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IPSE PARSIT
Public-Subscribe IoT platform for optimal management of Circular Economy processes*

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Abstract

The "IPSE - PARSIT" project (acronym for IoT Publish Subscribe Environment - For the Advanced Management of Recycling, Disposal, Citizen Information and Traceability) is aimed at creating a digital technological platform for LPWA services and devices that allow optimal control of processes of the circular economy. The circular economy is an economic system planned to reuse materials in subsequent production cycles, minimizing waste. Described in terms of economic models, the circular economy concerns not only changes in production processes, but also consumer habits, involving, especially in Italy, the SME system and at the same time guaranteeing the creation of jobs and value. economic while reducing the demand for non-secondary raw materials. The Public Administration plays a fundamental role in these new models of incentives through regulatory changes, the implementation of reward mechanisms and by favoring the purchase of "green" products and services for itself. In these terms, it is evident that market-matching, collaboration, information, traceability, and measurement are fundamental factors to be able to initiate an effective change of processes and models. The intent is to promote a marketplace that stimulates the birth of new business models and that allows the traceability and measurement of the level of circularity of a product. The platform will be used in concrete scenarios, such as waste collection and charitable donations. Unidata - partner of the project for a share of 30.57% - through its IoT LoRaWan^{TM} network already extended to the entire city of Rome and expanding in Lazio, will make it possible to manage low-cost devices with extremely high consumption levels. contents, which will allow you to receive information on the levels of conferment, on the status of the containers, on the traceability and on the process or service requests.

Keywords: circular economy, IoT, Internet of things, LoraWan, Block Chain, special waste

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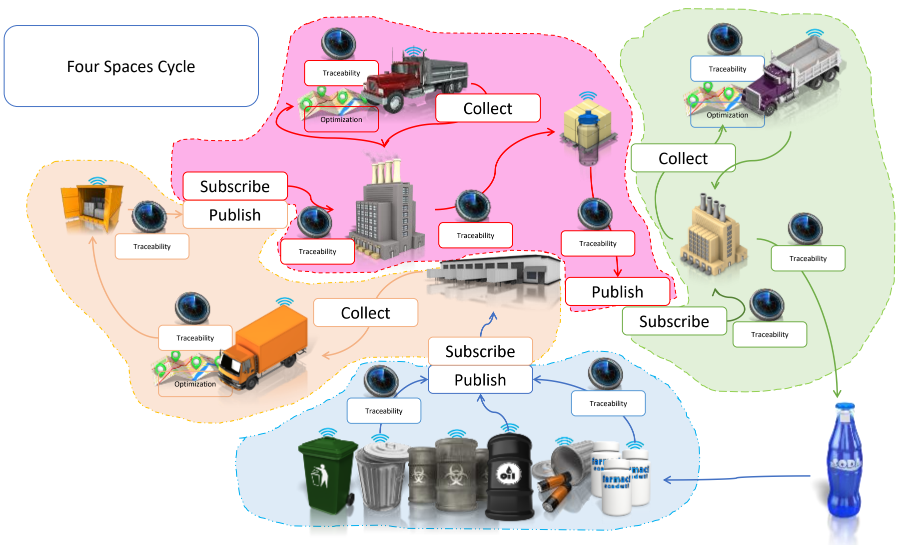
1. Introduction

The IPSE PARSIT project proposes the development of a digital technological platform (LPWA services and devices) which, through the micro-service management of Publish-Subscribe mechanisms, allows optimal control of the processes characterizing the circular economy, creating a market place that not only the current optimization needs are efficient QUESTION -> OFFER, but which can stimulate the birth of new business models and new enterprises (especially in the downstream phase), and which allows the traceability and measurement of the level of circularity of a product. This platform will be validated in two concrete operational scenarios: waste collection and charitable donations. With reference to the operational scenario of waste collection, the first use case of interest concerns the collection of oils, the details of the functional and logical - physical architecture of which will be described in the next paragraphs.

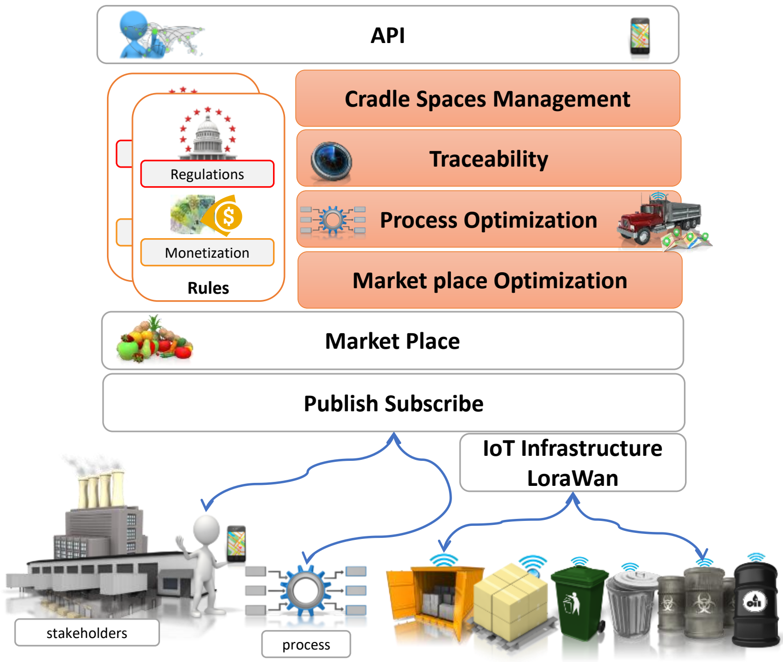
2. Objectives

The ambition of the IPSE PARSIT project aims to focus on some "technological" aspects, inserted in a context of "horizontal and generalist circular economy" but applied and validated on two concrete scenarios, aims to contribute: ● to the generation of a technological market place (not a website) that combines supply and demand ● to generate correct "information" that feeds the market place. ● the improvement of technological tools to minimize costs and optimize processes. ● the improvement of the technological tools for tracking and indexing transactions and QoS. ● the definition of a sufficiently dynamic and generalist architecture that can be applied in a modular way to many different "circular" scenarios. ● the implementation of process IoT networks based on low cost and very low consumption LPWA LoRa devices. The IPSE PARSIT MARKET-PLACE idea is based on the PUBLISH SUBSCRIBE service concept (PS below) and on the architectural concept of a space we call CRADLE SPACE (CS below), for obvious reasons given the Cradle To Cradle context (C2C below), that is the idea of designing systems by adapting industrial models to nature in order to bring the materials used back to natural elements, which are therefore able to regenerate.

The following figure represents the complete cycle of a waste that crosses four "Cradle Spaces" using PUB-SUB technologies to pass from one space to another.



Specifically, the IPSE PARSIT architecture must allow: (1) management of messages from the LoraWan ™ [*] devices used, such as information regarding the filling of the waste oil container tank; (2) prediction of Best Date and Best Route for collecting oil; (3) management of a Markeplace for collected oil; (4) Tracking of collected waste using a Block Chain.
[* Lora™ and LoraWan™ are registered mark of Semtech Corp].



3. Outline of the work

As for the application domains, the search for those of greatest interest was carried out by analyzing the realities in which we operate and analyzing specific needs that could give the right benefits to services and process modernization. As far as the circular economy is concerned, this is constantly evolving and aims in its maximum expression to trace and put back on the market products that would otherwise lose less virtue such as disposal. The European community and therefore also the member states are increasingly moving towards a sustainable and circular economy, so much so that directives no. 849/850/851 and 852/2018 have come into force in Italy and all go towards the focus of a truly circular economy. At present, along the entire chain of the circular waste economy, there are intermediate steps which, if not improved, lead to an interruption in the process that makes the entire material recovery process less efficient. Among the various obligatory steps of waste, some domains have been analyzed which at present determine criticalities which then influence the entire subsequent supply chain. Specifically, the application domains such as collection centers, roadside bins and containers of vegetable oils were analyzed.
Regarding waste collection, it was decided to develop and test the system for the use case of vegetable oil collection.

In the first phase of the project the architecture was designed, selecting the most suitable components and platforms for:

- IoT network
- optimization processes.
- traceability of transactions.
- management of the Publish Subscribe.
- management of administrative and bureaucratic procedures.
- Messaging and BOT UI.

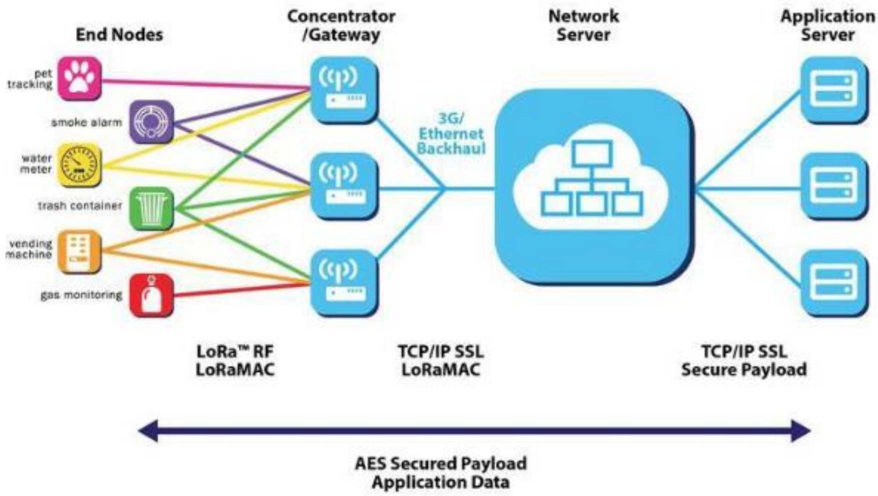
In the second phase we have developed and integrated all the components.

In the third phase we implemented the use case, installing the sensors on the oil containers of a municipality near Rome.

4. Materials and methods

The Internet Of Things (IoT) indicates the extension of the technologies of the Net to "objects that connect the physical world" [original definition - Kevin Ashton 1999]. In the current declination it is combined with cloud platforms and data storage in a scenario in which "objects (" things ") become recognizable and acquire intelligence thanks to the fact that they can communicate data about themselves and access aggregate information by others "[P. Magrassi, "Dictionary of the digital economy" Sole 24Ore]. In this "collaborative" and "aggregative" form, the IoT is the evolution of the traditional M2M Machine to Machine.

As IoT technology we have chosen LoraWan. LoRa ™ technology, developed by the French startup Cycleo, then acquired by Semtech, creates a low-energy, certified and stable type of low-power-wide-area LPWA (Low Power Wide Area) network. From a physical point of view, a radio spread spectrum modulation is used, which consists in transmitting the signal with a band greater than that necessary, thus allowing to decrease the energy associated with the transmission without decreasing that associated with the information transmitted.



Sensor: After various tests, we chose the LoraWan ultrasonic sensor from Nemeus to measure the filling level of the bins.

LoraWan network Server: Unidata's Uniorchestra platform was used both as a network server and as a design tool for the LoraWan network.

PUB-SUB Brokering: For PUB SUB services we have chosen the MQTT [Message Queuing Telemetry Transport] protocol. For the implementation we used the Broker Mosquitto.

Content Management: for the management of administrative and bureaucratic procedures, we have chosen the Alfresco platform.

Block Chain: for the traceability of all transactions through the Block Chain, we used the Multichain platform.

Process optimization: for process optimization we used Optaplanner, an Open Source Constraint Solver written in Java (based on Drools, a rule engine solver developed by JBoss).

BOT & Messaging: we chose Telegram as BOT & messaging platform.

5. Results and discussion

The sensors installed on the oil bins send the fill levels of each bin at hourly intervals.

The data, collected through the LoraWan network and Unidata's Uniorchestra platform, published through the MQTT protocol, transit through the ESB (Enterprise Service Bus) of the platform, and are stored on the database.

The optimization system, based on the historical series of the acquired data, predicts the best day and route for emptying the bins.

The application platform of Paoletti Ecologia receives the forecasts of the optimization system. When one of the forecasts proposed by the system is chosen, the exit of the vehicle is scheduled, and availability is published on the marketplace for oils.

On the day scheduled for collection, the vehicle leaves and follows the optimized route to empty the selected bins and to bring the oil to the collection center that bought it.

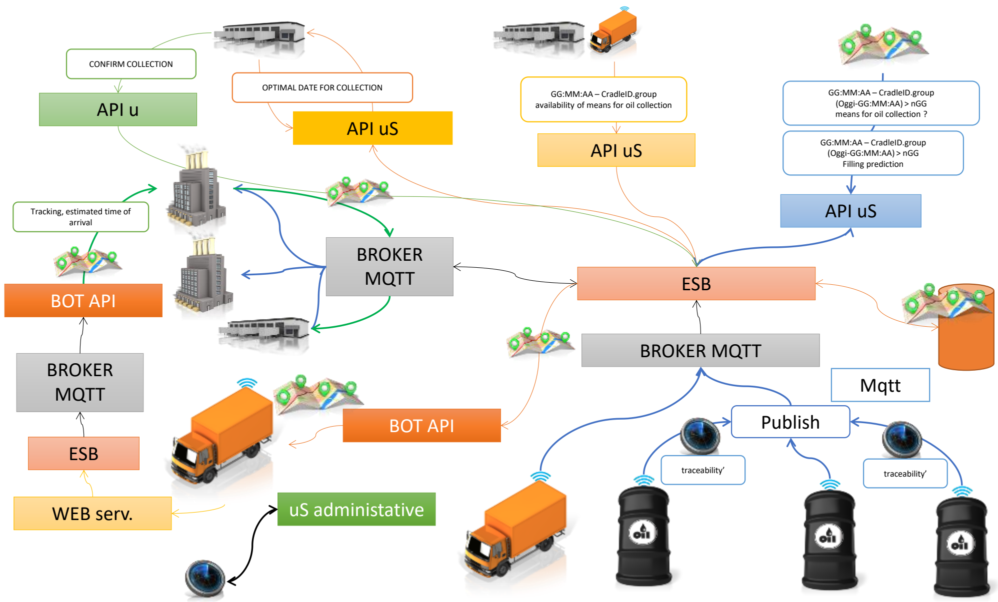
Administrative and bureaucratic practices are handled through Alfresco content management.

All transactions (collection and sale) are stored in the block chain.

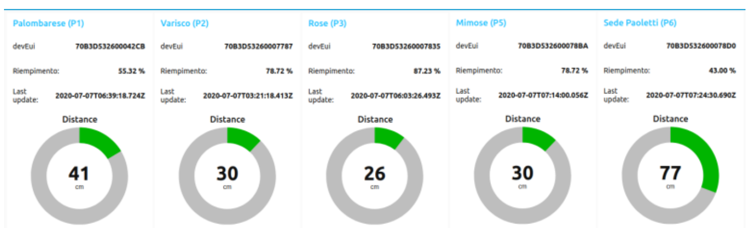
The system also has a dashboard that allows you to view the status of the bins.

Any alarms, and the messages for the collection means, are received on the operators' smartphones via a Telegram Chat BOT.

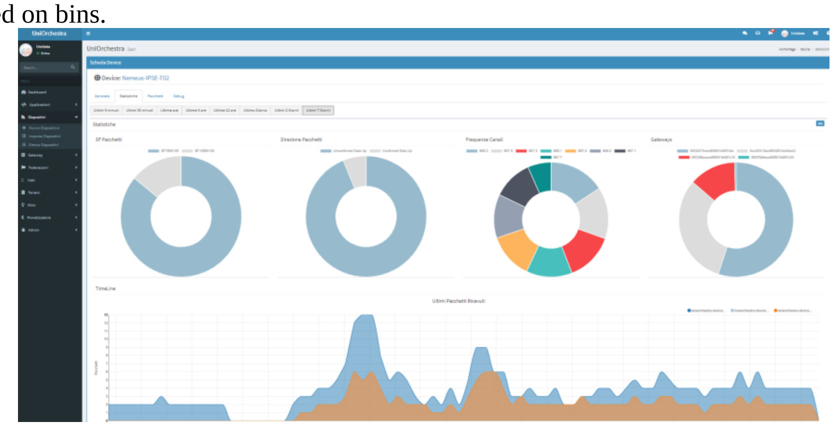
The following figure shows the developed system.



The following figures show the Dashboard and the Chat BOT of the system.



The following figure shows statistics of messages sent by one of the LoraWan sensors installed on bins.



6. Concluding remarks

To manage the complexity and challenges of the Circular Economy, a multidisciplinary approach is required, which involves collaboration between many actors.

The vision and architecture of IPSE PARSIT allow to model complete solutions for the Circular Economy, addressing all aspects of the process (physical devices, process optimization, administrative management, traceability).

The LoraWan technology makes the realization of the IoT network economically sustainable: the batteries of the sensors used last many years, the network allows to cover large geographical areas, the construction, operation and maintenance costs are low.

The developed system was validated with a real USE CASE to optimize the collection of oils from the bins located in a municipality near Rome.

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