverable D2.1, current system solutions was described more in detail. It has been taken as background of ESTABLISH platform in *Smart HVAC systems that ensure a healthy indoor environment* pilot. The basic architecture of simple local air quality monitoring system was explained. Two key system components were sensor devices and data aggregator, data were stored and interpreted using web-based interface for MAS DB data management, which has been developed on a Microsoft Silverlight platform.

[1] http://gobiernoabierto.valencia.es/en/

Applications developed on this platform offer a visually attractive and intuitive user-friendly interface to many database systems and fulfil all requirements to the user control comfort and data visualization. In this deliverable, we are going further in innovation of almost all system components described in D2.1.

The main goals that we pursue are assign the acquired data to owners, use credentials and secure connections, capability for editing of parameters for owners of sensors, graphical view at the optimal scale (time and value), alert notifications when critical (min/max) limits are exceeded, connect and setup the actuators in order to improve the environment conditions.

Pilot

The *Smart HVAC systems that ensure a healthy indoor environment* pilot will develop such a HVAC system (focusing on automatic window opener and air handling unit) that will also autonomously learn behavior patterns of the users/inhabitants of the building and take advantage of this knowledge to get the building ready for the predicted needs. It will try to resolve the tension between energy efficiency and quality of indoor climates that occurs e.g. after retrofitting of existing buildings by offering an affordable solution.

Based on technical requirements given in Chapter 3.2, we will develop more than basic monitoring concept on how the air quality monitoring should be integrated at home or office environment management, in order to ensure elimination of negative aspects of sealed up homes (offices) and to contribute to quality of living, see Figure 2.

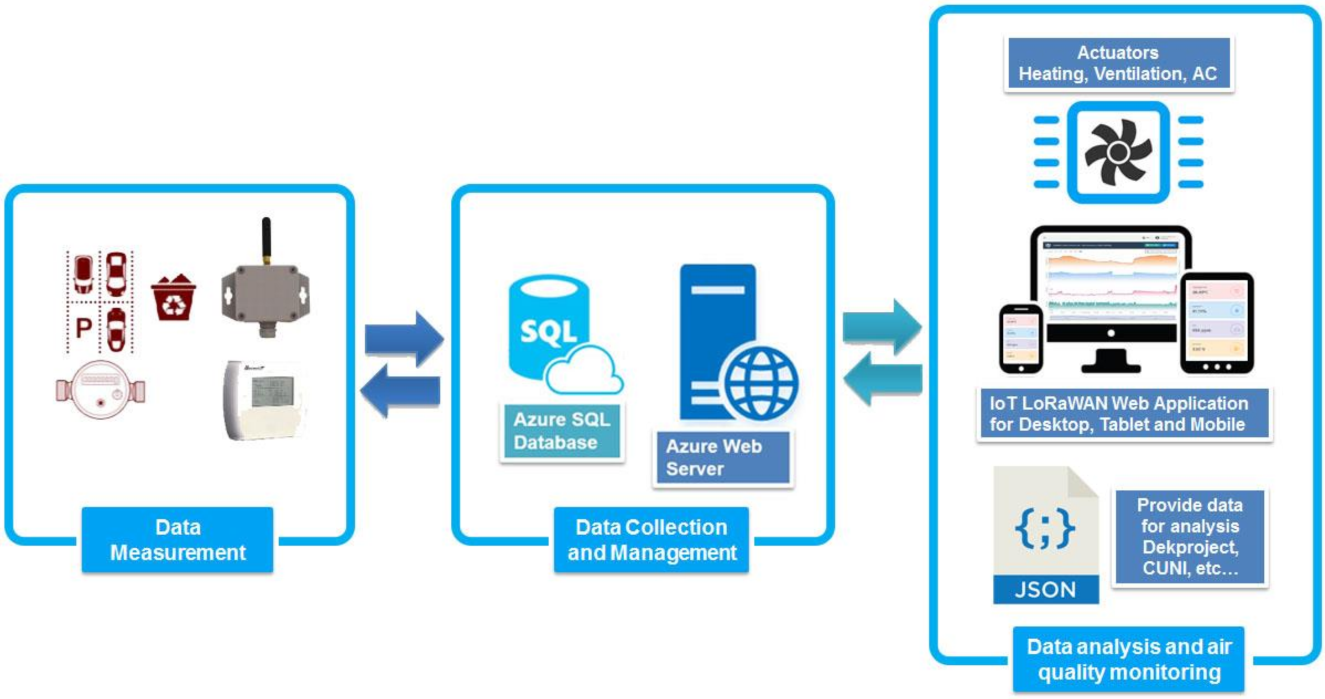

Figure 2. Usual management of home/ office environment.

The Data Measurement are sensors providing very long range and high interference immunity whilst minimising current consumption. Sensor makes it really easy to add humidity and temperature data. It's perfect for remote weather stations, home and office environmental control systems.

Data collection carried out Azure SQL Database. This is the intelligent, fully managed relational cloud database service that provides the broadest SQL Server engine compatibility. Data management carried out Microsoft Azure Web Sites is a cloud computing based platform for hosting websites, created and operated by Microsoft.

Sensor data is used for analysis and graphical representation. Moreover, the measured values can be viewed as numerical tables. If you need data for further use (calculations, statistics, analytics, etc.), you can simply export them directly to a CSV, XLS or PDF data file. The service evaluates when critical tempterature, humidity and CO2 limits are exceeded, immediately sends you a notification via e-mail or SMS. Using actuators, we can automaticly respond to changes in the environment. Actuators typically are used in manufacturing or industrial applications and might be used in devices such as ventilation and heating of office and home.

Impact

Providing superior indoor air quality (IAQ) can improve health, work and school performance, as well as reduce health care costs, and consequently become a source of substantial economic benefits. While some see energy efficiency and IAQ as contradictory goals, an integrated design suggested in the pilot can bring on the market an affordable high performing control system for buildings or flats that will bring savings in energy consumption (up to 15%) while maintaining good IAQ. All stakeholders yearn for healthy environment either if they stay there as residents or if they design new components of HVAC.

Building up a new subsystem - environmental sensor network - on top of ID system platform will extremely speed up introduction of new air quality services and applications within the current systems since the main system components and communication channels are already verified on presently running ID and building services. Facilitation of the new sensor subsystem implementation makes faster market access possible and brings essential competitive advantage.

2.3 Intelligent air quality management system

Description and goal

On the industrialization and the climate change in the world, the living environment of people is being exposed to the external pollutions. The indoor air quality is more affected by the pollutants, because of proceeding the purification within the confined spaces. For instance, Korea peninsular is seasonally influenced by the contaminated dust that generated from the industrial complexes in China. At that time, most of the citizen in Korea cannot open the windows for ventilation of air and should wear a mask when going out. If some technologies can rapidly detect and clear the source of pollutants when the contaminants came into the building such as the house and the office, it will be one of the solutions to ensure the fresh and safe air quality in indoors.

The *Intelligent air quality management system* pilot will contribute to developing the technologies and implementing the air purification system that can provide the clean and healthy spaces in the buildings, through connecting the information between the IAQ (Indoor Air Quality) / OAQ (Outdoor Air Quality) devices and the human activities. As the use case in the pilot, the ESTABLISH will assist the people residing in the buildings for a long time, e.g. patients, workers, senior citizens, children, by providing the comfortable environment.

Pilot

The *Intelligent air quality management system* pilot will contribute to developing a healthy indoor environment in the buildings that can automatically adjust its conditions to better temperature, air quality, humidity, etc. using the results analyzed by the environmental data, see Figure 3. The pilot will achieve the solution to generate the well-being, safe, comfortable indoor spaces for the people, especially the senior and the children.

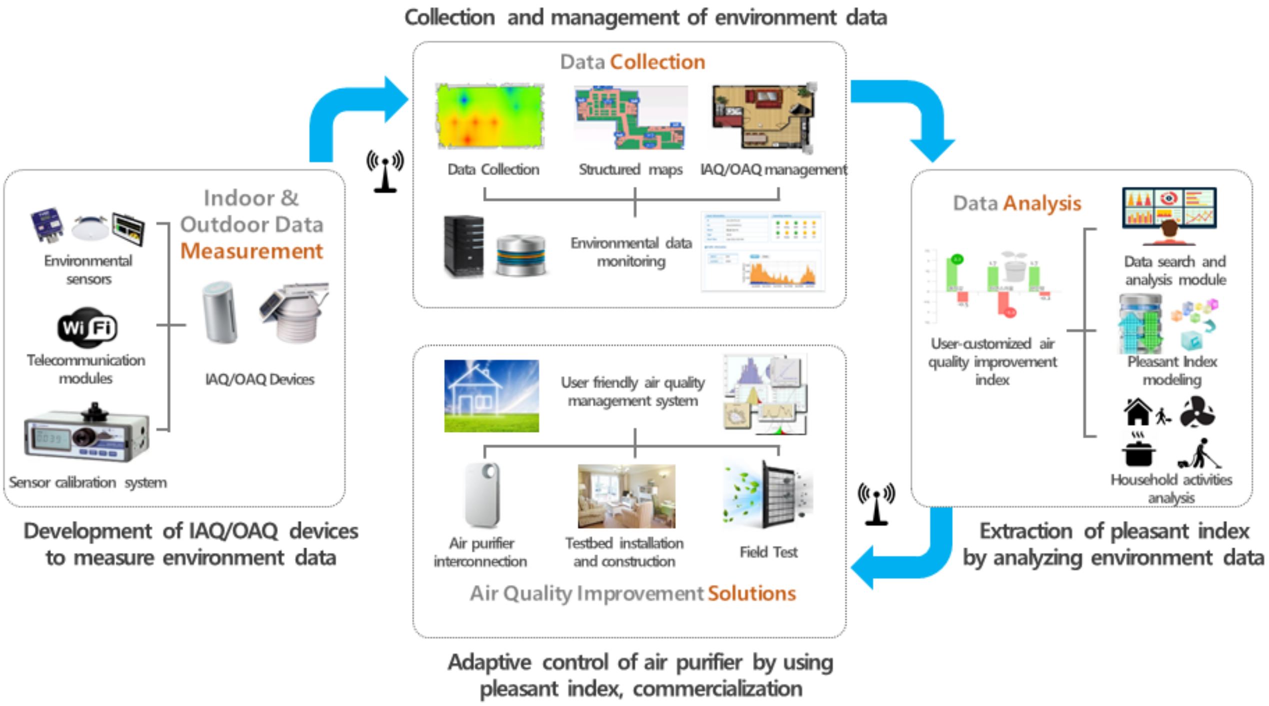

Figure 3. Intelligent air quality management system based on environmental data.

As shown in Figure 3, the pilot proposed the system architecture for data measurement, collection, analysis, and the solution in order to provide the clean air quality to the people by integrating the IAQ/OAQ devices, the server platform, and the air purifiers. The pilot is responsible for developing four major components to achieve the target goal of the system; data measurement, data collection and management, data analysis, and system solution.

<u>Data Measurement</u>: IAQ and OAQ devices integrate many kinds of sensors to measure the various environmental information into one hardware module. The devices also include the functions of the wireless communication to transmit the measured information.

<u>Data Collection and Management</u>: The server platform can manage the environmental data gathered by the IAQ and OAQ devices. Its main function is the extraction of the key information by analyzing the environmental data in the form of the big data.

<u>Data Analysis:</u> The algorithms such as the machine learning and data mining find out the indicators to improve the air quality by classifying the user life patterns and detecting the air pollution sources. It can improve the effectiveness and minimize the management cost of air purifiers by notifying the replacement cycle of filter parts, which are the core of the air purifier, through analyzing the contamination degree of the environment.

<u>System Solution:</u> The improvement indicators of the air quality are used for the program to interconnect the intelligent management system of the air quality and the air purifiers. The field test can improve the reliability of the developed system for the commercialization in the practical applications.

Impact

The pilot expects to achieve the positive effects in variety aspects. As the technical effect, the development of IAQ/OAQ devices can support to measure the various environmental data related to the air quality so that the air appliances such as air purifiers, air conditioner, humidifier, ventilator, etc. are used into the IoT technology ecosystem. In addition, as the economic and industrial effects, the developed system provides an opportunity to pre-empt the market related to the air quality through earlier commercialization since the people are more and more interested in the clean air of the living space according to increasing of the health threaten factor such as the fine dust, VOC, etc. Moreover, it contributes to improving the quality of life by providing the fresh air in indoors. Finally, as the social and cultural effects, the proposed system can improve the health of the people and minimize the social cost by preventing respiratory disease caused by the polluted air.

2.4 Rehabilitation decision support

Description and goal

The ESTABLISH project appeared in the context in which wireless technologies have opened up new possibilities and applications in increasingly diverse areas of the medical field. Using medical devices together with communication technologies to monitor certain conditions and/or symptoms has laid the foundation for the integration of M2M technology in the medical industry, a phenomenon referred to as telehealth and e-health. eHealth services and mHealth applications contribute to improving the efficiency and coverage of programs for personal health monitoring, also facilitating communication between patients and medical professionals.

The *Rehabilitation decision support* pilot will combine environmental sensor data with physiological and behavioral sensor data to empower patients in a rehabilitation clinic with decision support tools for behavioral choices and treatment options.

The goals of the pilot are to:

- monitor health parameters to continually improve the health of the population through rehabilitation programmes focused on physical recovery care, explicitly targeting the patient's functional aspect of integration in everyday life, environment, and work,
- develop a decision support system and services based on the outdoors environment parameters and indoor location, and
- reduce operations costs and improve quality of the services provided.

In order to find links between the biological data and environmental conditions it is required to monitor the pysical activities (monitoring heart rate, the burned calories, sleep patterns) during the recovery programmes as recommended by the kynetotherapists, trainers, or physical education teacher.

Pilot

The *Rehabilitation decision support* pilot will run in the premises of a Romanian NGO[2], in Bucharest; while monitoring the environmental data, temperature, relative humidity, pressure, wind speed, together with the air pollutants concentrations (SO2, CO, O3, NO2, PM2.5, and PM10).

For the running of the pilot has been chosen heretofore a ten subjects segment by different gender and ages, different affections and different recovery plans.

[2] ASOCIATIA MAME, https://asociatiamame.com/

Age groups			Gender	
Children	Middle Age	Old Age	Male	Female
6	3	1	2	8

The pilot's location is presented in Figure 4.

Figure 4. Location of the pilot.

In the pilot's study group we have identified different health affections such as overweight, obesity, kyphosis, scoliosis, lombosacralgia, rheumatoid arthritis, and lymphedema.

The main objectives and recovery plan in fighting the previously mentioned affections consists in physical therapy to promote weight loss, amelioration of the column posture, increase of the column flexibility, increasing muscle strength, improving breathing and increasing lung ventilation, promoting physical and mental health and fighting pain and inflammation. All of these are made through physical exercise and offers an excellent opportunity for multiple parameters monitoring performed by the physiological and behavioral sensors. Based on the biological parameters the physical therapist can personalize the patients' recovery programme either to improve it or to adjust it so that it does not harm the patient, and also assess in time the evolution of the patients' recovery.

In Figure 5, the proposed architecture for data collection and an experimental solution for monitoring functionalities[3] are presented.

[3] *http://graphite.readthedocs.io/en/latest/*

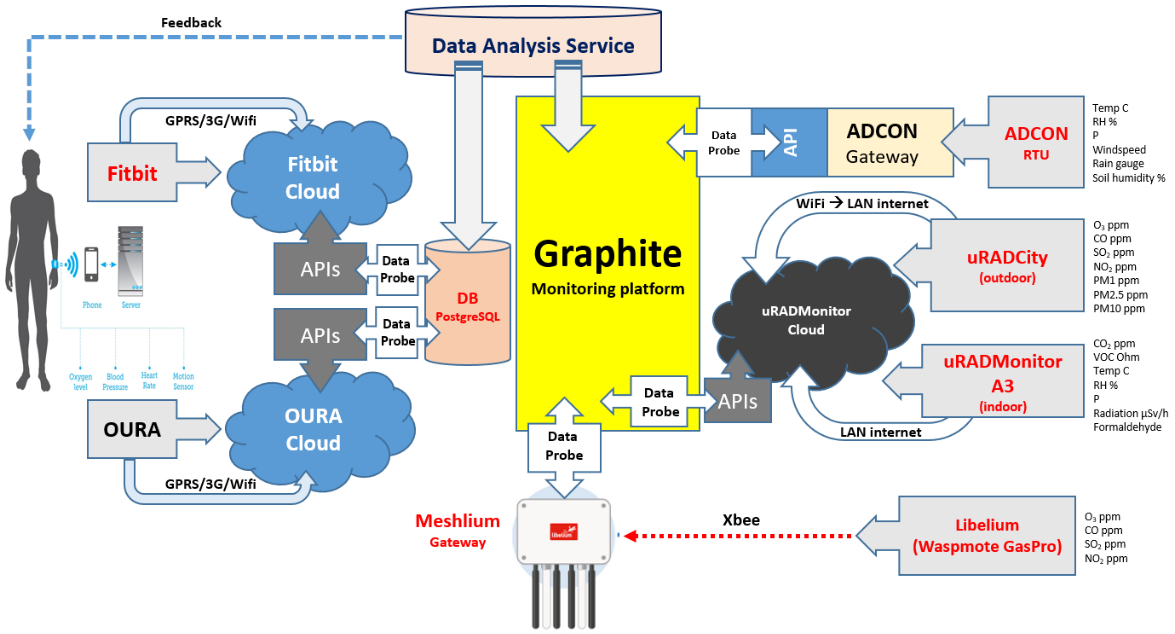

Figure 5. Sensors Architecture.

The rehabilitation decision support use case integrates the following hardware solutions:

- Libelium Plug&Sense Smart Cities Pro, this outdoor air quality (OAQ) monitoring stations includes the following sensors Temperature, Relative humidity, Pressure, PM1, PM2.5, PM10, NO2, Lux, CO, and O3. This OAQ station features a robust waterproof IP65 enclosure. Libelium Smart Cities Pro uses a 4G communication module to send data to cloud storage or Gateway.
- The outdoor air quality monitoring is also performed by a uRADMonitor City device. This OAQ device is equipped with the following sensors O3, SO2, NO2, CO, PM1, PM2.5, PM10. uRADMonitor City comes in a rugged aluminium enclosure with wall mounting support and communicates with the developer cloud platform through a WiFi module.
- Libelium Gas Board is an indoor air quality (IAQ) monitoring device which includes the following sensors Temperature, Relative humidity, CO, NO2, VOCs, and O2. The IAQ device communicates with the cloud storage through a WiFi module.
- ADCON telemetry station is an outdoor agro-meteorology station, designed for IoT projects like irrigation control, meteorology and water management. The RTU can send data through UHF radio or GSM/GPRS/UMTS and can operate on a solar panel in harsh environmental conditions.
- Fitbit Charge 2 it's a fitness wristband ideal for monitoring physical activities. Its an vital hardware unit due to its heart rate monitoring function, and other biological parameters like burned calories, steps, sleeping hours, etc.

In addition, to achieve the objective in developing the rehabilitation decision support, we analyzed several available solutions for correlations over the impact of air pollution on human health.

Links between air pollutants and health effects

For the establishment of the links between air pollutants and health effects we propose air quality indexes from various countries (i.e. U.K, U.S.A)[4].

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[4] *https://www3.epa.gov/airnow/aqi-technical-assistance-document-may2016.pdf*

UK air quality index[5] (UK – AQI) recommends breakpoints between the bands of Low, Moderate, High and Very High for each of the index pollutants (for SO2, O3, NO2, PM10 and PM2.5). The information that accompany the air quality index includes additional advice for susceptible individuals, together with advice for the general population. Short-term health effects of air pollution and action that can be taken to reduce impacts and health advice linked to each band to accompany the air quality index are presented. In addition, it is recommended the use of 'trigger' values to complement the air quality index and allow for the prediction of episodes of elevated air pollution in real time as they emerge.

U.S. air quality index (US- AQI) are estimated based on measured value for five pollutants (O3, PM10, PM2.5, CO, SO2 and NO2) and include the health effects messages, sensitive groups presentation, and cautionary statements for each pollutant. In Table 2, the pollutants specific sensitive groups are presented.

Table 2. Pollutant-Specific Sensitive Groups[6].

Pollutant that had registered an AQI above 100	Sensitive Groups
Ozone	People with lung disease, children, older adults, people who are active outdoors (including outdoor workers), people with certain genetic variants, and people with diets limited in certain nutrients are the groups most at risk
PM2.5	People with heart or lung disease, older adults, children, and people of lower socioeconomic status are the groups most at risk
PM10	People with heart or lung disease, older adults, children, and people of lower socioeconomic status are the groups most at risk
CO	People with heart disease is the group most at risk
NO2	People with asthma, children, and older adults are the groups most at risk
SO2	People with asthma, children, and older adults are the groups most at risk

The technical development for collecting the environmental and physiological data are detailed in section 3.4.

Impact

The pilot aims to offer people an innovative system, which will be their source of information on the environmental conditions in which they conduct daily activities. By analyzing this information through the decision support module, ESTABLISH aims to increase the quality of recovery programmes and aid medical personnel, trainers, or physical education teachers - while working with vulnerable groups (children, women, elderly) from the health care professionals specialized in recovery and rehabilitation.

This system will reduce the negative effects that environmental conditions may have on the health of the people in these types of groups and will increase their independence and wellbeing.

Air quality monitoring studies conducted in Romania draw attention to the risk areas and hazardous substances, highlighting the link between air pollution and the effects of this phenomenon on health.

[5] https://www.gov.uk/government/publications/comeap-review-of-the-uk-air-quality-index

[6] Source: Technical Assistance Document for the Reporting of Daily Air Quality – the Air Quality Index (AQI), U.S. Environmental Protection Agency, EPA-454/B-16-002, May 2016

The pilot will advance a solution designed for recovery centers and educational institutions (eg.high schools, sports universities, spa centers etc.).

The number of people who do outdoor physical activities (jogging) or in special gyms is on the rise. Apart from those who intend maintaining their fitness levels and preventing obesity, there are people who have been prescribed physical activities related to recovery / the restoring of motor functionalities, both outdoors and indoors.

2.5 Indoor air quality improvement at school

Description and goal

The *Indoor air quality improvement at school* pilot will study the use of a variety of indoor sensors and wearables combined with users' personal feedback and environmental sensing information to provide a healthier living environment for pupils, teachers, and other staff members at schools, see Figure 6. The goal is also to collect requirements on the service for better IAQ and well-being and to develop a service that provides real-time feedback (e.g. in the form or measurement visualisations) on the IAQ. It is also studied whether the objective measurements correlate with the subjective ones. The idea is to learn from sensor data by means of combining different data streams and applying environmental models, machine learning, data mining and supported by big data ICT. This will ultimately enable optimization of power provision and self-adaptive HVAC control and air purification in the building.

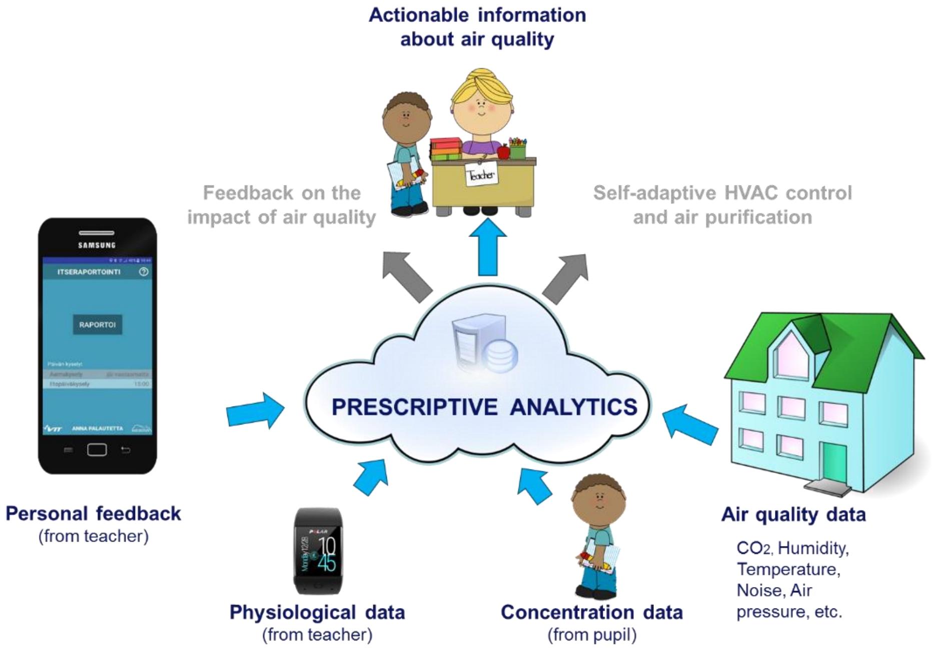


Figure 6. Idea of the Indoor air quality improvement at school.

Pilot

Before the pilot, there was **pre-pilot** at VTT in Spring 2018 and smaller group of volunteers continued until the Autumn for receiving data across seasons. Fifteen offices (20 participants) and one meeting room were equipped with indoor air quality monitoring systems and environmental motion sensors (depth cameras and/ or passive infrared motion detectors), and volunteer participants (14) used the wearable sensors to monitor their physiological data. The participants reported perceptions on the IAQ and symptoms with a mobile app developed for the project. In the pre-pilot, the pilot sensor setup was tested regarding their reliability to be able to choose the most suitable sensors to the actual school pilot. The pilot protocol was also tested.

The **actual pilot** will be performed at one school in Finland in Autumn 2018. Four rooms at the school will be equipped with air quality monitoring systems, determined in the technical specifications. Sensors for indoor air quality measurements will include temperature, humidity, air pressure, pressure difference (inside vs outside), carbon dioxide (CO2), and a TVOC (total volatile organic compounds) based Air Quality Indication. In addition, (pseudoanonymized) noise levels and person movements are tracked in each room. In the pilot, the staff members of the schools will receive suitable sensors for monitoring their health condition (physiological data) like heart rate (HR) or heart rate variation (HRV), and activity. They are able to provide feedback about their well-being, and their feelings related to the IAQ, using a mobile application. The concentratioin of the pupils will be measured with 5-minute pen and paper concentration tests on a group level.

The pilot at school is 4-phased (see Figure 7). *In the first phase* the teachers will be monitored with the IAQ sensors and wearable devices and report their feelings related to indoor IAQ and symptoms. *In the second phase*, the teachers will receive additionally visualisations of the measurements. *In the third and fourth phases*, there will be additionally indoor air purifier in the classrooms. Two of them are working normally and two of them are “fake” working. After the third phase, the purifiers will be changed so that the rooms that didn’t have truly working will get the working purifiers and vice versa.

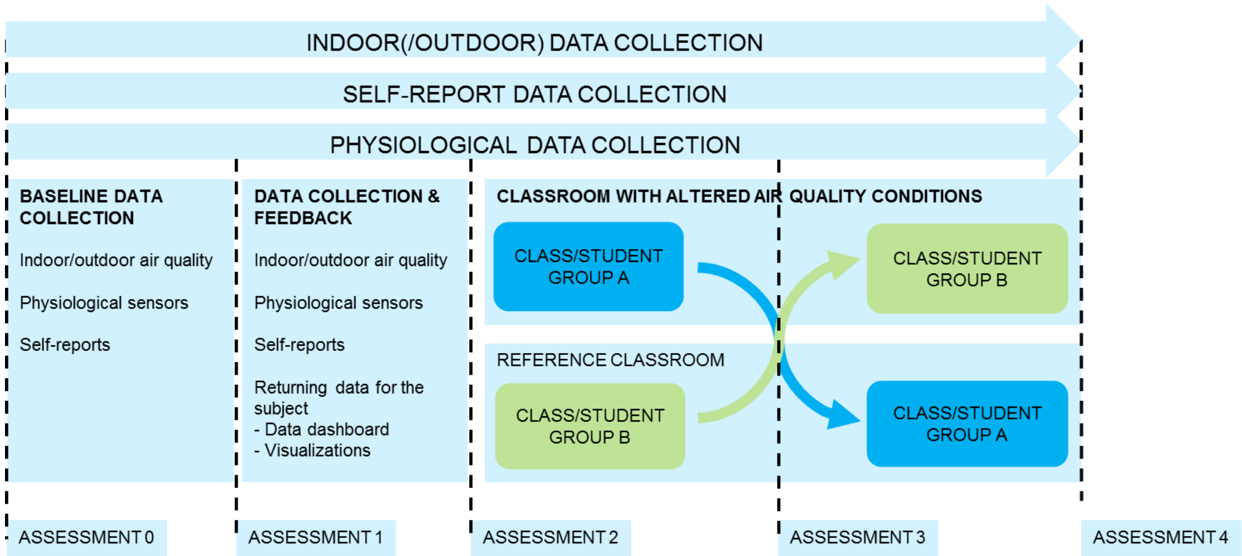


Figure 7. Pilot structure and contents.

The feedback data and data from the wearable devices and sensors will be collected to Azure cloud platform and stored, pre-processed and analyzed based on the time stamps. Based on the real-time analyses, users could get e.g. visualizations about the air quality (data from the sensors) compared to their wellbeing via the application. The need and possibility to utilize the air purifiers in the pilot at school will be evaluated.

Test environment. Available TePi environment will be utilized in the pilot including Azure cloud platform to data handling, as it has been planned in the real pilot. An unique TePi piloting environment at VTT comprises of an Internet of Things (IoT) platform, a data management & analysis platform and a demonstration facility. The Industrial internet platform exploits the latest advancements of 5G, IoT and cyber security technologies and methods. In addition, related data management and analysis platform includes a server cluster for computationally intensive tasks for enabling lightning fast parallel computation, *e.g.* training deep learning neural networks and fast processing of huge datasets.

User involvement. To understand the needs and expectations of the users, the work will be started to involve the users (VTT workers and staff members of the school) to the innovation process. Users of the buildings will be surveyed to understand the present state and how would they like to improve the air quality and service related to it. These results will be utilized when planning the application and future services for the users.

Impact

The goal of the *Indoor air quality improvement at school* pilot is to research, co-innovate and develop a cloud-based air quality measurement, analysis and feedback system that provides information on the impact of indoor or limited outdoor (*e.g*. mine, tunnel) air quality on people's health and wellbeing. The main application scope of ESTABLISH is products, services and solutions on an individual level utilizing environmental sensors (air quality, temperature) and combining the environmental input with other data sources, for example personal wearable sensors. This pilot will enable to go from *monitorin*g the indoor or limited outdoor to *managing* the environmental conditions on a personal level and thus improving the quality of life, reducing health costs and supporting vulnerable groups such as children.

The technological developments will lead to a wide range of new services and products that are all based on environmental sensors. Thus, ESTABLISH will create business opportunities for sensor manufacturers, service providers (*e.g.* facility management companies), software developers, health organizations, health insurance companies and HVAC manufacturers.

2.6 Tracking of professional / non-profesional athletes with weareable sensors

Description and goal

Because of its relation with sports, entertainment, health and economy, sport and even every sports category has been seen as an industry. From the sport industry point of view, tracking and managing the parameters affecting the sport such as physical condition, health, motivation, eating, drinking and sleeping for amateur and professional athletes operating in individual or team sports in Europe and in our country became important. The development of wearable devices has given rise to new fields such as data analytics, reporting, developing a recommender system, while removing the problem of data collection. Wearable sensors, sensors that enable measurement of environmental factors and data from mobile applications can be analyzed to give suggestions as health and life assistant to the athletes. In this sense, the pilot, which aims to close an important gap, will present innovations in the sense of solving the problems experienced with its goals. The main objective of this pilot is to define an IoT infrastructure that integrates different sensor technologies.This infrastructure will includes the several capabilities such that:

- Environmental factors, body basic state parameters will be collected and analyzed with machine learning and text mining methods.
- According to the results, the services and the applications that are able to provide guidance and direction can be developed.

Pilot

In the real world, each individual has his own scenarios, stories, sensitivities that will be priorities for him. The ESTABLISH is a platform that provides analysis, reporting and management of actions that an individual has taken to facilitate his or her life style. ESTABLISH will be implemented as a PaaS (Platform as a Service), see Figure 8. The platform will have the ability to receive and store data from any device that has the capability of communicating and will have the ability to make suggestions based on the prescription (Rule sets) that will be created by users based on their profile. Platform will include content based recommender system for recommendation. Thus, it will be a platform that can be used by amateur or professional individual and team athletes who want to record, report and manage their sports activities, as well as individuals who use lifestyle facilitating devices.

In the platform there is also another data type which is environmental measurement data such as air quality and temperature of ambient. This data type will be got from an state-owned organization which is authority about environmental issues.This organization publishes environmental measurements such as temperature and air quality on a neighborhood basis. If the athlete is outdoors, the published measurement data will be used. If the athlete is in the indoor environment, the measurements will be taken from the sensors that measure the indoor air quality and temperature.

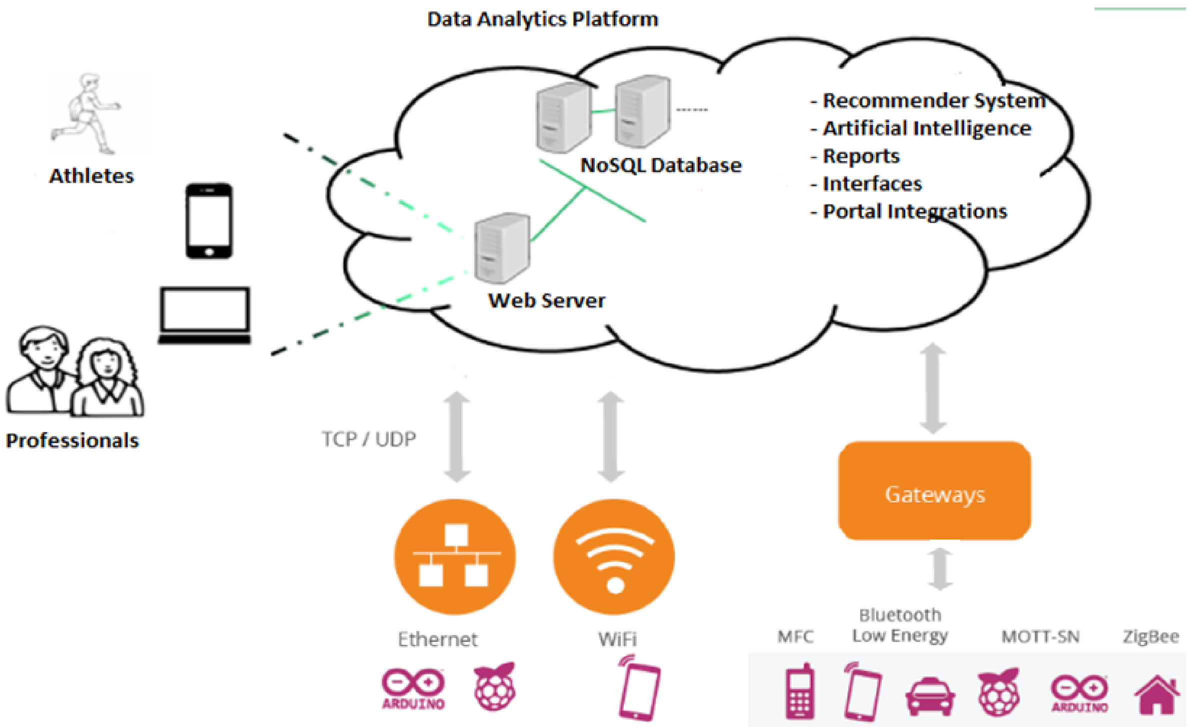


Figure 8. Tracking of Professional / non-profesional athletes with weareable sensors.

The goal of pilot is to implement necessary functions and algorithms that include coaching for the amateur and professional athletes, training management, recommender system that works with artificial intelligence.

For example, an athlete may keep his training program on his profile on the platform as a recipe. Wearable sensors can be used to transmit values that measure body behavior in his/her sports activities. The athlete will be able to see these values in meaningful reports and will be able to take recommendations on behalf of coaching according to the pre-entered rules and the results obtained from the analysis of the transferred data.The success and performance of athletes depends on spiritual motivation as much as they are physical in competitions and training sessions. Keeping this constantly high is the task of sports coaching, but after a certain point in the real world, the data that can reach from the different channels generated by the development of technology, and the reactions of the athletes are not followed. In the project the data can be riched out from different channels like social media messages and sharings, not just from sensors. This final data can be analyzed and corralated to provide appropriate results.

Semantik company will extract the morale of the athlete from the written and shared text messages and convert it to numerical value. And by sending the stimulus required to keep it high, actions can be taken to increase motivation.

Turkgen company has an expertize about data analytics and its technologies. Data acquisition, data analytics and information delivery steps will be realized by Turkgen.

The main components of the project are:

1. Extracting meaninfull information by analyzing collected data from mobile applications and IOT devices.

2. Integration of semantic data using Big Data platform,

3. Content-aware adaptation and automation of the IOT infrastructure,

4. Development of a suggestion system based on the results of data analysis.

5. Development of mobile and web applications software for tracking data, accessing analysis results and tracking recommendations.

Impact

Studies and products that are related to sensor data are about the definition of position, condition, environment and physical activities (motion) independently from content. The bottleneck of the today used technologies is that; collecting data from different sources (sensors, portals, wearable devices) into a holistic infrastructure and not converting these data into universally understandable meta-data. When this is done, the user's activity will be able to characterize the data content.

3. Technical requirements

3.1 Optimized City Mobility Planning

The pilot *Optimized City Mobility Planning* will build an advanced application for providing planning services and mobility information both for citizens and for city authorities considering relevant information such as contamination or traffic conditions. This pilot will also enable gamification methodologies to motivate people to improve efficiency of the transport system and promote sustainable habits in the context of transport mobility.

The pilot will provide a dashboard to display metrics and KPIs. The essential features of the dashboard product include a customizable interface and the ability to pull real-time data.

After the meeting between the Spanish consortium and the city council of Valencia, the scope of the pilot and the requirements have been defined.

Technical development

The use case will take into consideration the following technical aspects:

- Route planner:
  - Different means of transportation
  - Mono and / or multi-modal planning
  - Total flexibility in map definition and geographic scope
  - Fully configurable metrics (environmental impact, time, distance, mix, etc. ...)
  - Particularization according to habits of mobility and personal preferences. Integration of public and private transport modes (buses, bicycle and car exchange), others as electric vehicle, private vehicle, bicycle), and
  - Connection with environmental impact assessment and energy consumption systems.
- Precise forecasting of traffic loads and pollution, simulation of pollution protocols based on the information provided by the Traffic Simulation Platform.
- Real-time recommendations and alerts, and future predictions about mobility and pollution based on the fusion of different open data (such as air pollution, weather, traffic, etc.) using big data and machine learning techniques.
- Environmental impact assessment.
  - Estimation of environmental impact “air pollution” based on traffic, topographic and meteorological information,
  - Indicators by zones, and
  - Asynchronous notification of alarms against thresholds.
- Integration of different public data sources useful for the use case.
- Consideration of user preferences, fuel consumption and contamination of the user's vehicle and health problems.
- Provision of a web solution for city authorities and a mobile application for citizens.
- Develop a dashboard to analyze historical information and real time information. The dashboard will have to perspectives, one for the municipality and the other for the citizens.

Figure 9 presents a first approach for the implementation of *Optimized City and Mobility Planning use case*.

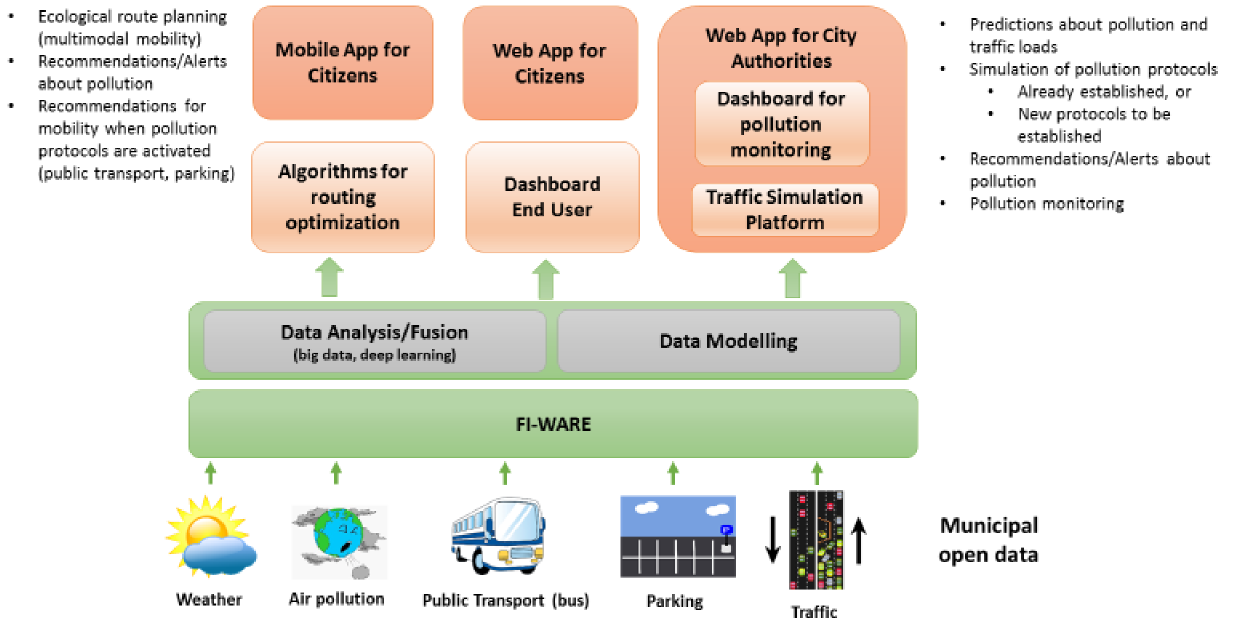


Figure 9. First approach for the implementation of Optimized City and Mobility Planning use case.

Technical requirements

Open data sources (Integration of different public data sources)

The use case will mainly use data obtained from the open data of the VLCi Platform. After several analysis of the current data available on the platform, the following data sources have been selected, as sources of data that can be incorporated into the demonstrator. Although the sources seem a priori to be of interest, these data should be analyzed deeply to determine whether data sources are finally selected. The criterion for choosing a data source would be based on the scope of data, reliability, and usefulness for the use case.

Data sources selected are:

- Air pollution stations distributed throughout the city, to be able to know the pollution in the districts of the city. These stations obtain daily data of the following measures: SO2, NO, NO2, PM10, Ni, NOx, Ozone, As, Pb, BaP, Cd)
- Measuring Stations for Pollen. Thes station are grouped by several tree species and measure the polen density per pollen. The species considered are: casuarina, ulmus, Ligustrum, Fraxinus, cupresuss, quercus, morus, olea, populus, pinus and Platanus.
- Bike line. Cycling routes of the city of Valencia.
- Bus. Google transit bus lines
- Night parking in the bus line
- Permanent no parking places. Geographical data on the location of the permanent no parking places
- Parking for motocycles.
- Bycicle parking
- Reduced mobility parking
- Real-time traffic status
- Sense of circulation. Traffic circulation directions
- Intensity of bicycle. Geodata of measurement points bikes (grouping of electromagnetic coils) and its time intensity

- Intensity of traffic by sections. The intensity data is updated every 15 minutes, the unit of measure is vehicles / hour. The data shown are collected by the electromagnetic loops.
- Status of the Valenbici stations "public bike transportation".
- ORA Expenders and parking
- Taxi stops
- EMT Stops. Location of the bus stops
- Street works in execution. Data on urbanization works carried out
- Municipal disctricts. Territorial Division integrated by Municipal Districts according to the amount of population.

The VLCi platform is based on Fiware, which is an open standard recommended by the European Commission for Smart Cities to ensure adaptation to the Internet of Things. The Main formats used by VLCi to expose the data are SHP, GML, WFS, WMS, KML, KMZ, CSV, JSON, JSON-LD, RDF XML/TURTLE /N3.

There are some means of public transport that go beyond the city of Valencia, as is the case of the metro that operates through several cities, for that reason the information of the metro is not included in the VCLi, to obtain this information, the use case will use the open data of the Generalitat Valenciana, that provides this data.

The Spanish consortium has initiated conversations with EMT to obtain the bus position in real-time.

In the last year new means of shared transport have arised in Valencia. If is possible, the pilot will condired these new services: shared electric bikes and electric cars.

In addition to the data obtained from the open data, the use case will make use of weather forecast systems; this information is relevant to make predictions of pollution levels.

To support the large amount of data required by the use case, the data will be stored in a non-SQL scalable database. It will provide a Restful API to manage data.

Data Fusion based on big data and deep learning techniques

This cloud platform for data fusion and data analysis based on big data and deep learning techniques intends to analyze the huge amount of heterogeneous information coming from the different municipal open data source (traffic, air pollution, weather, etc.) and to extract its meaning in order to infer and produce easily understandable higher-level information about mobility and pollution to the applications for stakeholders, allowing them to send predictions, recommendations and alerts for a dynamic urban mobility management to the citizens and city authorities in real time.

So, several specific technical requirements for this technical component have been identified as follows:

- This component should parse and process the heterogeneous data from the municipal open data source in order to homogenize them and so, to be able to infer new knowledge and higher-level information.
- This component should analyze historical municipal open data using big data and deep learning techniques to predict future problems related to mobility and pollution.
- This component should have learning capabilities using deep learning techniques.
- This component should produce recommendations and alerts about mobility and pollution in real time for the stakeholders.

This cloud platform for data fusion and data analysis follows the conceptual diagram shown in the Figure 10 below.

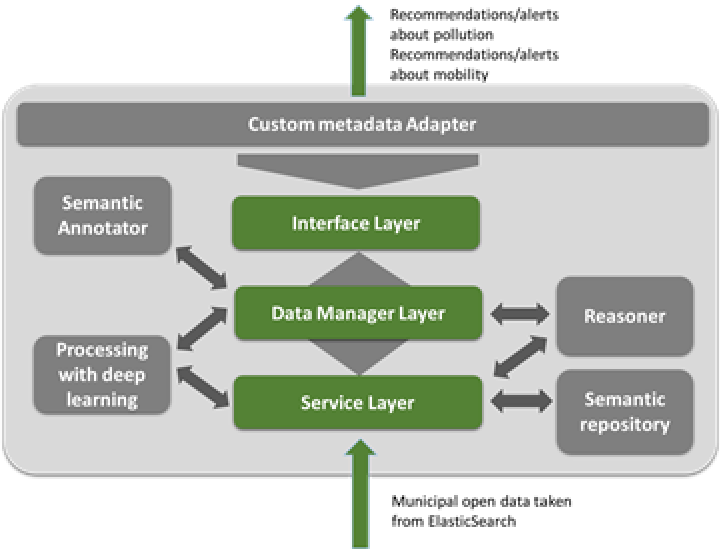


Figure 10. Data fusion and analysis in the pilot follow the conceptual diagram.

As observed, this technical component is a basic three-layered architecture made up of three layers:

- Interface Layer. The Interface Layer provides interfaces through which the cloud platform manages all of its input and output mechanisms.
- Data Manager Layer. The *Data Manager Layer* aims to annotate and store the incoming data in a unified model.
- Service Layer. The *Service Layer* is where semantics and reasoning are used to solve queries and to retrieve stored knowledge, and deep learning techniques are used to have learning capabilities.

Traffic Simulation Platform

Traffic Simulation Platform intends to predict the evolution of traffic loads and pollution levels in a city from historical municipal open data in order to optimize the mobility planning allowing to the city authorities to make decisions on:

- the urban mobility planning based on the pollution levels,
- the contingency plans (protocols against the pollution), while simulating how such (new or already established) protocols could evolve along the time.

or to perform different analysis about:

- the future predictions of the pollution levels,
- the management between the pollution levels and the traffic in the city.

So, several specific technical requirements for this technical component have been identified as follows:

- This Traffic Simulation Platform should generate blocks of historical and real-time data, by simulating the behavior of different vehicles travelling on different routes under different boundary conditions.
- The Traffic Simulation Platform should support the definition and the simulation of various scenarios.
- Traffic conditions, including light, heavy and very heavy traffic in parts of the road network.
- Road conditions, such as closed streets, congestion, etc.
- Weather conditions (this factor often affects time to reach a destination as well as the traffic conditions).

- The Traffic Simulation Platform should support the creation of multiple scenarios in order to setup and run different sets of repeatable boundary conditions for the underlying simulation tools
- The Traffic Simulation Platform should support the integration of additional plug-ins, in order to extend basic functionalities or to add specific features.

This Traffic Simulation Platform follows the conceptual diagram shown in the Figure 11 below.

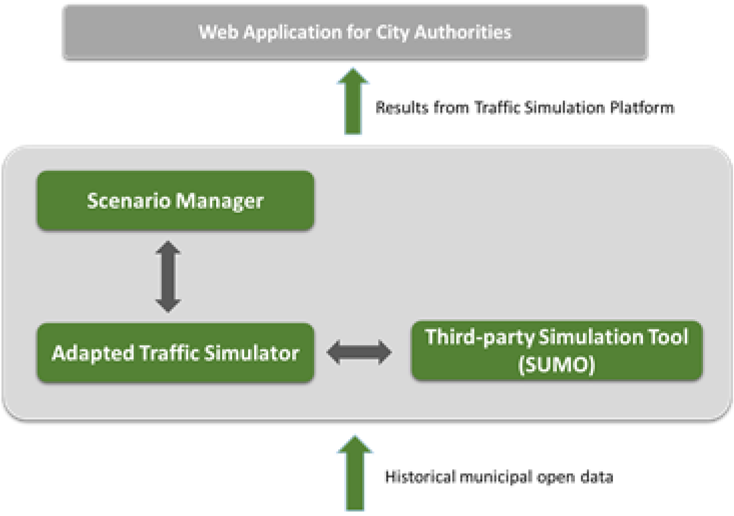


Figure 11. Traffic Simulation Platform.

As observed, this technical component is made up of three sub-components:

- Third-party simulation tool (SUMO). The Traffic Simulation Platform relies on an open source traffic simulator named as SUMO ("Simulator of Urban Mobility")
- Adapted traffic simulator. This subcomponent interfaces with SUMO for the execution of the simulation session. More specifically, it parses a simulation scenario, configures a simulation session according to the scenario, performs the simulation session of a configured scenario and besides, processes historical municipal open data in order to be more easily analyzed and delivered as input simulation data. This processing is done in external scripts to SUMO, which are developed in Python, since it facilitates the processing of XML files.
- Scenario Manager. This subcomponent generates a simulation scenario, parses simulation results and interfaces with the web application for city authorities. As in the above sub-component, the script which processes the results is developed in Python.

Mobile application for citizens

This mobile application intends to provide citizens with useful information about mobility and pollution in the city in real time, which has been produced by the cloud platform for data fusion and data analysis. Furthermore, this application also allows the citizens to have access to a route planner focused on the municipal open data.

So, several specific technical requirements for this technical component have been identified as follows:

- This mobile application should allow citizens to introduce a user profile with their preferences, their health problems, relevant information about their vehicles, etc.
- This mobile application should implement a notification management system in order to send recommendations and alerts about mobility and pollution to the citizens.

- This mobile application should allow citizens to calculate the most ecological route from any origin point to any destination point in the city.
- This mobile application should have an easy-to-use user interface that presents the information in a comprehensible way.
- In order to provide configurable and customizable routes, the system will consider the user's preferences when calculating the routes. These preferences include means of transport, heaths problems of the user and technical information (type of fuel, fuel consumption, gas emission) of the cars of the users.

It is important to remark that this mobile application will be an Android application and acts as the front-end side of the cloud platform for data fusion and data analysis and the route planner.

Web application for city authorities

This web application intends to help the city authorities in the decision-making about the urban mobility planning in terms of pollution levels, by showing them how the pollution is evolving in the city through a dashboard, and allowing them to analyze possible future situations/scenarios related to mobility and pollution through a traffic simulation platform.

So, several specific technical requirements for this application have been identified as follows:

- This web application should show the information on the pollution of the city in real time.
- This web application should allow the city authorities to create and configure different simulation scenarios.
- This web application should show the information related to the traffic loads and pollution levels according to the chosen simulation scenario.
- This web application should time responsiveness for basic user interactions.
- This web application should have an easy-to-use user interface that presents the information in a comprehensible way.

It is important to remark that this web application acts as the front-end side of the dashboard for pollution monitoring and the traffic simulation platform.

Multimodal Route planner

In the ESTABLISH project a route planner will be implemented in order to produce routes for different modes of transportation. Specifically the following modes are going to be considered for the pilot: walk, drive, bicycle, train (specifically the subway and light train handle by the MetroValencia, http://www.metrovalencia.es, company), bus (the network of buses of the metropolitan transportation company, the EMT, https://www.emtvalencia.es/). Figure 12 presents an example about multimodal routing.

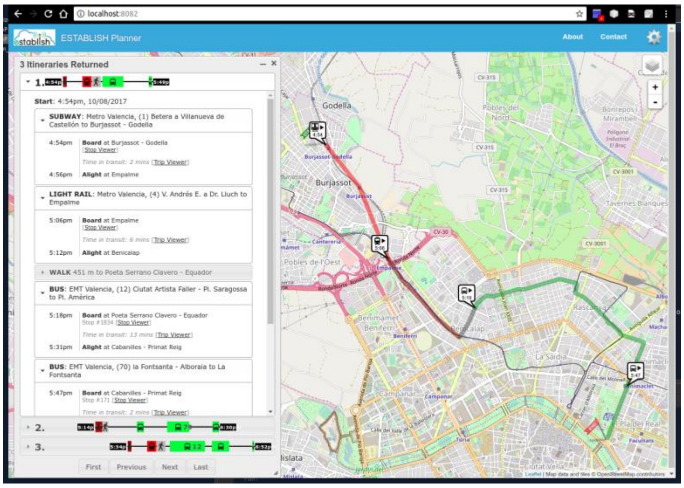


Figure 12. Example of a multimodal routing, which combines a leg by train, another walking and a final leg by bus.

These modes of transportation will be considered either in individual mode, usually referred as monomodal trip, or most likely in combinations of different modes multimodal routing. Multimodal routing has many different combinations, one of the most basic and most useful one is to consider public transit as the example shown in Example of a multimodal routing, which combines a leg by train, another walking and a final leg by bus. , this case considers travelling by bus, train or walk. Other types of multimodal travelling are also considered:

- “park and ride”, which implies using a private car up to a designated parking lot and from the using public transportation, and
- “kiss and ride” which implies that the first leg is realized as a passenger in a private car and therefore there is no need for a parking place, a designated area for performing the drop off is needed instead.

The geographic scope for the routing (Figure 13) engine englobes all of the metropolitan area of Valencia and beyond including the region where the buses belonging to the EMT give service.

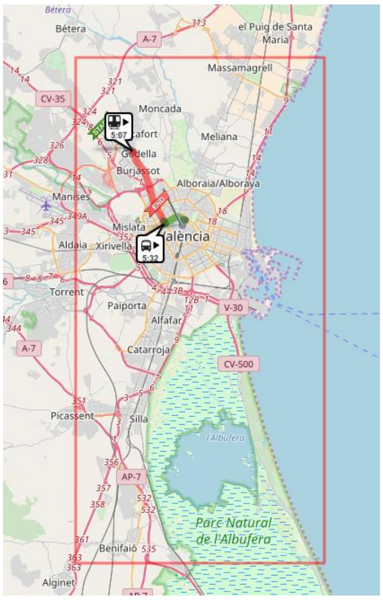


Figure 13. The considered area for the routing engine will include all the metropolitan area of Valencia and beyond.

The routing engine provides different metrics, which can be selected by the user in order to obtain the best route. For example, for the bicycle mode of transportation user will have the ability of choosing the shortest route, the easiest or the cleanest, i.e. the less pollute route or a combination of diffe rent metrics as it can be shown in Figure 14.

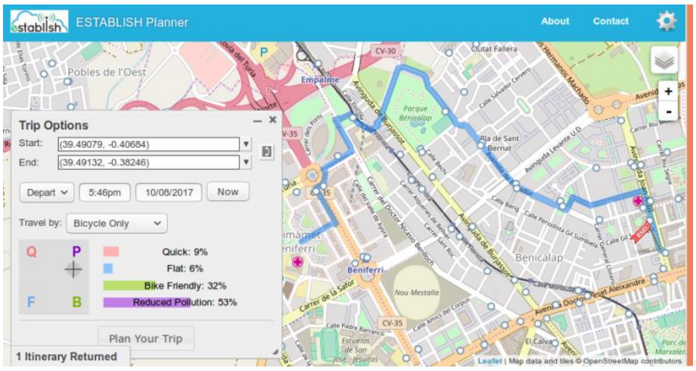


Figure 14. Metric configuration diagram for the bicycle mode of transportation.

The planner also will take into consideration the personal user preferences while providing a specific route. One specific way in which these preferences will be considered to consider the type of car the user will drive in order to gauge the impact in the pollution of a particular suggested route.

- Precise prediction and forecasting of traffic loads and pollution, simulation of pollution protocols based on based on the information provided by the Traffic Simulation Platform.
- Recommendations for mobility and alerts about pollution in real time based on the fusion of different open data (such as air pollution, weather, traffic, etc.) using big data and machine learning techniques.
- Environmental impact assessment

- Estimation of environmental impact "air pollution" based on traffic, topographic and meteorological information,
- Indicators by zones, and
- Asynchronous notification of alarms against thresholds.

Real time and historical Dashboard

The dashboard to be develop will use the latest technological advances and will be able to process historical and real time data and provide useful metrics and indicators for municipal technicians/politicians and users, incorporating advanced visualizations of information on maps and graphs.

The dashboard will allow municipal technicians/politicians to have access to different visualizations where they can request relevant information to obtain KPI and take decisions in real time. This dashboard will be configurable by municipal technicians to adapt the visualizations to their needs. In addition, the dashboard will have a second perspective for citizens, so users will have access to information provided by the city as operational decisions, strategic planning, real-time measurements, automatic alerts and reports. For instance, the dashboard will provide a real time status of bike stations and bus positions. The following images shows an example of a dashboard. Figure 15 presents an example of the dashboard for citizens.

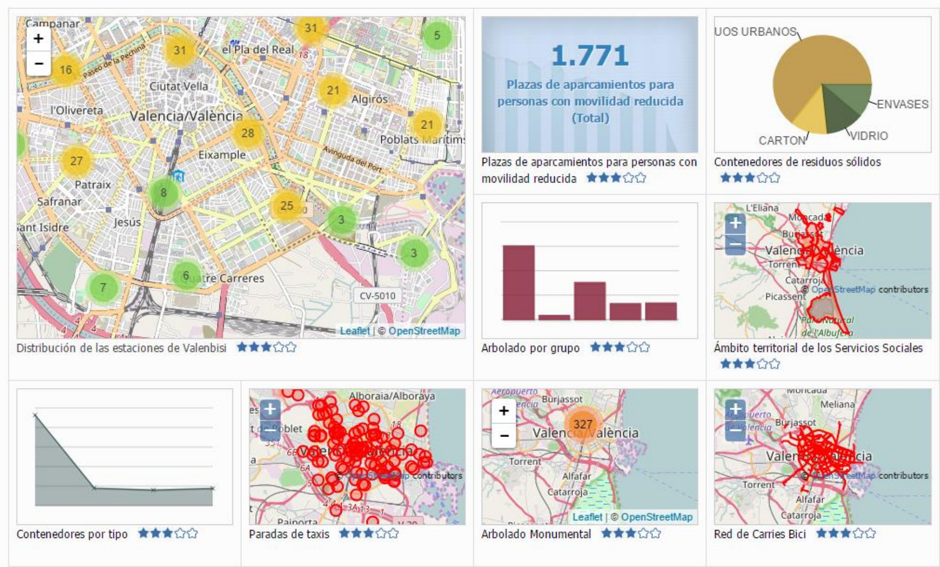


Figure 15. Example of a dashboard for citizens.

Technical specifications of the use case are presented in Appendix 1A. Use case requirements are presented in Appendix 1B.

3.2 Smart HVAC systems that ensure a healthy indoor environment

The use case *Smart HVAC systems that ensure a healthy indoor environment* will consist of hardware and software components, customer services and applications, running on specific cloud platform. The main requirements on hardware components are identified, partners will develop various sensors monitoring indoor air-quality, typically temperature, relative humidity and CO2 (IMA); Dekprojekt will develop ventilation actuators. The hardware components will be provided by control software. As for the software components, CU will develop edge cloud server and algorithms processing big data from sensors resulting in control processes at ventilation systems considering customer profiles and desired optimization schemes.

The use case will provide human interface and customer application to allow customer either feedback monitoring or/and active impact on the algorithm when optimization processed. Dekprojekt acts within the use case in role of system integrator and in role of technology user since its company business model.

All partners will participate at requirements elicitation and testing/validation. Test components of the use case will be deployed at IMA and Dekprojekt premises.

Technical development

Technical development will be concentrated to both new use case components and innovation of currently available components. Depend on partners' objectives the development is directed towards

- sensors, their interfaces and data gathering (gateway) (IMA),
- data processing on the cloud framework, algorithms, assessment, data interpretation (CU),
- control and act of HVAC components based on sensor data assessment (DEKPROJEKT).

The use case will demonstrate components running in the whole value chain when special interest is given on feedback control functions and services. Even though fully automatic process is intended, all the stakeholders will be able to influence the component behavior via their mobile devices and user profile can be employed.

Technical requirements on new HVAC pilot

Use case requirements list is built on current system experience.

Technology for data collection devices, sensors:

- low range wireless technology.
- low power,
- stabile and robust,
- easy to implement, operate and maintain,
- bi-directional communication,
- data encryption, and
- peripherals for various sensor integration.

Technology for data aggregation, gateways:

- industrial features,
- OSS (Open Source Software, e.g. Linux, MySQL, Apache etc.),
- full LoRa standard,
- GPS (Global Positioning System), and
- reliable casing for optional outdoor usage.

Application platform, data management & user services, interpretation:

- cloud like conception,
- availability and scalability,
- strong focus on security,
- enterprise volume,
- reputable platform,
- reliable with strong support,
- combining services IaaS and PaaS,

- user & device management, and
- advanced GUI (Graphical User Interface).

High-level HVAC specification

Compiling partners' technological contribution and potential user feedback, we will result in specification of new Establish smart HVAC use case. We went through two steps of development achieving detail system architecture as planned in D3.1. First, we drafted high-level function specification of HVAC pilot expressed by process V-diagram, see Figure 16. On the diagram are shown four system stages the system will go through, system initialization, events detection and monitoring, execution and system stabilization. These stages repeat at the system runtime.

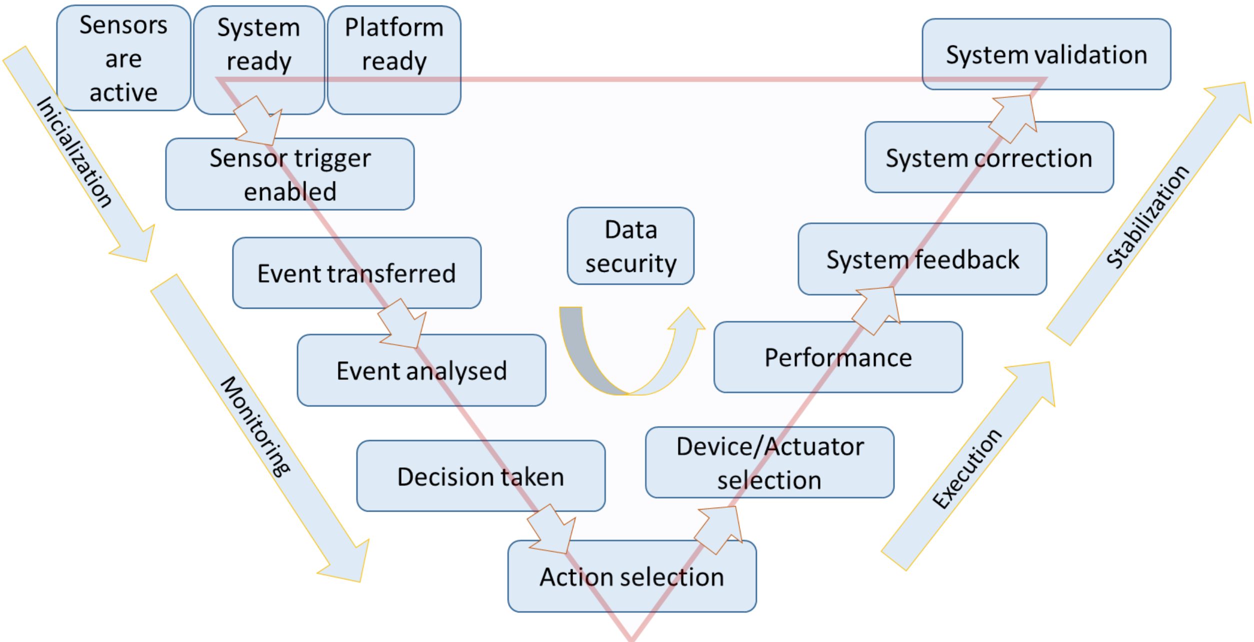


Figure 16. High-level function specification on the HVAC use case expressed by process V-diagram.

In order to provide all shown system functions, we need to design system components able to perform them. The Figure 17 with a high level HVAC system components specification is depicted. In the center of gravity is the cloud system platform involving system web application and services ensuring management of data, users and devices. This is the main role of the platforms. Beside this role, the platform needs to ensure system configuration, security, scalability, reporting and other services. The system runtime starts by sensors connected to gateway(s), gateways pre-process and transfer data to web platforms. The platform evaluates system behavior, takes decision and then control infrastructure usually requiring for a system change. To do that the infrastructure applications need to require actuation devices to take actions like open window, enable ventilation etc. The components specification correspond the list of requirements in the text above.

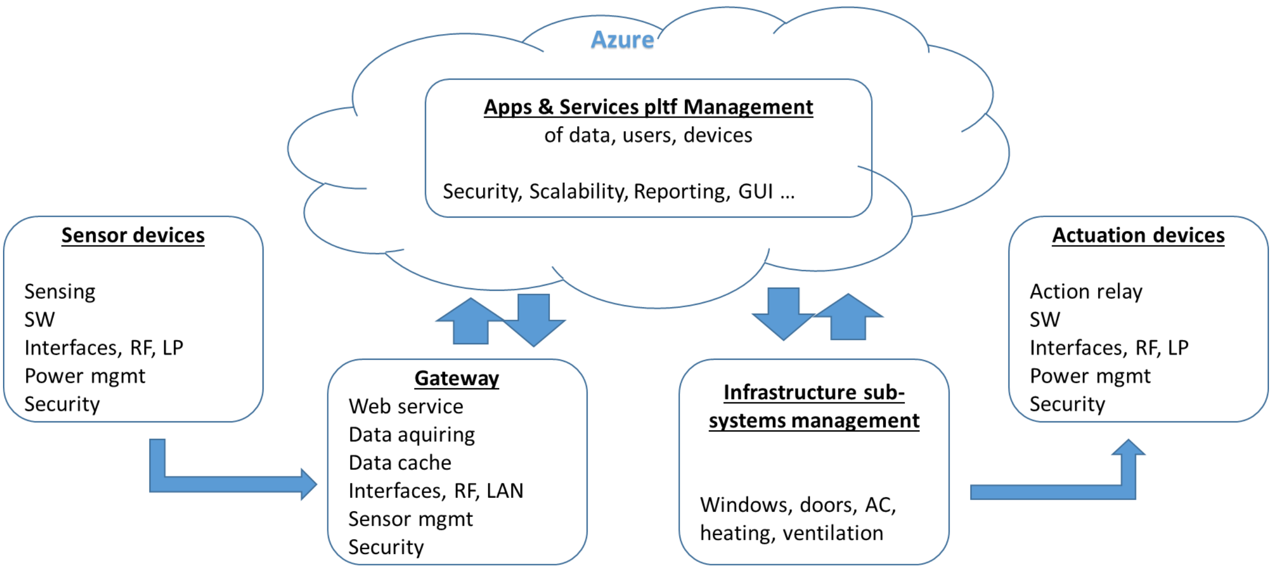


Figure 17. High-level component specification on the HVAC use case.

Technical specifications of the use case are presented in Appendix 2A. Use case requirements are presented in Appendix 2B.

3.3 Intelligent air quality management system

The *Intelligent air quality management system* pilot consists of key technologies to develop a healthy indoor environment in the buildings that can automatically adjust its conditions to better temperature, air quality, humidity, etc. using the results analyzed by the environmental data. As the indoor environments are affected by the outdoor pollutants as well as the indoor pollutants, Coway will develop the IAQ (Indoor Air Quality) and the OAQ (Outdoor Air Quality) devices in order to gather environmental data related to the air quality. Basically, the IAQ and OAQ devices will be equipped with the telecommunication modules based on Wi-Fi and the various environmental sensors. In addition, Coway will operate on the indoor testbed to evaluate the intelligent air quality management system interconnecting with the air purifiers. ETRI will build a server platform to manage and analyze the environmental data measured from the IAQ and OAQ devices. ETRI will also develop some machine learning algorithms to detect and classify the user behaviors and the analyzed results will be applied to air purifier to clean the indoor air quality in home and office buildings.

Technical development

In this pilot, Coway will contribute to the development of the IAQ/OAQ sensors for acquiring the environmental data and the adaptive control of air purifiers. ETRI will develop a data server to store the environmental data and efficiently access the data for further monitoring and analysis. In addition to that, ETRI will analyze the data from the sensors to automatically find pleasant index and user activity patterns that lead to the adaptive control of air purifiers to improve the environmental conditions. The technical development of the pilot will be concentrated on the development of four technologies as shown in the following Figure 18.

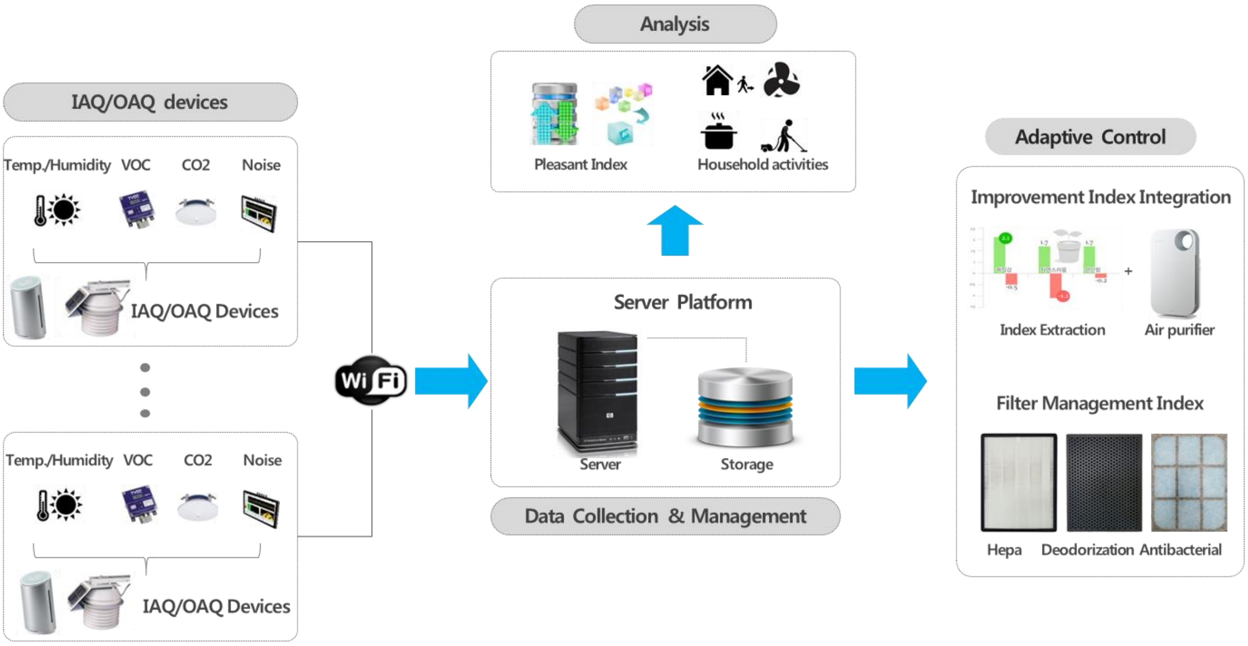


Figure 18. Main components consists of intelligent air quality management system.

The contributions of each partner will take into consideration the following technologies depending on their objectives:

- Development of IAQ/OAQ devices to measure environmental data (Coway),
- Collection and management of environmental data (ETRI),
- Analysis of environmental data to extract pleasant index (ETRI), and
- Adaptive control of air purifier by using pleasant index and commercialization of the integrated product (Coway).

The pilot has a yearly concrete development plan as the following Figure 19.

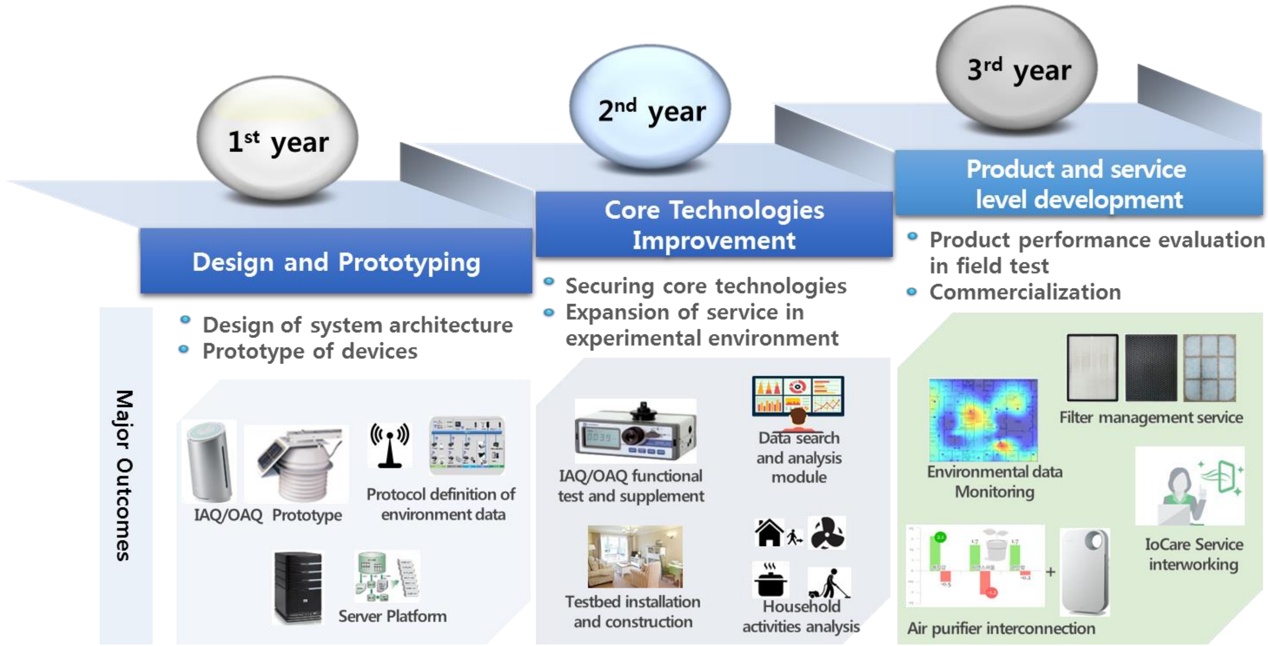


Figure 19. Contents of technology development by year for intelligent air quality management system.

In terms of the development plan, the pilot will carry out the following technical developments:

- First Year : Design and prototyping
  - Determination of the specification of IAQ/OAQ sensors,
  - Prototype development of IAQ/OAQ devices,
  - Development of the communication module between sensors and the management server,
  - Development of data structure for managing environmental data,
  - Development of search interface for efficiently accessing the stored data,
  - Development of data exporting module, and
  - Installation of IAQ/OAQ device test environment.

- Second Year : Core technologies improvement
  - Development of IAQ/OAQ devices,
  - Development of IAQ/OAQ device management module,
  - Development of IAQ/OAQ device displacement optimization module,
  - Development of pleasant index extraction technology,
  - Analysis of user activity patterns based on IAQ sensor data, and
  - Development of application interface for interoperating with air purifiers.

- Third Year: Product and service level development
  - Commercialization of IAQ/OAQ devices,
  - Development of environment data monitoring and statistics module,
  - Analysis of improvement index of air purifier filters,
  - Air pleasant index monitoring, and
  - Commercialization of the integrated system and services.

Technical requirements

The following Figure 20 shows the basic technical requirements of the pilot.

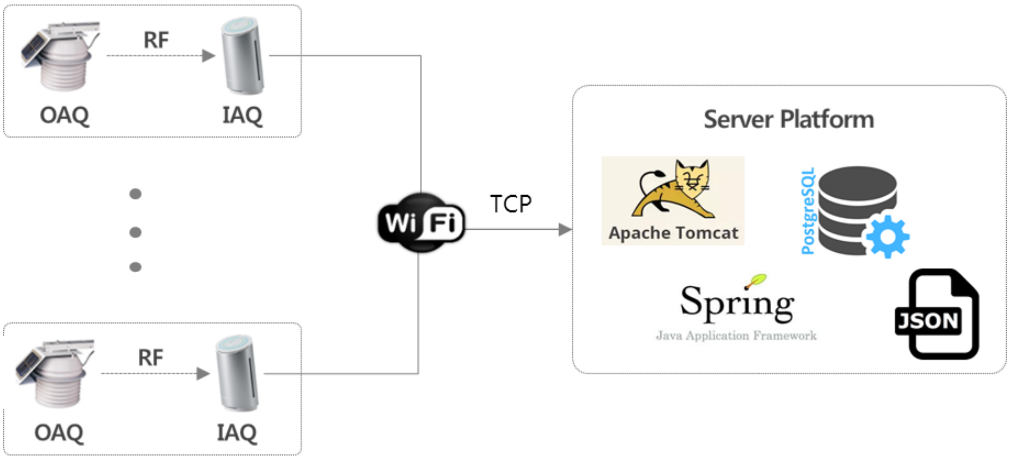


Figure 20. Basic technical requirement of intelligent air quality management system.

IAQ sensors for indoor air quality measurements will include temperature, humidity, CO_2, illuminance, noise, VOC (volatile organic compounds), Formaldehyde and dust sensors. OAQ sensors for outdoor air quality measurements will include temperature, humidity and dust sensors. An OAQ sensor will be developed to use solar energy as its battery charging and designed to endure the tough outdoor weather. An IAQ sensor communicates with its subordinate OAQ sensor through Radio Frequency (RF) to gather both IAQ and OAQ environmental data and send it to the backend data server via Transmission Control Protocol (TCP). The backend server platform communicates with the IAQ sensors via TCP in order to collect and store the data. In addition, the server provides data access service with JSON query format describing various query constraints over HTTP. The server will be implemented with Spring framework over Apache Tomcat for HTTP processing and PostgreSQL for environmental data storage.

The indoor air quality analytics system (see Figure 21) detects the user behaviors and executes spatio temporal air quality spatially analysis in order to extract user pleasant index. The analyzed results are applied to air purifiers to clean the indoor air quality in home and office buildings. The algorithms such as the machine learning and data mining find out the indicators to improve the air quality by classifying the user life patterns and detecting the air pollution sources. It can improve the effectiveness and minimize the management cost of air purifiers by notifying the replacement cycle of filter parts, which are the core of the air purifier, through analysing the contamination degree of the environment.

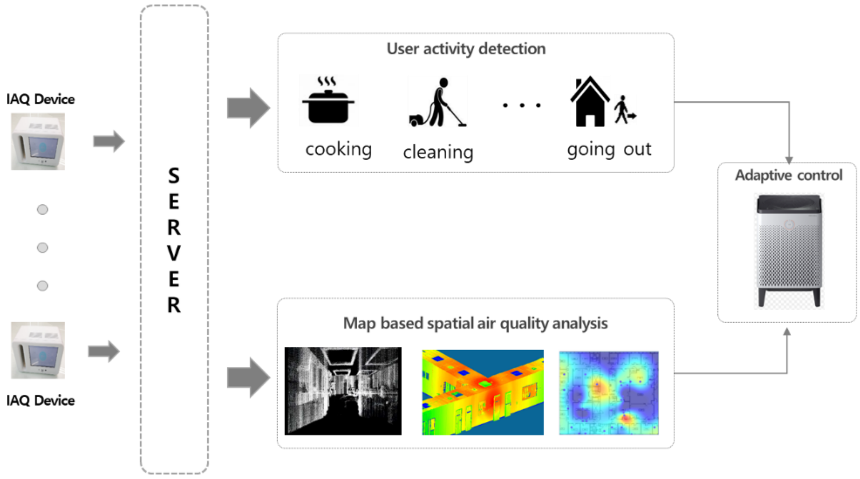


Figure 21. Architecture of Indoor air quality analytics.

The improvement indicators of the air quality are used for the program to interconnect the intelligent management system of the air quality and the air purifiers. The field test can improve the reliability of the developed system for the commercialization in the practical applications.

Technical specifications of the use case are presented in Appendix 3A. Use case requirements are presented in Appendix 3B.

3.4 Rehabilitation decision support

The *Rehabilitation decision support* pilot will use data from ambient sensors (air quality, atmospheric pressure, temperature, humidity) and the biometric, physiological and behavioral sensors (heart rate and respiratory number of steps), to provide patients in clinical rehabilitation/ keeping fit programs with decision support tools related to behavior and treatment options.

The pilot will test mobile and web applications that offer users/clients data regarding decision support and location information. The system will be integrated with handheld devices like Fitbit bracelet that record the steps distance and calories burned during the day and monitor sleep quality at night.

The first activities within the pilot started in February 2017 with the study of sensors and applications that monitor the physical activity, physiological parameters, and environmental conditions. In June 2018 the hardware equipment was installed at the NGO locations and started tracking the environmental conditions, and currently, we are processing the first stream of data retrieved for a period over than a month.

Technical development

The technical development section will summarize the achievements regarding the APIs for data collection from the meteorological station, air quality stations, and wearable devices.

Meteorological data collection addUPI

This section describes the communication protocol between the different TCP / IP components of Adcon Telemetry (addUPI – URL Programming Interface). Below are some examples of components that can implement this protocol:

- An addVANTAGE Pro client and an addVANTAGE Pro server;

- An addVANTAGE Pro client and a telemetry gateway (e.g. an A850 Gateway);
- A Telemetry Gateway and a Remote Telemetry Unit (RTU).

As shown also in Figure 22 below, the addUPI protocol requests a client and a server. The client will issue HTTP requests to the server and the server will respond to these requests. Client requests use the GET method, while responses return an XML document.

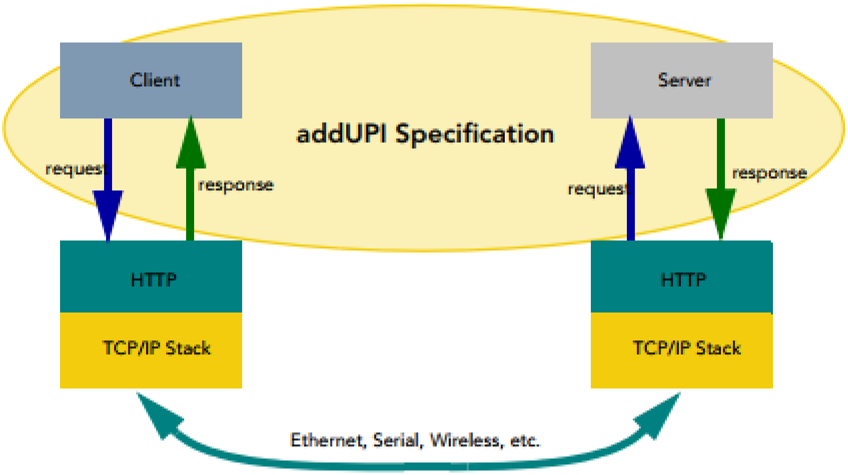


Figure 22. addUPI specification.

A typical session between a client and a server that communicates via addUPI follows the steps described below:

1. The client identifies the server: the server name (or IP address) must be known
2. Authentication of the customer (by authentication key, see example below)
3. The client asks the server to return its capabilities: in this context, the capability can be a list of proxy nodes
4. Each node is interrogated, which assumes the list of attributes and / or functions that the node has and / or can execute (this step can be done simultaneously with step 3 by requesting the node configuration, "getconfig"). Below are the authentication requests and "getconfig".

A request submitted by a client has the generic formula presented below:

```
http://hostname:port/addUPI?function=fn&session-id=nnnn&param1=p1&
    param2=p2&...paramn=pn
```

where:

• `hostname` is the address of the server,
• `port` is the port number to the server listens upon (if not specified, it is standard 80; it is recommended to use the port 80 for Telemetry Gateways and 8080 for addVANTAGE servers),
• `addUPI` is the name of the handler on the server that will be invoked to handle the request; this may be a servlet, a cgi, etc.
• `function` is the name of the invoked method,
• `session-id` is a number identifying a certain client (obtained after authentication),
• `param<i>=pn` are the parameters requested by a particular function.

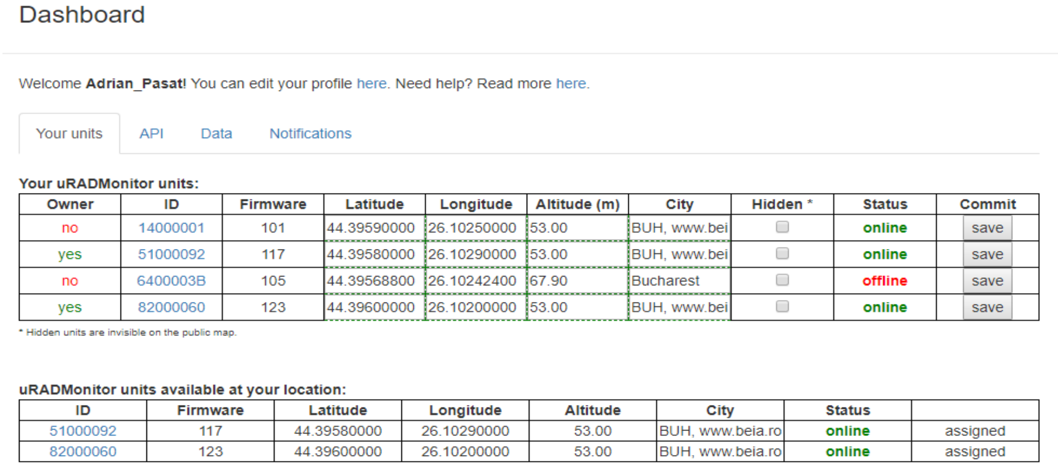
An XML example is shown below.

```
<?xml version="1.0" encoding="UTF-8" standalone="no"?>
<!DOCTYPE response SYSTEM "/xml/rs_getconfig.dtd">
```

```
<response>
	<node id="1" template="A850_SERVER_V8" name="Adcon A850 - 104399" class="SERVER"
subclass="GATEWAY">
			<attribs>
			<attrib name="manufacturer">
			<string>Adcon Telemetry</string>
			</attrib>
			<attrib name="type">
			<string>A850</string>
			</attrib>
			<attrib name="version">
			<string>3.4.10</string>
			</attrib>
			<attrib name="serialNr">
					<string>104399</string>
			</attrib>
			<attrib name="timeZone">
					<string>Europe/Bucharest</string>
			</attrib>
			<attrib name="date">
					<date>20170523T14:36:17</date>
			</attrib>
			<attrib name="uptime">
					<string>102 days, 21 hours, 21 minutes</string>
			</attrib>
			<attrib name="getdataMaxSlots">
					<int>10000</int>
					</attrib>
					<attrib name="getdataMaxNodes">
							<int>200</int>
							</attrib>
					</attribs>
					<functions />
					<nodes>
			<node id="34" template="A850_AREA" name="Beia" class="AREA" subclass="DEFAULT">
			<attribs />
			<functions />
			</node>
			</nodes>
			</node>
</response>
```


Air quality data collection

To access the uRADMonitor Data we used the uRADMonitor API presented on the dashboard menu (Figure 23 shows the list of devices attached to the user account), after creating an user account.


Dashboard

Welcome **Adrian_Pasat**! You can edit your profile here. Need help? Read more here.

Your units | API | Data | Notifications

Your uRADMonitor units:

Owner	ID	Firmware	Latitude	Longitude	Altitude (m)	City	Hidden *	Status	Commit
no	14000001	101	44.39590000	26.10250000	53.00	BUH, www.bei		online	save
yes	51000092	117	44.39580000	26.10290000	53.00	BUH, www.bei		online	save
no	6400003B	105	44.39568800	26.10242400	67.90	Bucharest		offline	save
yes	82000060	123	44.39600000	26.10200000	53.00	BUH, www.bei		online	save

* Hidden units are invisible on the public map.

uRADMonitor units available at your location:

ID	Firmware	Latitude	Longitude	Altitude	City	Status	
51000092	117	44.39580000	26.10290000	53.00	BUH, www.beia.ro	online	assigned
82000060	123	44.39600000	26.10200000	53.00	BUH, www.beia.ro	online	assigned

Figure 23. uRADMonitor dashboard.

The API protocol for retrieving data from uRADMonitor devices is described below:

- Method: **GET**
- Get devices list
  `//data.uradmonitor.com/api/v1/devices`
- Get device sensors list
  `//data.uradmonitor.com/api/v1/devices/[ID]`
- Get device data
  `//data.uradmonitor.com/api/v1/devices/[ID]/[sensor]/[interval]`
- Authentication:
- All calls must be authenticated with user-id and user-key sent in the headers section of the GET call as key-value pairs of the following format: `X-User-id:xxx, X-User-hash:xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx.`
- Response: JSON formatted answer, containing error message in case of failure or the requested data.

Figure 24 presents an API implemented on BEIA's website, www.beia-telemetrie.ro/livedata.

Figure 24. uRADMonitor API.

Wearable devices data collection. Fitbit API

Following the steps described at https://github.com/simonbromberg/googlefitbit, we managed to upload the data from a Fitbit Charge wearable device to a Google Spreadsheet. To retrieve the data in a Google Spreadsheet we followed the steps described below:

- firstly, we integrated the script available at https://github.com/simonbromberg/googlefitbit/blob/master/heartrate.gs;
- we added the OAuth 2.0 resources in the Libraries menu (Figure 25);

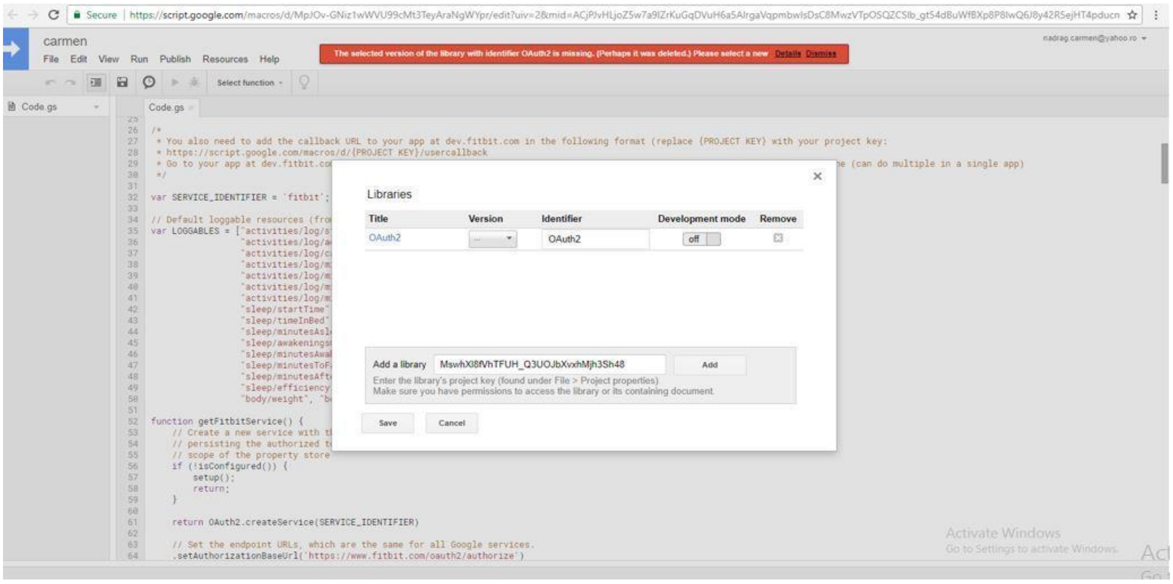


Figure 25. Google spreadsheet Libraries menu.

- we created the developer account at https://dev.fitbit.com/apps (Figure 26);

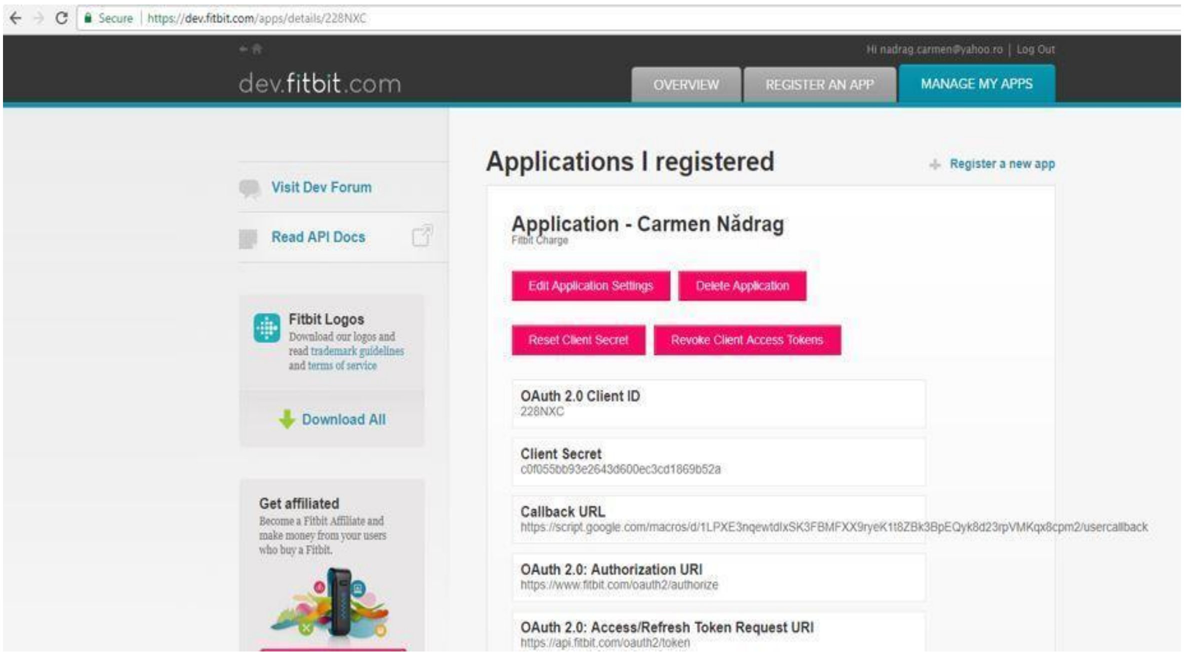


Figure 26. Fitbit developer account registration.

- in order to sync the data, we authorized the Fitbit application (Figure 27);

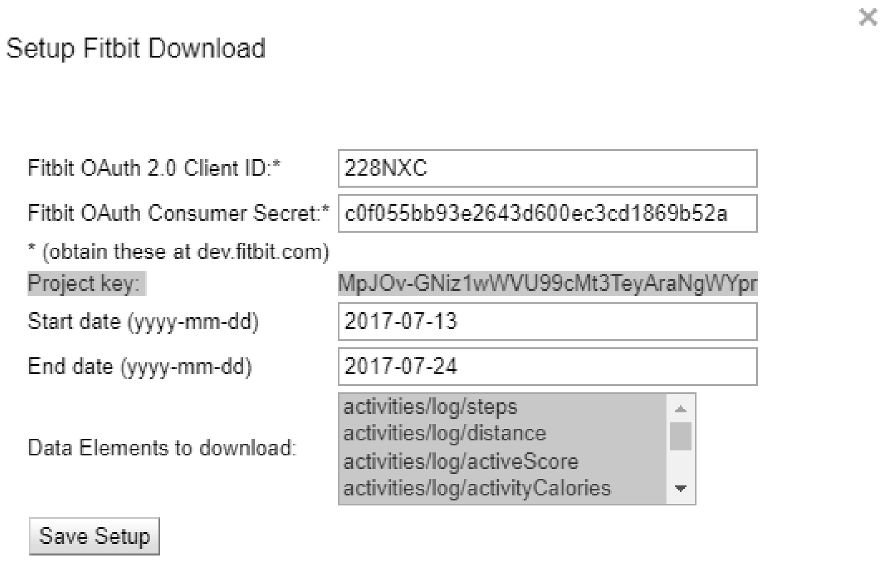
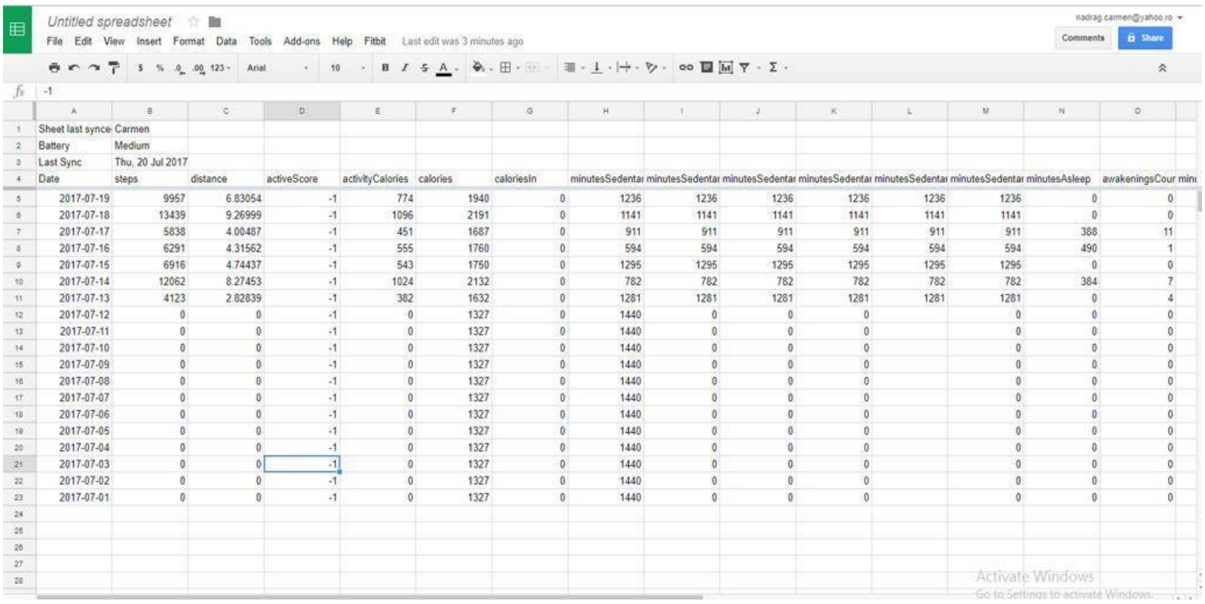


Figure 27. Authorizing Fitbit application.

- Returning to the spreadsheet, uploading and viewing data was done by selecting "Fitbit> Sync". In Figure 28, is presented the information retrieved from the Fitbit account.



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	
1	Sheet last synce	Carmen														
2	Battery	Medium														
3	Last Sync	Thu, 20 Jul 2017														
4	Date	steps	distance	activeScore	activityCalories	calories	caloriesIn	minutesSedentar	minutesSedentar	minutesSedentar	minutesSedentar	minutesSedentar	minutesSedentar	minutesAsleep	awakeningsCour	mini
5	2017-07-19	9957	6.83054	-1	774	1940	0	1236	1236	1236	1236	1236	1236	0	0	
6	2017-07-18	13439	9.26999	-1	1096	2191	0	1141	1141	1141	1141	1141	1141	0	0	
7	2017-07-17	5838	4.00487	-1	451	1687	0	911	911	911	911	911	911	388	11	
8	2017-07-16	6291	4.31562	-1	555	1760	0	594	594	594	594	594	594	490	1	
9	2017-07-15	6916	4.74437	-1	543	1750	0	1295	1295	1295	1295	1295	1295	0	0	
10	2017-07-14	12062	8.27453	-1	1024	2132	0	782	782	782	782	782	782	384	7	
11	2017-07-13	4123	2.82839	-1	382	1632	0	1281	1281	1281	1281	1281	1281	0	4	
12	2017-07-12	0	0	-1	0	1327	0	1440	0	0	0		0	0	0	
13	2017-07-11	0	0	-1	0	1327	0	1440	0	0	0		0	0	0	
14	2017-07-10	0	0	-1	0	1327	0	1440	0	0	0		0	0	0	
15	2017-07-09	0	0	-1	0	1327	0	1440	0	0	0		0	0	0	
16	2017-07-08	0	0	-1	0	1327	0	1440	0	0	0		0	0	0	
17	2017-07-07	0	0	-1	0	1327	0	1440	0	0	0		0	0	0	
18	2017-07-06	0	0	-1	0	1327	0	1440	0	0	0		0	0	0	
19	2017-07-05	0	0	-1	0	1327	0	1440	0	0	0		0	0	0	
20	2017-07-04	0	0	-1	0	1327	0	1440	0	0	0		0	0	0	
21	2017-07-03	0	0	-1	0	1327	0	1440	0	0	0		0	0	0	
22	2017-07-02	0	0	-1	0	1327	0	1440	0	0	0		0	0	0	
23	2017-07-01	0	0	-1	0	1327	0	1440	0	0	0		0	0	0	

Figure 28. Data retrieved from the Fitbit account.

Technical requirements

Technical specifications of the use case are presented in Appendix 4A. Use case requirements are presented in Appendix 4B.

3.5 Indoor air quality improvement at school

In the *Indoor air quality improvement at school* pilotIn the *Indoor air quality improvement at school* pilot, data from of indoor and outdoor sensors and wearables is combined with users' personal feedback and environmental sensing information to provide a healthier living environment for pupils, teachers, and other staff members. Users are involved in the planning of the pilot (e.g. deciding data collection methods for pupil concentration) and the future mobile service to really understand their needs and expectations. The idea is that the users can get timely information on the IAQ of their working environment. Feedback is collected regularly during the pilot by using different methods.

Technical development

In the school pilot, a variety of indoor sensors (temperature, humidity, air pressure, pressure difference (indoors vs outdoors), carbon dioxide (CO_2), a TVOC-based indoor air quality indicator, noise levels and camera-based recognition of people's movements) will be implemented at school environment. The data from indoor conditions monitoring will be combined with outdoor weather and air quality sensors (temperature, air pressure, humidity, CO_2, precipitation, wind speed and direction, particulates, NO_2, SO_2, CO, O_3) and wearable sensors (heart rate (HR) or heart rate variation (HRV), and activity). Participants are also able to share their feedback related to air quality and well-being by a mobile application.

The feedback data and data from the wearable devices and sensors will be collected to Azure cloud platform, and stored, pre-processed and analyzed based on the time stamps. Based on the real-time analyses, users could get e.g. visualizations about the air quality (data from the sensors) compared to their health via the application. A mobile application for the users to visualize the results and control the indoor air quality will be created based on their needs. The need and possibility to utilize the air purifiers in the pilot at school will be evaluated.

Technical requirements

The following describes the technical solutions and components intended to be used in the pre-pilot and the actual pilot. Unless stated otherwise, the same solutions are used for both. A separate Azure instance with the desired components is created for the pre-pilot and the actual pilot; this way, data from the two pilots can be kept separate.

Environmental data collection and storage

Environmental data collection in the pilot relies heavily on the Microsoft Azure platform and its services. The collection and processing setup is described in Figure 29.

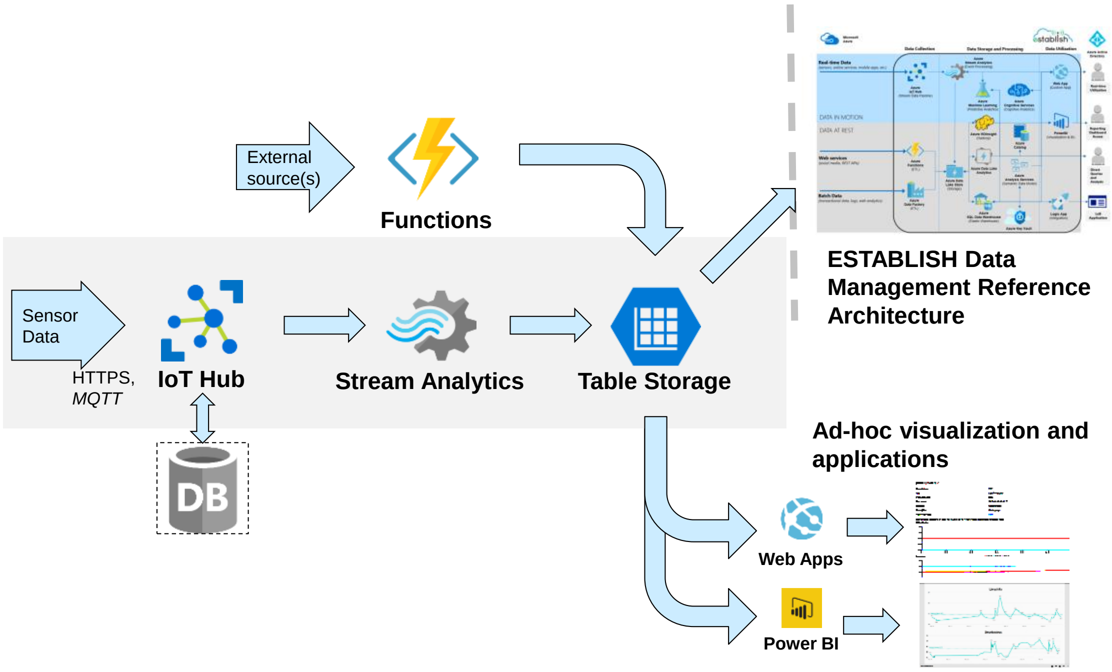


Figure 29. The reference implementation for environmental data collection and processing in the pilot.

Sensors and Data Collection

Data collection from various types of wireless sensor nodes into common storage is done using mains-powered gateways that communicate with the backend system (Microsoft Azure IoT Hub). Device management and end-to-end encryption of telemetry data is handled by Azure. Device management is applied at gateway level, whereas data itself will be made available on a node-by-node basis.

For the pre-pilot, VTT Nodes and Ouman Wireless nodes can be used interchangeably. Each office is equipped with at least one node sensing temperature, relative humidity, and CO_2 level. Pressure difference with respect to outside environment is measured where feasible. Libelium, uRADMonitor and MCF-LW12CO2 units are used in the monitored offices (not necessarily in every office all the time). The devices measure, to a varying degree, CO, CO_2, NO_2, SO_2, Particle Matter (PM_1 / $PM_{2.5}$ / PM_{10}), VOC, and Formaldehyde. Noise levels are measured with PeakTech 8005 sensors. Room occupancy/occupant activity are measured using PIR sensors and Orbbec camera based motion tracking.

For the actual pilot, VTT Nodes are used for classrooms. Other sensors to be used are MCF-LW12CO_2 units, PeakTech 8005 sound level meters and Orbbec depth cameras.

Data transfer to the cloud backend is done using gateways, which may need to be tailored for each new type of sensor node. The gateways are built on proto boards such as BeagleBone Black, Raspberry Pi 2/3/Zero, etc., with cloud connectivity from 3G/4G modems and/or WiFi. In the pre-pilot, LoraWAN is used for Libelium, uRADMonitor, and MCF-LW1CO_2, with a dedicated / common LoraWAN gateway at VTT.

Data processing and storage in the cloud

The incoming data, which comes from a variety of sources, needs to be ingested and routed into source specific tables for storage. The components used for this in the pre-pilot and actual pilot is the Azure IoT Hub, and Azure Functions. In practice, processing rules need to be specified for each different type of data source to determine the mapping of source data fields into database table fields. The rules are specified in the data processing component in the Azure Function that is triggered by each new data event.

All telemetry data is stored in Azure Table Storage, which is a simple NoSQL storage. Division of the data into separate tables may be based on, e.g., data similarity or source; for example, all data from one gateway may be stored into one table. Raw camera data is stored as files in Azure blob storage.

Data is expected to be processed at rest, i.e., by querying the data from the tables, and running analyses on it. Analysis is supported via both ad-hoc style querying within the Azure instance, and after exporting or linking to the ESTABLISH general architecture solution. Live processing is also possible, using, e.g., Azure Stream Analytics.

Metadata management

Especially when the number of data sources grows, it becomes necessary to record metadata on the location, measurement unit, accuracy, calibration data, etc. regarding the sensors and recorded sensor data. In the pre-pilot, metadata storage will be implemented in Azure as a purpose-built SQL DB with a REST API for managing the metadata. For the pilot, a similar metadata database will be created if needed, given that the number of devices in the pilot is significantly smaller than in the pre-pilot.

Either as a separate entity or as a part of the metadata system, dynamic device status info is also recorded for monitoring purposes. The status information may include, e.g., battery level, last battery change date, current signal strength, last access time, etc.

Analytics and applications

The cloud backend needs to support both “in motion” and “at rest” approaches for data usage. The exact analytics solution(s) to be used are not defined at the time of writing. Both “at rest” and “in motion” routing of the data, and any analytics applications implemented utilizing the routes, must provide flexible interfaces to other (backend) applications such as visualization and other types of decision support. For the school pilot, CGI will build visualizations of the sensor data as Power BI reports that can be utilized by both the participants (teachers) and researchers alike.

Physiological data collection

The physiological data collection scheme differs from environmental data collection in that it is based on a mobile client and an infrastructure-as-a-service backend where the collection architecture is built on a virtual machine. The virtual machine is deployed on Azure, although any other IaaS provider could do. Data storage is in Azure. The overall scheme is depicted in Figure 30.

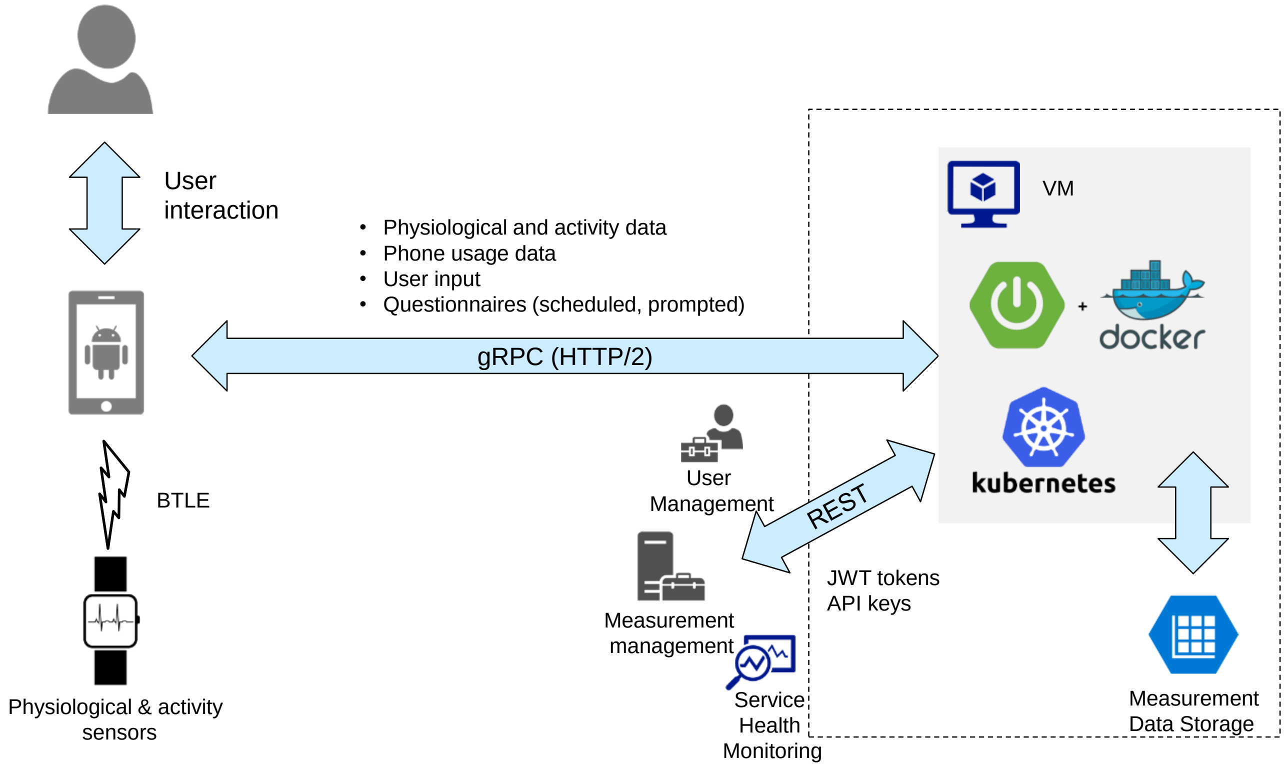


Figure 30. The overall scheme for physiological and activity data collection in the pilot.

Mobile client for physiological data collection

The mobile client is running on an Android device. The client may consist of several applications running at once. The client application(s) has four distinct tasks:

- Activity and phone usage data collection
- Physiological and activity data collection from wearable devices
- User feedback and questionnaires, and
- Data visualization.

Activity data from, e.g., accelerometer may be collected from the phone. In addition, phone usage data may also be collected in order to determine the user's stress level. The need for this data in the actual pilot will be decided after the pre-pilot. For example, phone usage data will not likely be available from teachers during classes. Positioning data may also be provided by the mobile application, either via phone GPS and other positioning methods (e.g., via Google APIs), or via a yet unspecified coarse indoor positioning solution such as raw Bluetooth beacon RSSI (Received Signal Strength Indicator) data. The application needs to timestamp the data, accumulate it into suitable batches and send the data to the backend application via a REST API.

The phone acts as a gateway for relaying measurement and activity data from various wearable devices, such as a heart rate monitor. The phone may also store at least part of the data instead of transmitting it over a radio link. In addition, the application may group the accumulated data into bigger chunks for transmission in order to save phone battery. The mobile application connects to the backend application via a REST API. The mobile phone may also act as a gateway for third party applications for collecting physiological data (i.e., via a device vendor provided app); in that case, the data needs to be made available to the ESTABLISH platform via backend operation, e.g., by connecting to the vendor's data API.

The client also provides an user interface (UI) for the user to give spontaneous feedback over his/her feelings and any symptoms. The same application could also be used for answering scheduled questionnaires and, if implemented, to prompt the user to answer a more immediate questionnaire when the backend analytics applications detect some change in the user's behavior or physiological data.

The application may also be used as the user's point of entry into seeing the recorded data. Visualization itself is done on the backend. Thus, the user could alternatively view the visualizations via a web browser. However, it is not entirely certain whether the users should see their data, at least very soon after being collected, as it may affect their behavior and symptoms.

Android Wear application for physiological data collection

An optional Android Wear application may optionally be used in conjunction with compatible wearable devices, e.g., in order to gain access to raw physiological measurement data. In the VTT pre-pilot, a Polar M600 device will be evaluated with respect to usability of raw PPG data gained from it in the context of ESTABLISH.

Backend data collection and storage for physiological data

The backend for collecting and storing the data sent by the mobile client is done via a dedicated server based on Docker services, running on a virtual machine. The server communicates with the client via gRPC over HTTP/2, and provides a REST API for all data operations. The measurements are configurable at the server (e.g., granularity of location data). The server provides the necessary services to pre-process the data before storage to comply with the measurement configuration. For example, if location collection granularity is set to distinguish between a set of user-specified locations only, a service will convert the raw geolocation info (GPS coordinates) into one of the specified locations (e.g., "home").

All physiological, activity, and phone usage data is stored in Azure Table Storage. The server also implements API key and JWT token-based access control for the users and data. In addition, service health monitoring will also be provided. The server is built as Docker (micro)services deployed in a Kubernetes container orchestrator.

More detailed technical specifications of the use case are presented in Appendix 5A. More detailed use case requirements are presented in Appendix 5B.

Self-report application

The participants record their subjective sensations, working efficiency and a number of other factors that are later compared with measured indoor environment parameters to determine their potential correlation. The self-reporting application is implemented as and Android application that sends periodical questionnaires to the users and also allows spontaneous reporting of air quality problems or specific sensations (tiredness, headache, etc.). Answers to the questionnaires and reports are anonymized via user and room specific ID hashing.

The android application communicates with an http server in an Azure VM via gRPC. The VM hosts a Python server application that parses and stores the answers into a MongoDB document database. Questionnaires are defined in a Google Sheets document that the server reads into MongoDB documents that it further passes to the self-report application clients. A REST API is provided by the server for querying data.

3.6 Tracking of Professional / non-profesional athletes with wearable sensors

Because of its relation with sports, entertainment, health and economy, sport and even every sports category has been seen as an industry. From the sport industry point of view, tracking and managing the parameters affecting the sport such as physical condition, health, motivation, eating, drinking and sleeping for amateur and professional athletes operating in individual or team sports in Europe and in our country became important. You can find below the specifications of the pilot that is tracking of professional / non-professional athletes with wearable sensors. The project has three important phase that are

- Data Acquisition
- Data Analytics on the Cloud Data Analytics Platform
- Information Delivery.

The Figure 31 below includes the responsibilities of the companies and basic components of the project from technical development point of view.

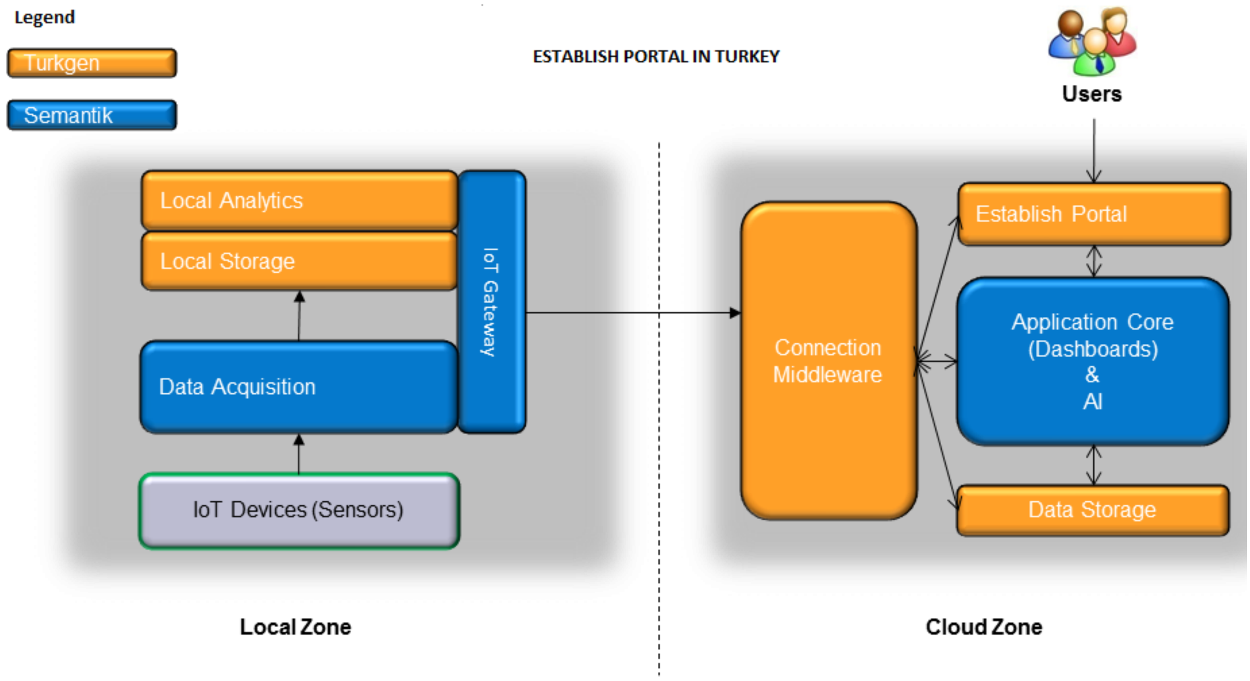


Figure 31. The overall scheme for technical details of the pilot.

Technical development

A REST service should be implemented for authentication from local zone to cloud zone and a program that catch the sensor data should be written. When the data is transfered to the cloud zone machine learning algorithms should be used to gather data analysis results. Environmental measurements will be taken from web services of state-owned organization that is an authority about environmental issues in Turkey.

Technical requirements

To realize the project, two parts should be deployed Local Zone and Cloud Zone. Local zone includes some data analytics and data aggregation and manipulation steps, data acquisition from sensors. Data can be collected in local storage mechanisms or data can be stream immediately to Cloud Zone via IoT Gateway. There are Authentication and Authorization mechanisms on the data transfer and monitoring. A REST API will be implemented to data transfer between zones.The API will include Login and several pushData services.

Cloud zone will include some Big Data Analytics Components such as Cassandra, Machine Learning Libraries & Tools, Spark, in-memory databases, Kafka etc. The core data analytics will realize in this site of project. Of course there will be many open source technologies for the monitoring of te result and information delivery to related people such as Apache Web Server, Dasboards, Reporting tools etc.

The technologies that will be used, are shown below Figure 32.

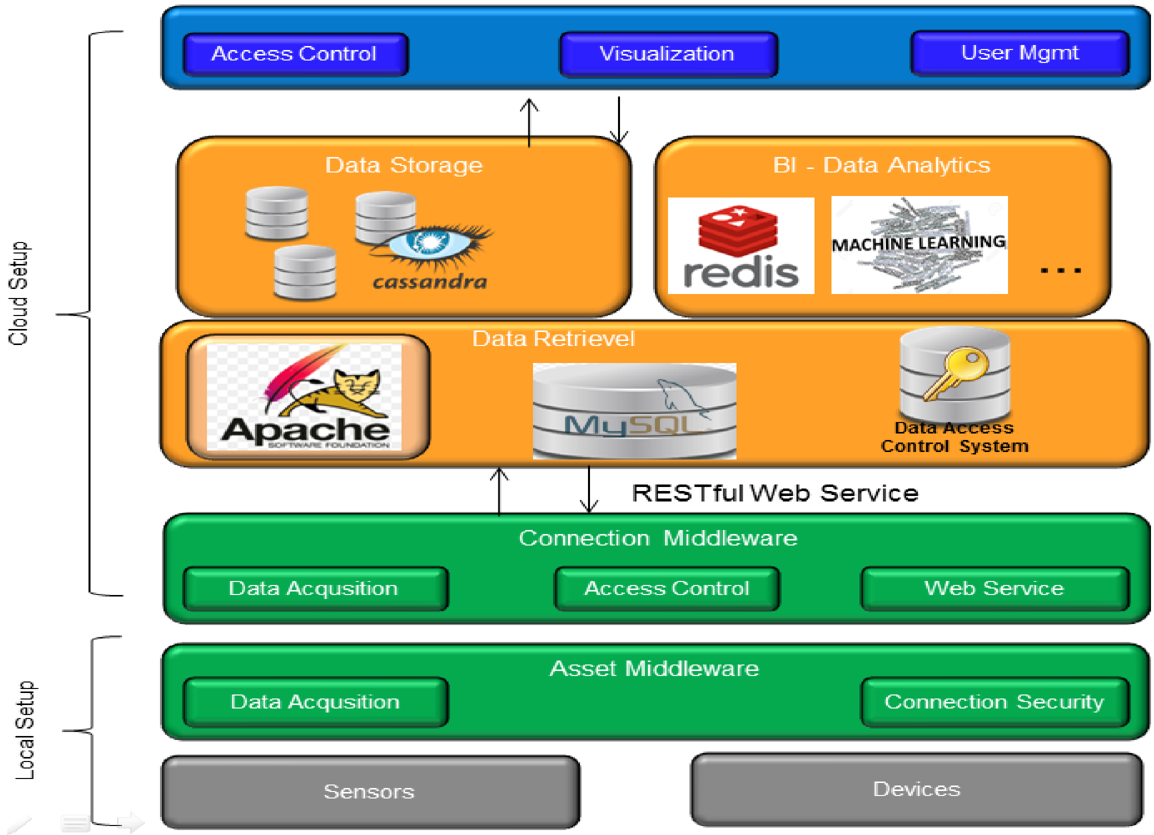


Figure 32. The overall scheme for technical requirements of pilot.

4. Conclusions and next steps

Six different pilots (under three use cases) have been defined for ESTABLISH project: 1) Optimized City Mobility Planning, 2) Smart HVAC systems that ensure a healthy indoor environment, 3) Intelligent air quality management system, 4) Rehabilitation decision support, 5) Indoor air quality improvement at school, and 6) Tracking of professional / non-profesional athletes with wearable sensors.

The first pilot / use case, Optimized City and Mobility Planning, concentrates on outdoor air quality; planning of urban development and traffic greatly affects air quality and consequently living conditions of a city. Based on public open data e.g. about environment, building footprints, demographics, and traffic information, precise prediction and forecasting of traffic loads and pollution in the city can be provided. Recommendations for route planner and alerts about pollution in real time will be shared to the users by mobile and/or web applications.

The use case *Developing smart HVAC systems that ensure a healthy indoor environment,* including two pilots, the *Smart HVAC systems that ensure a healthy indoor environment, and* the *Intelligent air quality management system,* will develop a HVAC system that will also autonomously learn behavior patterns of the users/inhabitants of the building and take advantage of this knowledge to get the building ready for the predicted needs. A smart application developed in the pilot, will automatically adjust indoor conditions to better temperature, air quality, humidity, etc. using the data analyzed from different air quality sensors.

The third use case *Promoting independence of specific vulnerable groups* includes three pilots. The pilots, the Rehabilitation decision support, the *Indoor air quality improvement at school,* and Tracking of professional / non-profesional athletes with wearable sensors, will combine environmental sensor data (indoor and / or outdoor) with physiological and behavioral sensor data from wearable devices to empower decision support tools for behavioral choices. Applications to visualize the indoor air quality and wellbeing will be developed in the pilots.

All the pilots of the ESTABLISH project are progressing at the moment, and technical specifications has been planned and reported carefully. Now, the pilots will be implemented in different countries.

This deliverable concentrated on concrete technical specifications of pilots of the ESTABLISH project. These pilots have been described more in detail with state-of-the-art description in the previous deliverable D2.1. In WP2, in addition to end users also the stakeholders will be involved to evaluate ESTABLISH use cases and co-develop a novel ones. The feedback from the stakeholders will be reported as a part of master's thesis work. The usability of ESTABLISH solutions (end user perspective) will be reported at the end of the project in D2.3.

Appendixes

Appendix 1A. Optimized City and Mobility Planning, technical requirements

	Discription
Devices, sensor management (WP3 System architecture)	
Other data sources	Open data from Valencia City Council - Valencia Smart City Platform (http://gobiernoabierto.valencia.es/en)
Data (WP4 Connecting and managing sensors)	
Data sources	
Storage	Cloud platform
Recording of data	Air pollution from weather stations Traffic data in real time Static data of public transport (buses) Bike lanes Public and private parkings Information about regulated parking service
Monitoring	Air pollution from weather stations Traffic data in real time Static data of public transport (buses) Bike lanes Public and private parkings Information about regulated parking service
Gateways	FI-WARE
Integration	Open Data from Valencia Smart City Platform analyzed and integrated in the ESTABLISH platform
Analytics (WP5 Data analytics and adaptive control)	
	Data fusion based on big data and deep learning techniques in order to provide recommendations for mobility and alerts about pollution in real time
	Data analysis with algorithms using geographical aware complex event processing (geoCEP) in realtime situations.
Privacy and Security	
Application	
User needs	Applications providing planning services and mobility information considering all relevant information about traffic conditions and pollution
Front end	Mobile application with multimodal route planning and alerts/recommendations about pollution. Web application with dashboard and traffic simulation platform
Back end	Algorithms for ecological route optimization Dashboard Traffic Simulation Platform
Pilot Implementation	
Implementation	In progress
Integration	To be done
Testing	To be done

Appendix 1B. Optimized City and Mobility Planning, use case requirements

PILOT	Optimized City and Mobility Planning
COUNTRY	Spain
DESCRIPTION	The pilot will build an advanced application for providing planning services and mobility information both for citizens and for city authorities considering relevant information such as contamination or traffic conditions..
OWNER, CONTACT PERSON (in the project)	Ismael Torres (Prodevelop)
	Description
Use case preparation	
Brainstorming	Kick-off of spanish partership (20/02/2017).
User scenario development	Plan for scenario writing D2.1, preliminary of work structure and invovement of partners, candidate technologies, etc.
User experience planning	User experience viewpoints in the pilot / how / how often… Aproach based on an iterative process with mockups, to be refined once the use case definition is concluded
Contacting the users, recruitment	User community building. Check use case with final users (City interface and responsables (mobility, infrastrcture, smart city and innovation)). Revent communities, associations and relventa users (citizen view)
Informing about the pilot	Contrast meetings with Valencia City responsables
Business modeling	At this stage identification of relevant stakeholders and partners. Business Model Canvas to be developed duirng the project lifecycle
Evaluation criterias	When we have succeeded. Brainstorming around the initial proposal (KPIs and relevant data acquisition processes)
Use case specification	
Use case definition	Definition of the spanish use case according the common template defined for the project.
Business modeling	At this stage identification of relevant stakeholders and partners. Business Model Canvas to be developed duirng the project lifecycle
Feedback from stakeholders	Meetings with Las Naves-InnDEA, entity of the Valencia City for innovation issues (representants for Smart City and mobility innitatives). To prepare questionnaires and groups dynamics to refine and evaluate in an incemrental way the different developments.
Feedback from advisory board	To define and involve reference compies and organizations to complete the spanish chapter. To prepare: formal invitation, questionnaires, interviews, group discussions, co-creation tools…
Technical specifications	See Technical specifications sheet

Use case design	
Concept visualization	Adopting a lean or incremental development lifecycle, different tools and methods will be used to align work among partners under a common picture (paper prototyping, mock-ups…)….
Feedback from stakeholders	Concept evaluation, iterative meetings with relvant staksholders (city and final users associations, if applies)
Feedback from advisory board	Concept evaluation
Implementation	
Contacting the users	A common plan to contact and involve users (How, how often, what to inform…). With the City, a communication and coordination scheme have been established during the first weeks of the project (see KoM minutes); with other users, this plan will be defined once user engagement is running and a clear concept of the pilot available
Review meetings	Meetings (F2F or teleconference) involving all the pilot partners are expected each two weeks or monthly at latest. Minutes will be prepared and agred among partners.
Detailed architectural specifications	Detailed architectural specifications
Detailed architectural design	Detailed architectural design
Integration plan	Integration plan
validation plan	validation plan
During the pilot	
Contacting the users	According the common plan to contact and involve users (how, how often, what to inform…), involve the city on the pilot expoitation, KPI monitoring and evoluation, risks and integration on the public strategy. Contact channels with users will keep alive during the piloting stage, by means of questionaires and working gruops dynamics if possible.
User experience	Selection of tools for Questionnaires, interviews, group discussions, co-creation). Involvement of users.
After the pilot	
Evaluation of the pilot	Evalaution with final users: KPIs final evaluation, sucess of project according just defined criteria
Contacting the users	By using previous tools, acquire feedback of users
Conclusions and recommendations	Extract conclusions, best practices, guidelines from user, stakeholders and advisory group feedback for next steps of the consortium and European community.
Feedback from stakeholders	Specific working meetings to analyze business and co-deisng nof business oportunities, technology evalaution and new lines of work opening
Feedback from advisory board	Evalaution with final users: KPIs final evaluation, sucess of project according just defined criteria and bsuienss opportunities.
Feasibility check	Assessing the feasibility of the concept to go to market and defining the necessary steps
Business model update	Finalisation of the business model canvas

Appendix 2A. Smart HVAC systems that ensure a healthy indoor environment, technical requirements

	Description
	Devices, sensor management (WP3 System architecture)
Sensor 1	Temperature sensor(s)
Sensor 2	Humidity sensor(s)
Sensor 3	CO_2 sensor(s)
Sensor 4	Radon gas sensor(s) (optional)
Sensor 5	Illuminance sensor (s)
Sensor 6	Noise sensor(s)
Actuator 1	Window opener
Actuator 2	Local AHU with heat recovery
Actuator 3	Thermostat / Heater valves
Data source	Online weather data (e.g. CHMI)
	Data (WP4 Connecting and managing sensors)
Storage	MS Azure cloud platform
Recording of data	Location-fixed indoor conditions data (temperature, humidity, CO_2, pressure difference w.r.t outdoors) every 5 minutes.
Recording of data	Outdoor conditions data; every 5 minutes
Recording of data	Indoor air quality data from fixed sensors every 5 minutes or according to sensor specification (to be defined)
Recording of data	Physiological sensors; maximum rate available by sensors for one-day operation between charging.
Recording of data	User-defined labels; user initiated (any time) and scheduled (three times during working day; morning, midday, when leaving work). Option for backend-originated querying of user label based on observed physiological data.
Recording of data	Air purifier; filtering efficiency (e.g., power vs airflow and/or purification efficiency). Optional: Incoming air quality (if not available via the external indoor air quality sensors)
Monitoring	Visualizations updated at least once a day for participants.
Monitoring	Air purifier filter status; daily
Gateways	Location-fixed indoor sensors connect via IMA gateways and/or vendor specific selected cloud IoT Hub. Mobile phone may be used as gateway for pilot participants' physiological sensors.

Connectivity	Sensor <=> gateway via LoRa and/or BLE Gateway <=> cloud via 3G/4G cellular, Wi-Fi and/or Ethernet
Integration	IMA indoor conditions data are made available to project consortium.
	Analytics (WP5 Data analytics and adaptive control)
Mathematical model	A mathematical representation of the building will be used to control the HVAC system in the pilot. Model will be able to use the measured data to predict optimal parameters of the HVAC system in the future.
	Privacy and Security
	Privacy and security provisions will be performed within WP4 and WP5. Main focus on – protect sensor data (values, placement, type) against misuse, gateway encrypted protocols, user identity and user activity protection, actuators breaking, infrastructure misuse and user authentication on applications.
Application	
User needs	Interviews / questionnaires / focus group discussions to understand users' needs.
Front end	Sensor data collection; visualizations of collected and predicted data. Visualization of actuators settings.
Back end	Data aggregation for analytics, visualization and prediction. Connecting the measured date with mathematical model.
System feedback	Adjustment of actuators based on observed environmental conditions and predicted conditions. Feedback loop validation process, auto-reconfiguration proposition.
	Pilot Implementation
Implementation	Implementation steps come out of description of use case development and main actors of Step 1 to Step 5 will take part the implementation process regardless of either administrative or technical provisions are taken.
Testing	Based on the use case development and deployment definition. Phase 1: At IMA premise, limited number of users/testers, supported by development sources in order to ensure fast system corrections. Phase 2: Depending on stakeholders' involvement, industrial partners will deploy tested components of the phase 1, Dekprojekt operational environment.

Appendix 2B. Smart HVAC systems that ensure a healthy indoor environment, use case requirements

Use case requirements and technical specifications	
PILOT	Smart HVAC systems that ensure a healthy indoor environment
COUNTRY	Czech republic
DESCRIPTION	The pilot will show up defined technical as well as formal aspects. Partners will develop HW and SW components of the use cases - sensors, gateways, coordination platform, SW services, applications including data interpretation interfaces. Determined stakeholders will be familiar with functionalities and expected results. Use cases will be deployed at selected test sites in Czech. The focus of the pilot is to assess the impact of smart HVAC technologies on health status improvement.
OWNER, CONTACT PERSON (in the project)	Jiri Havlik (IMA)
	Description
	Use case preparation
Brainstorming	Discussing with partners involved.
User scenario development	Step1 – use case components specified in D2.2 collection in laboratory conditions both at development partner (IMA) and industry partner (Dekprojekt). Step 2 – setup and configuration of HVAC system, debugging, requirements revision Step 3 – first run of the use case, limited number of users, system monitoring Step 4 – second run based on feedbacks, preparation for real operation Step 5 – real operation of demonstrator, deployment at Dekprojekt and premise.
User experience planning	User experience viewpoints in the pilot / how / how often etc. will be planned together with use case developers - IMA, CU, DEKPROJEKT..
Contacting the users, recruitment	The contact person will be contacted and a planning meeting will be arranged.
Informing about the pilot	Informative meetings will be arranged before, during and after the test period.
Business modelling	Business model canvas will be created when the pilot will be defined. The canvas will be discussed in the steering group meeting also.

Evaluation criteria	TBD
	Use case specification
Use case definition	The pilot will develop such a HVAC system that will also autonomously learn behavior patterns of the users/inhabitants of the building and take advantage of this knowledge to get the building ready for the predicted needs. It will try to resolve the tension between energy efficiency and quality of indoor climates that occurs e.g. after retrofitting existing buildings by offering an affordable solution.
Business modelling	Business model canvas will be developed during the pilot.
Feedback from stakeholders	Questionnaires, interviews, group discussions, co-creation tools will be utilized to collect feedback. It will be determined together with testees how the feedback will be collected during the pilot.
Technical specifications	See the other sheet: Technical specifications
Use case design	
Concept visualization	Paper prototyping, mock-ups will be utilized. The real application will be developed iteratively based on the feedback got from the users.
Feedback from stakeholders	UC concept and design will be validated using stakeholders' feedback and with DEKPROJEKT support. The feedback will be assessed by US developers.
Implementation	
Contacting the users	The contact person will be contacted and a planning meeting will be arranged. All testees will be informed about pilot.
Review meetings	The stakeholders will be informed at the meeting before the pilot. At the end of the pilot, a feedback event / group discussion meetings will be arranged.
During the pilot	
Contacting the users	TBD
User experience	Questionnaires, interviews, group discussions, co-creation tools will be utilized to collect feedback. It will be determined together with testees how the feedback will be collected during the pilot.
Analytics	Differences between predicted and measured indoor air quality will be evaluated during the pilot. Measures to maximally closing the gap will be developed.

After the pilot	
Evaluation of the pilot	The pilot will be evaluated with the stakeholders by the criteria defined before the pilot.
Contacting the users	The results of the pilot will be shared with the users in a meeting / by email.
Conclusions and recommendations	The results of the pilot will be analyzed and shared with the stakeholders in a meeting.
Feedback from stakeholders	Feedback from the stakeholders will be collected in a meeting. They are also able to comment and update the report of the results.
Feasibility check	Assessing the feasibility of the concept to go to market and defining the necessary steps.
Business model update	Finalization of the business model canvas with the stakeholders.

Appendix 3A. Intelligent air quality management system, technical requirements

	Description
Devices, sensor management (WP3 System architecture)	
Sensor 1	Temperature and humidity sensor(s) in IAQ and OAQ
Sensor 2	CO2 sensor(s) in IAQ
Sensor 3	Illuminance sensor(s)
Sensor 4	Noise sensor(s)
Sensor 5	VOC sensor(s) in IAQ
Sensor 6	Formaldehyde sensor(s) in IAQ
Sensor 7	Dust (PM2 and PM10) sensor(s) in IAQ and OAQ
Battery 1	Battery pack in OAQ
Battery 2	Solar module in OAQ
Communication 1	Wi-Fi module in IAQ and Server
Communication 2	RF module(Sub-GHz) in IAQ and OAQ
Actuator 1	Air purifier
Data (WP4 Connecting and managing sensors)	
Storage	Server Platform
Storage of additional research data	Structural map in the building
Recording of data	Indoor conditions data (temperature, humidity, CO2, Illuminance, Noise, VOC, Formaldehyde, Dust) every 1 minutes.
Recording of data	Outdoor conditions data (temperature, humidity, Dust, Battery) every 1 minutes
Monitoring	Indoor air quality data every 20 minutes or according to sensor specification (TBD)
Monitoring	Outdoor air quality data every 20 minutes or according to sensor specification (TBD)
Monitoring	Air purifier filter status; daily
Connectivity	IAQ <=> Server via Wi-Fi OAQ <=> IAQ via RF(Sub-GHz)

Integration	Indoor and outdoor conditions data are made available to project consortium
Analytics (WP5 Data analytics and adaptive control)	
Mathematical model	The mathematical algorithms will be used to estimate the current air quality in indoors and outdoors. Moreover, the mathematical methods such as machine learning and the data mining will contribute to finding out the indicators to improve the air quality by classifying the user life patterns and detecting the air pollution sources.
Privacy and Security	
	The collected private information will be anonymized by hashing the person identifier, and not save the unhashed identifier in the server platform and processing system.
Application	
User needs	Interviews / questionnaires / focus group discussions will be opened to collect the user requirements for the target or the current customers.
Front end	IAQ/OAQ devices; sensor data collection; visualizations of collected data; visualization of actuators settings
Back end	Data aggregation for analytics; visualization of the space conditions; field of outdoor air quality analysis; advanced air purifier
System feedback	Adjustment of air purifiers based on the indicators extracted by using the environmental data. Feedback loop control and validation to automatically improve the air quality in indoors.
Pilot Implementation	
Implementation	The implementation works are performed according to the progress of the use case development from step 1 to step 5.
Testing	Each partner will perform the evaluation on a module-by-module basis about the key components such as “IAQ/OAQ devices”, “Server Platform”, “Algorithm”, “Interconnection to Purifiers”. After each module is completed at the prototype level, the partners try to integrate and evaluate the whole system on the testbed similar to the real field.

Appendix 3B. Intelligent air quality management system, use case requirements

PILOT	Intelligent air quality management system
COUNTRY	Korea
DESCRIPTION	The pilot will implement the intelligent air management system for providing the fresh and healthy air to the users residing in the buildings for a long time. For the successful R&D, the partners should survey the user requirement, design the system architecture, implement the hardware and software, and evaluate the performance in the testbed.
OWNER, CONTACT PERSON (in the project)	Yu-Cheol Lee (ETRI)

	Description
Use case preparation	
Brainstorming	Generation of the ideas through the regular meetings once a month in Korea
User scenario development	Step 1) survey and collect the requirements for the air purifier users Step 2) define the technical specifications corresponding to the user requirements Step 3) develop the hardware (IAQ/OAQ devices, air purifier) and software (server platform and algorithms) Step 4) evaluate the performance in the laboratory level and reflect the feedbacks Step 5) evaluate the performance in the real operation level and stabilize the components
User experience planning	User experience viewpoints in the pilot / how / how often etc. will be planned together with the use case partners - ETRI and Coway.
Contacting the users, recruitment	Staff members managing the end customers in the air purifier business
Informing about the pilot	Opening the workshops to prepare and perform the evaluation of use case
Business modeling	Designing the business model canvas based on expansion application of the air purifier through rental and sales

Evaluation criteria	Performance test of the developed technologies to implement the use case, Survey results of the function satisfaction corresponding to the end-customers
Use case specification	
Use case definition	The pilot will contribute to developing a healthy indoor environment in the buildings that can automatically adjust its conditions to better temperature, air quality, humidity, etc. using the results analyzed by the environmental data. It will achieve the solution to generate the well-being, safe, comfortable indoor spaces for the people, especially the senior and the children.
Business modeling	Designing the business model canvas based on expansion application of the air purifier through rental and sales
Feedback from stakeholders	Questionnaires, interviews, group discussions, conference, and co-creation tools will be used for collecting the feedbacks from the various sources such as customers, technical experts, and business partners. The feedback will be periodically reflected in the implementation of the use case.
Technical specifications	See the other sheet: Technical specifications
Use case design	
Concept visualization	Paper publication and the mock-up prototyping will be used to describe the concept of the use case. The real application will be developed iteratively based on the feedback received from the users.
Feedback from stakeholders	The concept will be evaluated in the regular meetings with the partners in the pilot. The co-work with other pilots will be defined during the project.
Implementation	
Contacting the users	Staff members managing the customers in the air purifier business will be arranged the interviews and survey meeting with the target users.
Review meetings	The stakeholders will be informed at the meeting before the pilot. At the end of the pilot, a feedback event / group discussion meetings will be arranged.
During the pilot	

Contacting the users	Staff members managing the customers in the air purifier business will explain the effect and the functions about the use case to the users.
User experience	Questionnaires, interviews, group discussions, conference, co-creation tools will be utilized to collect feedback. It will be determined together with testees how the feedback will be collected during the pilot.
Analytics	Evaluating the effectiveness of the use case based on the user experiences. The gap between the predicted and collected results of the responders will be used for refining the questions and the survey methods.
After the pilot	
Evaluation of the pilot	The pilot will be evaluated with the stakeholders by the criteria defined before the pilot.
Contacting the users	The results of the pilot will be shared with the users through the report in the meeting.
Conclusions and recommendations	The results of the pilot will be analyzed and shared with the stakeholders in a meeting.
Feedback from stakeholders	Feedback from the stakeholders will be collected in a meeting. They are also able to comment and update the report of the results.
Feasibility check	Assessing the feasibility of the concept to go to the market and defining the necessary steps.
Business model update	Finalization of the business model canvas with the stakeholders.

Appendix 4A. Rehabilitation decision support, technical requirements

Description	
Devices, sensor management (WP3 System architecture)	
Sensor 1	Temperature, atmospheric pressure and humidity sensor(s) in IAQ and OAQ
Sensor 2	CO2 sensor(s) in IAQ and OAQ
Sensor 3	NO2 sensor(s) in IAQ and OAQ
Sensor 4	PMs sensor in OAQ
Sensor 5	VOC sensor(s) in IAQ
Sensor 6	Formaldehyde sensor(s) in IAQ
Sensor 7	O2 sensor(s) in IAQ
Battery 1	Battery pack in IAQ and OAQ
Battery 2	Solar module in OAQ
Communication 1	Wi-Fi module in IAQ
Communication 2	4G module in OAQ
Data (WP4 Connecting and managing sensors)	
Storage	Gateway and Server Platform
Recording of data	Indoor Air Quality parameters every 15 minutes
Recording of data	Outdoor Air Quality parameters every 15 minutes
Monitoring	Heart rate, pedometer, calories burned / once a minute during physical activities
Integration	Indoor and outdoor conditions data are made available to project consortium
Analytics (WP5 Data analytics and adaptive control)	
Mathematical model	Will be finalized after ESTABLISH platform prototype is ready.
Privacy and Security	
	Users personal data will be available only for kynetotherapists and rehabilitation staff
Application	
User needs	Maintaining their physical condition and performing exercises in order to recover and restore motor functionalities, both indoors and outdoors.
Front end	Personal data, medical data, sensors data entries.
Back end	Data aggregation for analytics; indoor and outdoor air quality analysis; physiological data.
Pilot Implementation	
Implementation	In progress
Testing	In progress
Integration	In progress

Appendix 4B. Rehabilitation decision support, use case requirements

PILOT	Promoting the independece of vulnerable groups
COUNTRY	Romania
DESCRIPTION	The pilot will study the use of variety of IAQ and OAQ sensors combined with pilot's participants personal feedback and physiological data to aid recovery centers – medical personel in customizing the patients recovery programmes.
OWNER, CONTACT PERSON (in the project)	Denisa Becheru (SIVECO)

	Description
Use case preparation	
Brainstorming	Done with BEIA, ONG "Asociatia MAME", also first discussions with National Institute of Rehabilitation, Physical Medicine and Balneoclimatology of Bucharest
User scenario development	Done
User experience planning	User experience viewpoints in the pilot: - kynetotherapists – asses their oppinion regarding how to organize the information - patients – personal feedback
Contacting the users, recruitment	Done
Business modeling	Business model canvas
Evaluation criteria	Defined in D6.1
Use case specification	
Use case definition	The goals of the pilot are to: ▪ monitor health parameters to continually improve the health of the population through rehabilitation programmes focused on physical recovery care, explicitly targeting the patient's functional aspect of integration in everyday life, environment, and work, ▪ develop a decision support system and services based on the outdoors environment parameters and indoor location, and reduce operations costs and improve quality of the services provided.
Business modeling	Business model canvas
Feedback from stakeholders	Questionnaires, interviews, group discussions, conference, and co-creation tools will be used for collecting the feedbacks from the various sources such as pilot's participants – patients and medical personnel. The feedback will be periodically reflected in the implementation of the use case.
Technical specifications	See the other sheet: Technical specifications
Use case design	
Concept visualization	Paper publication and the mock-up prototyping will be used to describe the concept of the use case. The real application will be developed iteratively based on the feedback received from the users.

Feedback from stakeholders	Concept evaluation.
Implementation	
Contacting the users	How, how often, what to inform …
Review meetings	Who to involve, when, how often …
During the pilot	
User experience	Questionnaires, interviews, group discussions, co-creation tools …
After the pilot	
Evaluation of the pilot	To be performed

Use case specification	
Use case definition	The Romanian pilot will combine environmental sensor data with physiological and behavioural sensor data to empower patients in a rehabilitation clinic with decision support tools for behavioural choices and treatment options. The Romanian ESTABLISH project's goals are: - to monitor health parameters to constantly improve the health of the population through rehabilitation and spa care, specifically targeting the patient's functional aspect of integration in everyday life, environment and work. - to develop a decision support system and services based on the outdoors environment parameters and indoor location. - to reduce operations costs and improve quality of the services provided. We will use a first group of students from highschool and a second pilot group of adults. We will register their physical activities, the cardiac rithm, the burned calories, in order to find links between them and the air conditions.
Business modeling	Business model canvas
Feedback from stakeholders	Questionnaires, interviews, group discussions, co-creation tools…
Feedback from advisory board	Questionnaires, interviews, group discussions, co-creation tools…
Technical specifications	See the other sheet: Technical specifications
Use case design	
Concept visualization	Paper prototyping, mock-ups… (WYP)
Feedback from stakeholders	Concept evaluation
Feedback from advisory board	Concept evaluation
Implementation	
Contacting the users	How, how often, what to inform…
Review meetings	Who to involve, when, how often…
During the pilot	
Contacting the users	Users will receive notifications everytime is necessarily: overcoming their concentration level of sulfur dioxide (SO2), nitrogen oxides (NOx), carbon monoxide (CO), ozone (O3), particulate matter (PM10 and PM2)
User experience	Questionnaires, interviews, group discussions, co-creation tools…
After the pilot	
Evaluation of the pilot	to be done
Contacting the users	How, how often, what to inform…
Feasibility check	Assessing the feasibility of the concept to go to market and defining the necessary steps
Business model update	Finalisation of the business model canvas

Appendix 5A. Indoor air quality improvement at school, technical requirements

	Description
Devices, sensor management (WP3 System architecture)	
Sensor 1	Indoor conditions monitoring; temperature, humidity, CO2, pressure, pressure difference. VTT TinyNode
Sensor 2	Outdoor air quality sensor at VTT (Vaisala AQT420); Humidity, pressure, temperature, CO, EPA AQI, NO2, O3, PM10, PM2.5, SO2.
Sensor 3	Weather sensor (Vaisala WXT536): pressure, temperature, humidity, rain (accumulation, duration, intensity, peak intensity), hail (as with rain), wind (min/max dir, avg dir, min/max/avg speed)
Sensor 4	Door state sensors (VTT TinyNode)
Sensor 5	Physiological activity sensors with heart rate, HRV, breathing rate; Polar M600
Sensor 6	Indoor air quality monitoring (MCF-LW12CO2): CO2, humidity, illuminance, pressure, temperature, IAQ index derived from tVOC
Sensor 7	Environmental activity sensors: depth cameras (Orbbec Astra Pro) and passive infrared motion detectors (PIR) in VTT nodes
Sensor 8	(within air purifier) - optional: incoming air quality, purification efficiency
Sensor purchasing	Sensors 1-4 and part of sensors 7 (PIR sensors) are available from VTT. Personal sensors, indoor conditions and air quality monitoring sensors were purchased for the pilot.
Implementation	Design and coding of the backend applications for environmental, air quality and physical data collection. Implementation of necessary APIs for data retrieval for analysis & further visualization.
Computing platforms for environmental activity sensors	Existing laptops
Mobile phones	Phones are purchased for development purposes; no specific requirements (stock Android smartphone). In case separate phones are decided to be used by pilot participants, similar phones may be purchased. Otherwise, pilot participants may use their own (Android) phones. It is highly preferrable that pilot participans use their own phones because in this case we can evaluate human condition also on the basis of mobile phone usage data.
Mobile applications	Design and coding of the application. See Application part from this document.
Data (WP4 Connecting and managing sensors)	
Storage	MS Azure cloud platform
Storage of additional research data in VTT pilot	MS Azure cloud platform
Recording of data	Location-fixed indoor conditions data (temperature, humidity, CO2, pressure difference wrt outdoors) once a minute.
Recording of data	Outdoor conditions data and weather: once a minute

Recording of data	Indoor air quality data: every 15minutes
Recording of data	Physiological and activity sensors; 135Hz (approx 6-7h battery life)
Recording of data	Category-wise mobile phone application usage data in VTT pilot (timestamps when user started and stopped applications of each category, such as business, social etc.)
Recording of data	User-defined labels; user initiated (any time) and scheduled (two times during working day; morning, when leaving work). Option for backend-originated querying of user label based on observed physiological data.
Recording of data	Air purifier; filtering efficiency (e.g., power vs airflow and/or purification efficiency). Optional: Incoming air quality (if not available via the external indoor air quality sensors)
Monitoring	Visualizations updated at least once a day for participants.
Monitoring	Air purifier filter status; daily
Gateways	Location-fixed indoor sensors connect via VTT gateways and/or vendor specific (e.g., Lorrier LR2) to MS Azure IoT Hub. Mobile phone is used as gateway for pilot participants' physiological sensors.
Connectivity	Sensor <=> gateway via BTLE, LoRA. Gateway <=> cloud via 3G/4G cellular and/or WiFi
Integration	VTT indoor conditions and outdoor conditions are made available to project consortium.
Analytics (WP5 Data analytics and adaptive control)	
	Started during VTT pre-pilot; seek to find correlation between user-defined labels (feelings, symptoms, activity), physiological measurements (e.g., heart rate, breathing rate) and behavioural data. Find correlation between symptoms and spaces the participant visits. Seek to classify sources of indoor air quality problems by correlating symptoms (user-specified and physiological), indoor and outdoor air quality measurements, questionnaire
Privacy and Security	
	Collected physiological data will be pseudoanonymized by hashing the person identifier, and not storing the unhashed identifier in the data collection and processing system.

Application	
User needs	Interviews / questionnaires / focus group discussions to understand users needs. User needs the application for labelling data (feelings, symptoms, etc.) and in order to see their personal collected data (visualizations). If location cannot be determined otherwise, ask the user.
Front end	User data collection (labels); visualizations of collected physiological data. Positioning / location tracking.
Back end	Data aggregation for analytics and visualization. Collection of mobile phone usage data at least in VTT pre-pilot, such as for how long the user used applications of different categories (social, business,´etc.
Front end / Back end (division TBD)	Adjustment of air purifier operation based on observed environmental conditions, and determination + indication of need for filter cleaning & replacement.

Pilot Implementation	
Implementation	what, when, who to cantact, how, who…
Testing	At VTT pre-pilot

Appendix 5B. Indoor air quality improvement at school, use case requirements

Appendix 6A. Tracking of Professional / non-profesional athletes with wearable sensors, technical requirements

	Description
	Devices, sensor management (WP3 System architecture)
Sensor 1	Motion sensor(s)
Sensor 2	Blood pressure sensor(s)
Sensor 3	Brain activities sensor(s)
Sensor 4	Focus or attention sensor(s)
Sensor 5	Sleep sensor (s)
Sensor 6	Body Temperature sensor(s)
Actuator 1	Electrocardiogram sensor(s)
Actuator 2	Cardiac fitness
Actuator 3	Stress
Data source	Mobil Devices (Tablets, phones etc.), wearable sensors, smart swatches
	Data (WP4 Connecting and managing sensors)
Storage	Cloud platform
Recording of data	Body activities and body health parameter periodically.
Recording of data	Auxiliary data about the condition of environment
Recording of data	Constant data that is recorded previously such as recepies, health reports etc.
Monitoring	Rich reports for Athletes
Monitoring	Body activities
Gateways	Sensors connect via gateways and/or vendor specific selected cloud IoT Hub. Mobile phone may be used as gateway for pilot participants' physiological sensors.
Connectivity	Sensor <=> gateway via LoRa and/or BLE Gateway <=> cloud via 3G/4G cellular, Wi-Fi and/or Ethernet
Integration	Data and architecture can share to project consortium.
	Analytics (WP5 Data analytics and adaptive control)
Mathematical model	Big Data Analytics Tedhnologies will be used to analyze data that is gathered from the sensor via APIs. Spark, Kafka, NoSQL, Spark Streaming etc. are the examples of technologies that will be on Cloud as a platform. Platform can be used as Platform as a Service.

	Privacy and Security
	Privacy and security provisions will be performed within WP4 and WP5. Main focus on – protect sensor data (values, placement, type) against misuse, gateway encrypted protocols, user identity and user activity protection, infrastructure misuse and user authentication on applications.
Application	
User needs	Interviews / questionnaires / focus group discussions to understand users' needs.
Front end	Sensor data collection; visualizations of collected and predicted data. Visualization of data which is analyzed.
Back end	Data aggregation for analytics, visualization and prediction. Connecting the measured date with mathematical model.
	Pilot Implementation
Implementation	The main components of the project are: 1. Extracting meaninfull information by analyzing collected data from mobile applications and IOT devices. 2. Integration of semantic data using Big Data platform, 3. Content-aware adaptation and automation of the IOT infrastructure, 4. Development of a suggestion system based on the results of data analysis. 5. Development of mobile and web applications software for tracking data, accessing analysis results and tracking recommendations.
Testing	Devices test that includes data streaming tests. Cloud components that are big data analytics technologies availability and working correctly tests will be done. APIs and Visualization services control. Data accuracy test.

Appendix 6B. Tracking of Professional / non-profesional athletes with wearable sensors, use case requirements

Use case requirements and technical specifications	
PILOT	Tracking of Professional / non-profesional athletes with wearable sensors
COUNTRY	Turkey
DESCRIPTION	From the sport industry point of view, tracking and managing the parameters affecting the sport such as physical condition, health, motivation, eating, drinking and sleeping for amateur and professional athletes operating in individual or team sports in Europe and in our country became important. The development of wearable devices has given rise to new fields such as data analytics, reporting, developing a recommender system, while removing the problem of data collection.
OWNER, CONTACT PERSON (in the project)	Ahmet Sever (Turkgen)
	Description
	Use case preparation
Brainstorming	Discussing with partners involved.
User scenario development	1. Extracting meaninfull information by analyzing collected data from mobile applications and IOT devices. 2. Integration of semantic data using Big Data platform, 3. Content-aware adaptation and automation of the IOT infrastructure, 4. Development of a suggestion system based on the results of data analysis. 5. Development of mobile and web applications software for tracking data, accessing analysis results and tracking recommendations.
User experience planning	User experience viewpoints in the pilot / how / how often etc. will be planned together with use case developers.
Contacting the users, recruitment	The contact person will be contacted and a planning meeting will be arranged.
Informing about the pilot	Informative meetings will be arranged before, during and after the test period.
Business modelling	Business model canvas will be created when the pilot will be defined. The canvas will be discussed in the steering group meeting also.
Evaluation criteria	TBD

	Use case specification
Use case definition	The pilot will develop a project that will include Data Acquisition, Data Analytics and Information Delivery steps. Data is gathered from the device that is wearable sensor. The data is sent to Establish Big Data Analytics Portal on the cloud. Data will be stored on a storage mechanism and it will be analyzed with machine learning and data analytics methods.
Business modelling	Business model canvas will be developed during the pilot.
Feedback from stakeholders	Questionnaires, interviews, group discussions, co-creation tools will be utilized to collect feedback. It will be determined together with testeers how the feedback will be collected during the pilot.
Technical specifications	See the other sheet: Technical specifications
Use case design	
Concept visualization	Paper prototyping, mock-ups will be utilized. The real application will be developed iteratively based on the feedback got from the users.
Feedback from stakeholders	Concept evaluation with companies involved and project partners in the meetings.Co-operation possibilities with other partners will be discussed during the project.
Implementation	
Contacting the users	The contact person will be contacted and a planning meeting will be arranged. All testees will be informed about pilot.
Review meetings	The stakeholders will be informed at the meeting before the pilot. At the end of the pilot, a feedback event / group discussion meetings will be arranged.
During the pilot	
Contacting the users	TBD
User experience	Questionnaires, interviews, group discussions, co-creation tools will be utilized to collect feedback. It will be determined together with testees how the feedback will be collected during the pilot.
Analytics	Big Data Analytics techniques will be used on the cloud Establish Portal.
After the pilot	
Evaluation of the pilot	The pilot will be evaluated with the stakeholders by the criteria defined before the pilot.
Contacting the users	The results of the pilot will be shared with the users in meetings / by email.
Conclusions and recommendations	The results of the pilot will be analyzed and shared with the stakeholders by meeting.

Feedback from stakeholders	Feedback from the stakeholders will be collected by meeting. They are also able to comment and update the report of the results.
Feasibility check	Assessing the feasibility of the concept to go to market and defining the necessary steps.
Business model update	Finalization of the business model canvas with the stakeholders.