D7.5 ECF4CLIM digital platform - Module 3 - IoT Ecosystem space

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Contributing organizations	QUE		
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WHO WE ARE

The ECF consortium consists of ten partners. The project is coordinated by Centro de Investigaciones Energeticas, Medioambientales y Tecnologicas-CIEMAT.

Name	Country	Logo
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Instituto Superior Técnico. University of Lisbon. IST	PT	
Universidad de Sevilla USE	ES	
University of Jyväskylä JYU	FI	
Universitat Autònoma de Barcelona UAB	ES	
Meda Research Ltd MedaResearch	RO	
Instituto de Soldadura e Qualidade ISQ	PT	
Trebag Szellemi Tulajdon Es Projektmenedzser Korlatolt Felelossegu Tarsasag TREBAG	HU	

Smartwatt Energy Services SA Smartwatt	PT	
Que Technologies Kefalaiouchiki Etaireia QUE	GR	

ABOUT THE PROJECT

Through a multidisciplinary, transdisciplinary and participatory process, ECF4CLIM develops, tests and validates a European Competence Framework (ECF) for transformational change, which will empower the educational community to take action against climate change and towards sustainable development.

Applying a novel hybrid participatory approach, rooted in participatory action research and citizen science, ECF4CLIM co-designs the ECF in selected schools and universities, by: 1) elaborating an initial ECF, supported by crowdsourcing of ideas and analysis of existing ECFs; 2) establishing the baseline of individual and collective competences, as well as environmental performance indicators; 3) implementing practical, replicable and context adapted technical, behavioural, and organisational interventions that foster the acquisition of competences; 4) evaluating the ability of the interventions to strengthen sustainability competences and environmental performance; and 5) validating the ECF.

The proposed ECF is unique in that it encompasses the interacting STEM-related, digital and social competences, and systematically explores individual, organisational and institutional factors that enable or constrain the desired change. The novel hybrid participatory approach provides the broad educational community with: an ECF adaptable to a range of settings; new ways of collaboration between public, private and third-sector bodies; and innovative organisational models of engagement and action for sustainability (Sustainability Competence Teams and Committees).

To encourage learning-by-doing, several novel tools will be co-designed with and made available to citizens, including a digital platform for crowdsourcing, IoT solutions for real-time monitoring of selected parameters, and a digital learning space. Participation of various SMEs in the consortium maximises the broad adoption and applicability of the ECF for the required transformational change towards sustainability.

LEGAL NOTICE

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1. EXECUTIVE SUMMARY

The following document – deliverable D7.5 – belongs to task 7.1 of ECF4CLIM project.

The document contains an overview of the IoT ecosystem purpose in the context of the ECF4CLIM project and provides a detailed description of the deployment plan. The integration architecture between the IoT ecosystem and digital platform is also described. It is worth mentioning that this integration is not fully defined, i.e., at the date of this deliverable is a work in progress, since the use cases and information to be shown in the Digital Platform is still being defined by the different partners involved in the project. Nevertheless, the main technical guidelines for establishing the interactions between the IoT ecosystem and the Digital Platform are identified. As such, the next steps regarding the IoT ecosystem integration with the ECF4CLIM digital platform are also outlined in this document.

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2. IoT Ecosystem Within ECF4CLIM Digital Platform

In previous deliverables [1] a high-level description of the Digital Platform architecture was thoroughly presented. All the modules and tools that will be integrated in the digital platform were described in [1], namely from a functional and technical point of view.

Briefly, the digital platform consists of an integrated ecosystem that combines different modules and tools from different partners. Particularly, it consists of four different spaces(modules): crowdsourcing, learning, simulators, and IoT ecosystem.

The digital platform provides a fully integrated and user-friendly environment to undertake different simulations and analysis in line with the project scope and respective goals. It is also worth mentioning that this environment is prepared to handle different types of users, such as students, teachers, school managers, etc.

To enable interactive simulations on the digital platform, one crucial step for its development consists of defining and establishing data acquisition processes that can be implemented on top of different data sources, according to the data needs from each of the abovementioned tools. In this regard, it is already defined that the main sources of information to feed the digital platform's modules, namely Simulators and Ecosystem space, will be:

- Batches of static data provided by partners, like CIEMAT and USE, and stored in digital dedicated database;
- IoT Ecosystem that will communicate with the digital the platform through RESTful Application Programming Interfaces (APIs).

The IoT Ecosystem works as a data collector from the different sites, like schools, available in the project. This ecosystem will provide data like energy consumptions, temperatures, resulting from sensors installed in these sites. In section 3 it is provided a more thorough description of the IoT main goals.
The Ecosystem Space in the digital platform will display Key Performance Indicators (KPIS), using different means according to the type of information to be shown, namely by using tabular and graphical representations. The KPIs will be defined by ECF4CLIM partners, in other WPs, such as WP4/5. Its calculation will be performed inside the IoT Ecosystem and then, the digital platform will gather this information automatically through the REST APIs and make the necessary data transformations to show/display these KPIs in the user interface of the platform (front-end layer

Figure 1 depicts IoT ecosystem integration within ECF4CLIM digital platform.

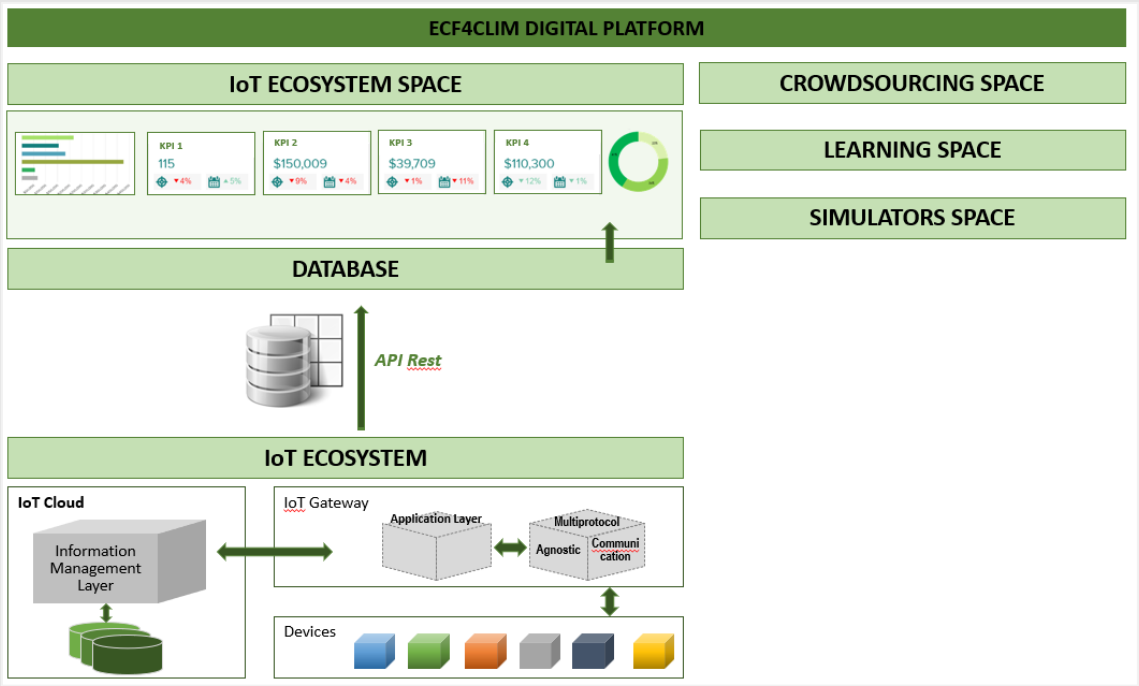

Figure 1. IoT Ecosystem integration in ECF4CLIM digital platform

3. SCOPE AND DEPLOYMENT PLAN OF THE IOT ECOSYSTEM

The purpose of the IoT ecosystem in ECF4CLIM project is to extract sensing metering data of the selected educational building institutes, in order to have a better overview of the educational community carbon footprint. Sensing and metering data usually consists of energy production and consumption values and ambient conditions such as temperature, humidity etc. Schools and universities, by being involved in the data collection and processing procedure, they will raise their environmental awareness and will be engaged towards a greener way of thinking.

To tackle this task, QUE develops a tailored solution for each selected pilot site to collect, cleanse and pre-process real time data. Each pilot site serves a different purpose and has its unique characteristics and equipment, like different heating or cooling systems. Therefore, a pre-installation deployment procedure was designed, to propose the suitable IoT equipment to match the projects and building's infrastructure requirements. For this reason, two energy audits were circulated among the pilot partners to extract comprehensive information of the existing technical building's systems.

Additionally, workshops were conducted and guidelines were distributed to minimize the errors. The specific procedure will be documented in detail in Task4.3 *Environmental Performance of the selected educational establishments.* As part of the same task Que will examine the energy audits to identify the buildings' needs and requirements. Before

delivering the final Bill of Materials, Que will test and evaluate every candidate IoT solution in its lab facilities, and it will integrate it to Que's IoT ecosystem. Except from the proposed IoT equipment that involves meters and sensor, the solution will include the IoT gateway, which is a Raspberry Pi 4 model illustrated in Figure .

Figure 2. IoT gateway

Through the IoT gateway all the available data from the IoT devices inside the building are collected and streamed to the IoT Cloud. In a nutshell, the IoT gateway acts as a bridge between the digital and the physical world. Below it is illustrated an UML diagram, Figure 3, that demonstrates the connection of the IoT Cloud to the IoT Building IoT equipment and IoT gateway, as well as the interactions with the Smartwatt database.

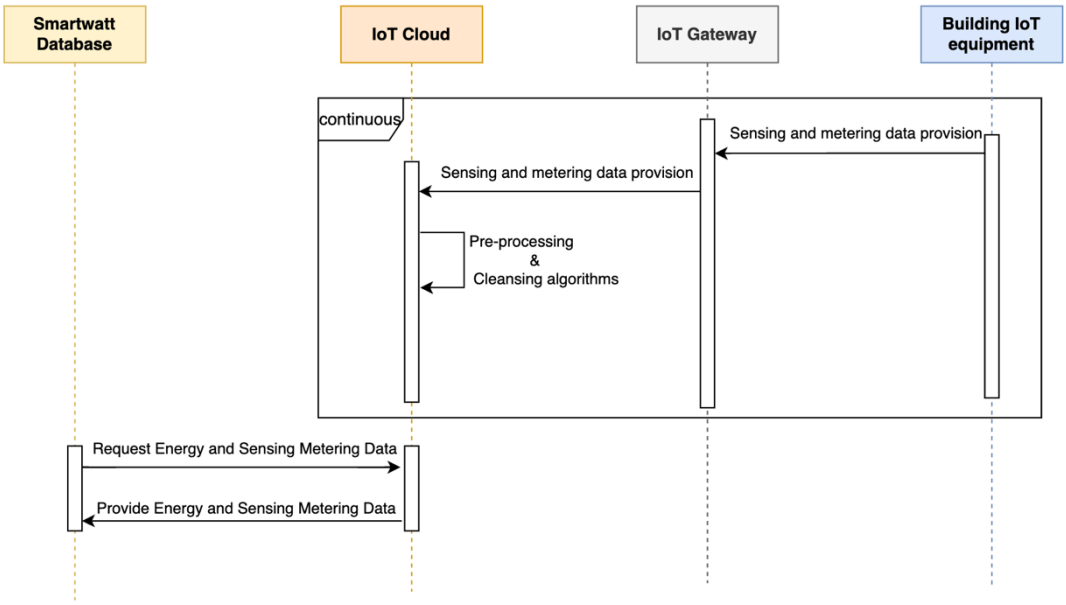

Figure 3. UML Software Components communication diagram

The Building IoT devices list will include Smart meters and Smart Sensors. The Smart meters will be able to capture metrics of the preferable building aspects like energy consumption, power consumption, amperage, voltages and will report them in real time.

On the other hand, the proposed smart sensors will be able to extract data regarding the indoor air quality of the respective rooms of the pilot site, for example, CO_2 emissions, Volatile Organic Compounds, temperature, humidity and etc.

All these devices communicate with the IoT gateway through Zwave, Wi-fi and Bluetooth protocols.

As presented in the UML diagram, Figure 3, all this information is streamed from the IoT gateway to the IoT Cloud. Summarizing, the raw collected data are pre-processed through various data cleansing algorithms like moving window and outlier detection in the IoT Cloud and will be send to Smartwatt Database. More detailed documentation will be presented in Task 7.4 *IoT Ecosystem for Multipurpose Monitoring.*

4. ARCHITECTURE OVERVIEW

As presented in more detail in D7.2**[1]** the IoT ecosystem is divided into two separate parts. The first one consists of the IoT Cloud and the latter one the IoT gateway. The IoT gateway, illustrated in Figure , is in charge of orchestrating the data collection process from the on-site IoT equipment and the secure data transfer to the IoT Cloud.

The developed system is embedded in a Raspberry Pi 4 device, and in Figure 4 an overview of its architecture is presented. In a nutshell, it consists of 4 different main components:

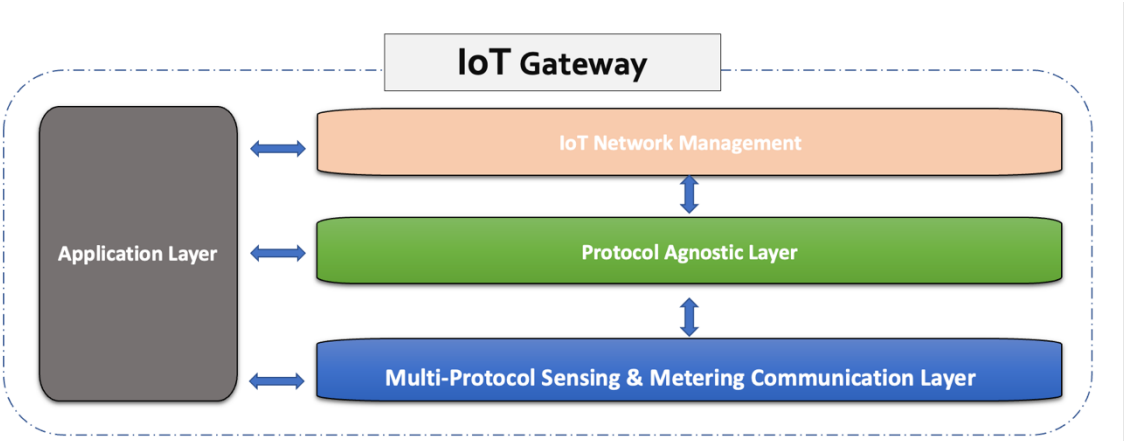

Figure 4. IoT Gateway architecture (source: [1])

- **The Multi-Protocol Sensing & Metering Communication Layer**, which includes the drivers of the gateway like the Wi-fi Manager, the Z-Wave Manager and the BLE Manager, granting integration with the networks of the IoT devices.
- **Protocol Agnostic Layer**, which acts as an interpreter of the IoT devices with the IoT gateway. It utilizes an open-source platform that allows interoperability between different IoT devices from different brands and specifications.
- **IoT Network Management**, that is responsible for the health of the whole IoT system in the deployed pilot site.

- **The Application Layer**, that is responsible for the secure information gathering, for updating the software and to temporarily save data in case there is no connection of the gateway with the Cloud, due to power or internet connectivity issues.

Regarding the IoT Cloud which was also documented in D7.2 [1], this software module acts as a supervisor of the whole data extraction process. Its key responsibilities are the data acquisition from each IoT gateway, data pre-process and finally the secure data distribution to the third-party partners. Its main software components as presented in Figure are:

- **The Application Layer,** which hosts all the services that participate in the Data Handling and Data Processing procedures.
- **The IoT interface,** which is the digital bridge between the IoT Cloud and the IoT gateway, ensuring stable and secure communication exchange.
- **The Common Information Interfaces,** which is responsible for the connection of the IoT Cloud with third-party software components.

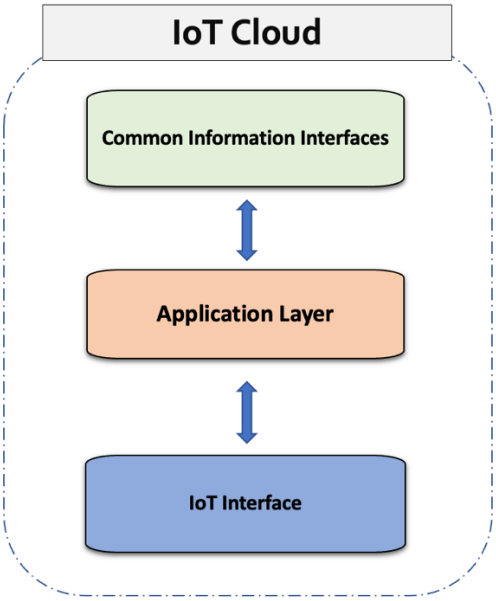

Figure 5. IoT Cloud architecture (source: [1])

The architecture of the IoT Cloud and IoT gateway will be documented in detail in Task 7.4 *IoT Ecosystem for Multipurpose Monitoring.*

5. INTEGRATION ARCHITECTURE

The communication exchange between IoT ecosystem and Digital Platform will be implemented through RESTful APIs. A RESTful API is the set of definitions and protocols based on the REST architectural style, responsible to implement the application program interface (API). Through HTTP request is able to read, update, create and delete with GET, PUT, POST and DELETE request respectively. The abbreviation RESTful stands Representational State Transfer and it's an architectural method for communication between different modules.

APIs will be utilized to establish constant, seamless, and secure communication exchange between the IoT ecosystem and the Smartwatt Database. Those APIs provide information regarding the configuration of the digital representation and the metering data that will be extracted and pre-processed of the selected pilot sites.

Through these services the digital platform developed by Smartwatt partner could retrieve all the available metering data that the IoT ecosystem collects. On top of that it will also correlate them with the respective rooms and building systems of each pilot site.

The data of the pilot sites are transmitted in JSON format, which is an open standard file format that is commonly used, for example, in web applications. The data streaming to the Smartwatt database will be constantly with 15-minute intervals granularity.

A vital part of this communication process is the Authentication & Authorization module, a separate component that acts as a bridge between the IoT Cloud and every other external software component, of the ECF4CLIM ecosystem that want to interact with it. This module is responsible for two main tasks. Primarily to protect the exchange of information between the various components, and on a second level to store private or sensitive data. As part of the integration process the authentication procedures in the IoT Cloud, will allow or denies access to the external software components through the Authentication & Authorization module. In addition, via the Authorization processes the IoT Cloud decides what type of data they will be streamed to the rest of the ECF4CLIM ecosystem.

6. ECOSYSTEM SPACE DESCRIPTION

Data received from the IoT ecosystem in (almost) real time will be displayed in the ecosystem space of the digital platform, using different methods such as charts and tables. The best ways to display each KPI information will be discussed with partners, namely with the partners responsible for the KPIs definition, in order to create a friendly and educational environment that allows not only real-time monitoring/measurement of the environmental performance of the demonstration schools and universities, but also to improve their knowledge on the of the causal relationships between behavioural changes and environmental.

It was not yet defined the type of interactions and permissions that each type of user will have within the ecosystem space, in the digital platform. However, each user will be able to see and interact with the information concerning his corresponding demonstration site. More complex interactions may be designed, but at this stage the only interaction between the users and the platform will be filtering interactions, such as choosing KPI type, time periods, e.g. The users will be able to read data, but not to write data in the dedicated databases. It is being evaluated the possibility download raw data and reports. Despite having to handle different types of users, the digital platform will be developed with simplicity in mind so that everyone can use it in the smoothest and easy way as possible. The aim is to deliver a platform that can clearly speak the results of the simulations of the project regardless of the type of user that is interacting with it.

7. FUTURE STEPS

Following the project schedule, the teams allocated to the IoT ecosystem (QUE) and Digital Platform (Smartwatt) will carry on developing all the necessary applications in order to achieve a fully integrated and interoperable solution. More particularly, in the short to medium term both entities will undertake the implementation of the interfaces between the digital platform and the IoT platform so that it is possible to establish a bidirectional communication flow, according to the data needs of the project. This process can start as soon as all the use cases and data needs are defined by the partners involved in the project. In parallel the necessary algorithms to perform calculations on top of the raw data will be implemented. Finally, the user interfaces to display the information collected by IoT ecosystem will be designed and implemented in the Digital Platform.

8. REFERENCES

[1] 101036505_Deliverable_24_(ECF4CLIM digital platform architecture)