INTERNET OF THINGS
Success Stories

SERIES 3
NOVEMBER 2015

Editor: **Philippe Cousin**

SMART ACTION
Innovating beyond IoT

IERC
European Research Cluster on the Internet of Things

AIOTI
ALLIANCE FOR INTERNET OF THINGS INNOVATION

Foreword

by Thibault Kleiner

Network Technologies, DG CONNECT, European Commission

The Internet of Things (IoT) is the next digital revolution through which billions of connected things (nearly five billion, in present, reaching 25 billion by 2020) will transform people's lives, drive growth, create employment, increase comfort, provide better healthcare and increased independence, and address societal challenges.

Since 2009, the European Commission has funded pioneering research in cooperation with Member states and third countries to develop the most dynamic and agile Internet of Things (IoT) ecosystem in the world, which would enable Europe to get a global lead in this field and foster a Digital Single Market (DSM) for IoT. To achieve such ambitious goals, in 2010, the European Commission initiated the Internet of Things European Research Cluster (IERC) to bring together projects related to the IoT. This was especially efficient in the case of SMEs and start-ups, which wanted to innovate in the IoT area but might not have resources to invest in lengthy and costly research. Therefore, the IERC could offer ready-to-use solutions and best practices, and even more when some solutions are free and open source.

Nevertheless, we thought that there was not enough awareness of the potential of using IoT, and that could limit its expected massive deployment and the Large Scale Projects (LSP) that the European Commission will support in its upcoming H2020 call. Accordingly, the European Commission initiated the Alliance for Internet of Things Innovation (AIOTI) in March 2015, to develop and support the dialogue and interaction among the Internet of Things (IoT) various players for the creation of a dynamic European IoT ecosystem to unleash the potentials of the IoT. Thus, the members of AIOTI jointly work on the creation of a dynamic European IoT ecosystem, which is going to build on the work of the IoT Research Cluster (IERC) and spill over innovation across industries and business sectors of IoT, thus transforming ideas to solutions.

I hope that in reading the following success stories, you can find useful information that give you further confidence in IoT technologies and inspire you to exploit, innovate in or develop the Internet of Things growing market.

AIOTI

ALLIANCE FOR INTERNET OF THINGS INNOVATION

Aware of the potential of using the IoT, in March 2015 the European Commission initiated the Alliance for Internet of Things Innovation (AIOTI), aiming at creating an IoT Ecosystem that would enable Europe to get a global lead in this field and foster a Digital Single Market (DSM) for IoT. The overall goal of this Alliance is, therefore, to strengthen links and to build new relationships between the different IoT players (industries, SMEs, start-ups, stakeholders) and sectors, also promoting interoperability and convergence between standards, thus facilitating policy debates, and preparing a Commission's initiative for large scale testing and experimentation, scheduled for 2016.

Resulting from the intensive work carried out over the past eight months, although the AIOTI has been recently born, it has already managed to gather more than 325 members from different sectors, bringing together:

- Different industries: nanoelectronics/semiconductor companies, Telecom companies, Network operators, Platform Providers (IoT/Cloud), Security and Service providers.
- Different sectors: energy, utilities, automotive, mobility, lighting, buildings, manufacturing, healthcare, supply chains, cities, etc.
- Some of the worldwide largest companies: Bosch, Cisco, IBM, Intel, Nokia, Orange, OSRAM, ABB, Philips, Samsung, Schneider Electric, Siemens, Telecom Italia, Telefonica, Vodafone, Volvo, and counting.
- Many Small and Medium Enterprises (SMEs) and start-ups.

Hence, the AIOTI members currently comprise many IoT industry players and successful start-ups, and it is still open to new members, as the next step is to involve more IoT players. Any entity (firm/corporation/association) recognised by law and having a distinct legal entity, that demonstrates having a legitimate interest in being part of the Alliance can become a member of the AIOTI. By joining it:

- You become member of a unique network which brings together the European and worldwide IoT key players across the value chain both from private and public sector.
- You get a special link with the EU Institutions and the EU Member states.
- You contribute to the shaping of the EU policy-making on IoT.
- And you are given the unique opportunity to be involved in the design of EU IoT large-scale pilots 2016-2017.

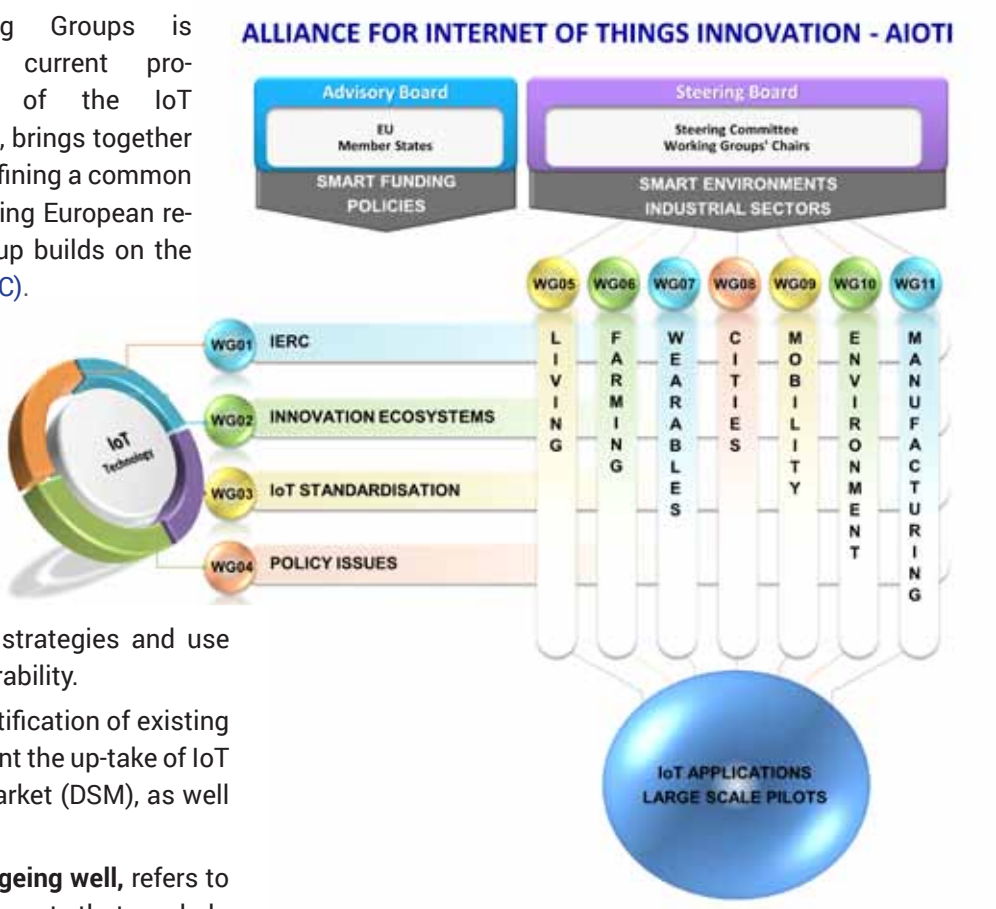
Later on, EU Member states will also be fully associated to this initiative boosting this dynamic ecosystem further.

Regarding the organisation of the AIOTI, it is structured in two layers: the Board (Steering Committee) and the Working Groups (WGs). The Chairs of the WGs will be the members of the Board. Thus, any AIOTI member interested in being part of the Steering Committee must also chair a WG. Additionally, as AIOTI memberships are not granted *ad personam*, different representatives for the role in the Board and the respective WG can be proposed.

ABOUT AIOTI

The structure of the Working Groups is as follows, corresponding to current prominent areas of development of the IoT

WG 1, IoT European Research Cluster, brings together EU-funded projects with the aim of defining a common vision of IoT technology and addressing European research challenges. This working group builds on the work of the IoT Research Cluster (IERC).



WG 2, Innovation Ecosystems, aims at designing actions to develop innovation ecosystems by stimulating start-ups, the use of open IoT platforms and linking up between large and small companies through open innovation.

WG 3, IoT Standardisation, implies the mapping of existing IoT standards and gap analysis, as well as strategies and use cases to develop (semantic) interoperability.

WG 4, Policy issues, pursues the identification of existing or potential market barriers that prevent the up-take of IoT in the context of the Digital Single Market (DSM), as well as the Internal Market perspective.

WG 5, Smart living environment for ageing well, refers to smart homes and smart living environments that can help people staying active, independent and out of institutional care settings. This will lead to reduced costs for care systems and better quality of life for vulnerable categories of citizens (elderly, citizens with various disabilities, etc.).

WG 6, Smart farming and food security, tackles IoT scenarios/ use cases that would allow monitoring and control of the plant and animal products life cycle from farm to fork.

WG 7, Wearables, seeks IoT solutions that integrate key technologies (e.g. nano-electronics, organic electronics, sensing, actuating, communication, low power computing, visualisation and embedded software) into intelligent systems to bring new functionalities into cloths, fabrics, patches, watches and other body-mounted devices. The WG focus its work on healthcare, well-being, safety, security and infotainment applications.

WG 8, Smart cities, searches for IoT solutions used by a city in order to enhance performance and well-being, to reduce costs and resources consumption, and to engage more effectively and actively with its citizens. Key 'smart' sectors may include transport, energy, health care, water and waste.

WG 9, Smart mobility, refers to IoT solutions that allow for increased multi-modal mobility, more efficient traffic management, a dynamic road infrastructure, automated road tolling, usage-based insurance and improved policy making through the analysis of road usage data.

WG 10, Smart environment (smart water management), relates to IoT solutions that improve water management efficiency by monitoring and controlling surface water retention, flooding, etc.

WG 11, Smart manufacturing, looks for IoT solutions that join information, technology and human ingenuity for a rapid revolution in the development and application of manufacturing intelligence to every aspect of business.

These Working Groups prepare policy recommendations for the European Commission and draft the Large Scale Pilots (LSP) testing and experimentation.

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Agriculture 2.0

CESENS, a comprehensive system for agriculture intelligence

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ABSTRACT: Agriculture is one of the pillars of economy worldwide. Decisions for crop management are frequently made ignoring important agro-climatic information or, in the best of cases, reviewing that recorded by public stations. However, such information refers to very large areas, while agro-climatic conditions can vary in really short distances. Thus, the information available gives only a vague idea or an incorrect one when agronomists have to make a decision for a specific plantation.

Cesens consists of an innovative system based on agro-climatic stations to monitor fields combined with mathematical models based on weather, plant and soil conditions. The system is able to predict when the plants need water or whether certain pests and diseases are likely to appear, so treatments and water can be applied to each specific plantation only when needed.

KEY WORDS: crop management, sustainability, geolocation, agro-climatic monitoring, pest and disease predictive models

CESENS, A COMPREHENSIVE SYSTEM FOR AGRICULTURE INTELLIGENCE

1. Problem

The agricultural sector is one of the most traditional activities where technology has penetrated with less intensity. Other than agricultural machinery and plant protection products, agriculture today is very similar to that practiced for thousands of years and in many cases decisions are still made looking at the sky.

It is increasingly common that field technicians (agronomists) give advice based on meteorological data recorded by public stations. Although there is a substantial improvement in the process when basing a decision on such data, there is a problem of imprecision derived from the distance to the nearest public station of each plantation.

The specificities of topography, plant canopy or even human works in each plot are determining factors in setting the climatic conditions in small areas. For example, a small hill can make differences in the level of rainfall, wind speed and temperature in plantations less than one kilometre apart. This means that the data recorded by a public station are not always representative of the whole area which is supposed to be covered. In addition, sometimes the required information is not available for an area or is really difficult to process it since complex models need to be used.

Due of the mentioned methods and limitations, farmers have to face consequences such as water waste or deficiency, wrong timing treatments, lower crop quality, higher field contamination and also higher costs.

On the other hand, the current growth trend of agricultural production is unsustainable because of the negative impacts it causes on natural resources and the environment. One of the key points in making progress towards **sustainable agriculture** is to improve efficiency in the use of resources, such as water and others (FAO, 2015).

Irrigation systems have been under pressure to produce more with lower supplies of water. As world population grows and global food production increases to meet the demand, water management in agriculture, which accounts for approximately 70% of all water use, is becoming one of the key collective challenges to achieving sustainable development worldwide (Crop Life International, 2004). The European Commission emphasises “technological innovation in the field of **water,** given that water efficiency will be an increasingly important factor for competitiveness”. Innovative technologies can enhance water efficiency, gaining an economic advantage while also reducing environmental burdens (Levidow et al., 2014).

Another major agricultural practice is the use of **pesticides** that brings various benefits - mostly economic - for farmers. Pesticides improve or safeguard agricultural yields and the quality of agricultural products and they also minimise labour input. However, when pesticides are not used appropriately, they can be harmful to non-target organisms, and can have unwanted adverse effects on human health and the environment (European Commission, 2007). Moreover, they are frequently applied in wrong timing or in excess, what not only makes them less effective but also implies high and unnecessary costs (up to 58%).

With the aim of making a better use of resources, sustainable agricultural practices should make more use of technology, research and development, with greater integration of local knowledge than in the past (FAO, 2015). The ability to determine whether a plant needs water, fertilizers or pesticides, or when and how much, is key to sustainable agriculture. Thus, having specific agro-climatic data for each plantation at agronomists´ disposal is a need in order to obtain reliable conclusions to make decisions related to cultural practices and crop management.

2. Solution

What is Cesens?

Cesens is a next-generation system to assist agricultural management throughout the whole phenological cycle of plants. Based on agro-climatic field sensors, the system provides key information that allows to prevent pests and diseases, reduce treatment costs and help in the decision making process regarding watering and other cultural practices in different crops.

How Cesens works?

Agro-climatic monitoring

The geographical accidents and atmospheric currents can make weather conditions change in short distances. Thus, when building and applying algorithms based on agro-climatic parameters to protect and manage crops, meteorological data recorded by public stations are not fully reliable.

In order to overcome such limitation, Cesens counts with own developed low cost agro-climatic field stations which allow to monitor each plantation individually in real time and also access the historical data from any digital device.

Cesens agro-climatic field stations are able to monitor a range of parameters that provide valuable information for crop management such as:

- Atmospheric temperature
- Ground temperature
- Atmospheric humidity
- Ground hygrometry
- Atmospheric pressure
- Solar irradiation
- Leaf wetness
- Rainfall
- Wind speed
- Wind direction
- Internal temperature

Advanced information analysis

Cesens transforms these data received from the agro-climatic station network distributed in the plantations into valuable information. This information is gathered and organized in flexible and configurable charts that allow the user to select the parameters and the time interval to be shown. Cesens automatically normalizes different magnitudes to make them comparable, so it's easier to thoroughly analyse any parameter and therefore obtain correct conclusions.

Configurable alerts

Cesens counts with a system of alerts and notifications that allow the user to set thresholds for the different parameters. When such limits are achieved, the system sends an automatic alert to the designated user. It is also possible to define alerts that combine several metrics, for example «rainfall greater than 4mm and temperature greater than 28°C». Moreover, Cesens is able to define alerts about derived metrics such as thermal integral, specific pests or diseases infection risk, etc.

Pests and diseases prediction

Cesens implements several predictive models for pests and diseases that allow to determine the risk of infection in the monitored plantations at any time. The implemented models have been developed and validated by universities and research centres so they provide reliable data about the risk of infection such as the produced by mildew or botrytis in vineyards, for example. The value of knowing the risk of infection at any time (and even receive an alert when a threshold is reached) is to avoid the application of premature or unnecessary treatments, with the economic and environmental costs they imply.

3. Business Model

In 2010, in the EU-28 there were 12.2M farms comprising an agricultural area of 76M ha, 40% of the total land. In 2013, EU-28 agricultural labor was estimated at 10.1M annual work units. The output value of the EU-28's agricultural (crop) industry was around €240 billion in 2013. Main figures for harvested production in the EU-28 in 2013: 305.5 million tones (MT) of cereals, 109.1MT of sugar beet, 25.2MT of grapes, 21MT of oilseeds, 14.9 MT of tomatoes, 14MT of olives, 12MT of apples, 11MT of citrus fruits.

In this context, Cesens system was conceived as a product to revolutionize the modern agriculture, helping farmers to better manage their crops in a smart, cost-effective and sustainable way.

The idea was born in La Rioja (Spain), where ENCORE-LAB was first founded. Since one of the region´s main activities is agriculture, many of their customers were wineries and other agricultural businesses frequently struggling to save costs and make a profit without ruining or damaging their fields. Thus, ENCORE-LAB decided to work on a technological solution that could make the difference, whatever the kind of crop.

Cesens has been designed to adapt to any kind of outdoor plantation, from grapes to fruit trees or even vegetables. Depending on the crop and soil/weather conditions, Cesens agro-climatic stations are able to cover between 1 and 50 ha so, having in mind the previously mentioned numbers, the potential European market for Cesens is estimated in €1.5M.

Once the monitoring stations and digital control platform were developed, in the first phase of the business plan ENCORE LAB built and installed in field the first batch of agro-climatic stations. From that point on, the production of the agro-climatic stations has been externalized, while the company keeps working in the implantation in field and platform developments, new functionalities and maintenance.

The first crops to be addressed were those that the company was more familiar with because of its location: vineyards and fruit trees, although Cesens is being adapted to other crops, since pests and diseases affecting them can be different.

To date, sales have been made directly to the final customer through ENCORE LAB´s current client network, but the main target for the company are agronomists and agricultural consultants who can introduce Cesens to a wider range of companies and cooperatives. Moreover, they are usually who give support to many of these businesses in the decision making process, so they eventually will need to be trained to take full advantage of the system.

Speaking of countries, Spain is the first market being explored, since Cesens can be introduced in a more agile way through some distributors such as agricultural equipment vendors and agronomists. In a second phase of the business plan, the system will be commercialized in the rest of European countries and worldwide afterwards, for what the company is already establishing some agreements also with several distributors.

Some of the companies already using Cesens are Bodegas Ontañón, Bodegas Franco-Españolas and Pernod Ricard Winemakers, all of them renowned wineries, and also Fincas Señorío, a company producing high quality fruit varieties.

4. Underlying Magic

Cesens consists of two main elements: first, the in-field agro-climatic stations and second, a private cloud management and control platform which can be accessed from any digital device, such as PC, smartphone or tablet.

Figure 1. Cesens general diagram

CESENS, A COMPREHENSIVE SYSTEM FOR AGRICULTURE INTELLIGENCE

The agro-climatic stations are robust and count with several types of sensors which are responsible for collecting crop data and send them to the real-time cloud platform. The following diagram shows the types of supported sensors.

The cloud platform receives the data recorded in the agro-climatic stations and processes them, calculating and obtaining many more parameters derived from the raw data, such as thermal integral or risk indexes produced by the pest predictive models. The functionality of the cloud platform allows:

1. To **manage the connected agro-climatic stations.** It allows to add descriptions and phenological stages, query GPS location, check the connected sensors, etc.

2. To **query *raw* and *cooked* data**, review interactive graphics, compare data with past seasons', display several superimposed graphics, etc.

3. To **set alerts**. It is possible to set simple or complex alerts (for single or combined parameters) to notify interesting events such as risk of infection, need for irrigation, etc.

4. To **configure reports**. The system can send emails including periodic reports with recent parameters, charts, graphs, etc.

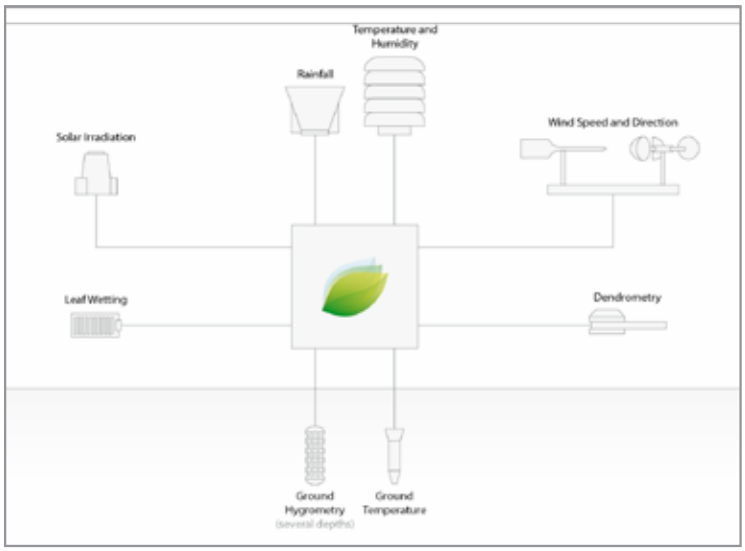

Figure 2. Cesens Agro-climatic station diagram

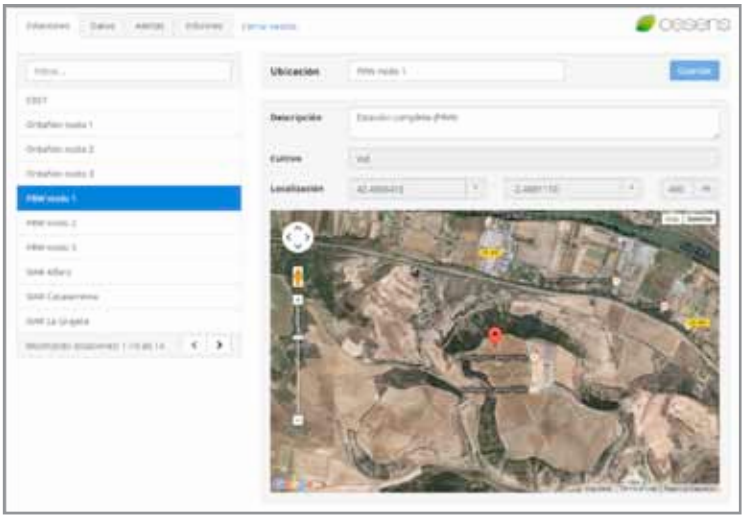

Figure 3. Cesens agro-climatic station remote control

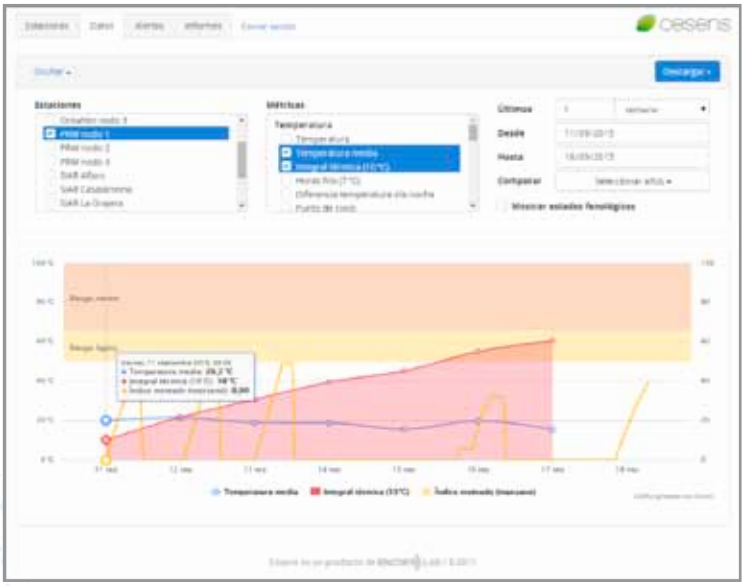

Figura 4. Cesens cloud platform screenshot

5. Current Status

Cesens is currently entering its commercialization phase. The prototype phase is being successfully completed and ENCORE LAB has already started selling the product at a regional level. In order to achieve an optimal performance, several agro-climatic station prototypes were installed in field and have been validated for one year in different plantations covering a significant cultivated surface.

The results to date have been very satisfying and the companies which are already using the system are offering a really positive feedback. The most valuable reviews at this point are the ones collected from the agronomists and agronomical consultants, who are the final users of Cesens. They confirm that the system provides quality information that is allowing them to make more accurate decisions on watering and pesticide applications specific for each plantation.

The next steps are the introduction and consolidation of the product in the Spanish market, for what commercial agreements are being established. After that, this distribution model will be replicated in other countries of the European market through partnerships with suitable collaborators. In the medium to long term, the aim is making the distribution of Cesens global in the same manner.

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Mobility

How IoT turned a car-sharing vision into a sucess story

productize

About us

Productize is the first IoT Agency, providing Business Consulting services, Technical expertise, and Prototyping capabilities to our clients willing to innovate in the IoT environment.

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ABSTRACT: D'Ieteren, a key player on the automotive market in Belgium, started a car-sharing operation based on an "off the shelf" technology. Thanks to IoT and Productize's fast-prototyping approach, D'Ieteren was able to develop an innovative car-sharing system that consists of a SAAS virtual key vault releasing keys to a smartphone: Keyzee.

Today, D'Ieteren has join forces with Continental to become the most innovative technological solution to share vehicles.

HOW IOT TURNED A CAR-SHARING VISION INTO A SUCESS STORY

1. Problem: a good business vision with no supporting technology available

After two decades of connecting people (fixed and mobile Internet networks and devices), the things that surrounds us are now getting connected (cars, buildings, cities, houses, etc.).

The Internet of Things is the next massive trend, and is expected to radically change the environment we live in: the volume of connected devices (think of a wearable, a smart meter, a connected car, a billboard, a scale,...) overpassed humans count several years ago and are expected to exceed 50-100 billion of devices that can talk on the network in 5 years.

In this technological environment, speed of product development cycles is significantly increased, and new innovation opportunities are showing up in every industry.

D'Ieteren is a key player on the automotive market in Belgium. D'Ieteren started a car-sharing operation based on an "off the shelf" technology. This was a great idea to seize a not-yet-born market allowed by new technologies.

However, despite this great vision, the initial technology choice was not good enough to deliver the project: they faced many problems during the project, both technical and conceptual. It did not fit its needs and the promised features were not delivered.

We audited the technology for them and offered to consider changing the approach for something smarter and leaner. After several months of hard work, Keyzee was born, a revolutionary device that allows users to share cars via their smartphone. From early prototypes to a small batch of pre-series hardware and successful customers test, then mass production.

D'Ieteren's car sharing operation did pivot dramatically to become one of the most innovative technological solution to share vehicles. Today Keyzee is the top listed technology in most car sharing projects. The future is certainly very promising for them. You can follow their success **here on Facebook.**

2. Solution: reinventing car-sharing

Stuck with a great idea but a technology that didn't work, D'Ieteren called Harold Grondel & Joost Damad (who will be the founders of Productize after the project) for help.

After an initial analysis, Productize suggested to pivot the business model and completely change the underlying technology: D'Ieteren would develop an innovative car-sharing system that mixes a SAAS virtual key vault releasing keys to a smartphone.

D'Ieteren, the well-known and leading car distributor in Belgium, wanted to launch a solution to open & close cars at a distance. This was a great opportunity to seize a not-yet-born market enabled by new emerging technologies.

Figure 1. Market evolution towards digital car keys

In order to validate the project and move forward with the implementation, the team needed a working prototype to show the the board of directors. After looking for available solutions on the market with little success, Productize decided to build the connected device as an early-prototype.

Productize initially built the functional prototype from the ground up, including hardware and embedded software.

Figure 2. OTAkeys in-car device

3. Business model

The vision behind the virtual key enabler is to allow mobility players to offer their customers secured and innovative services

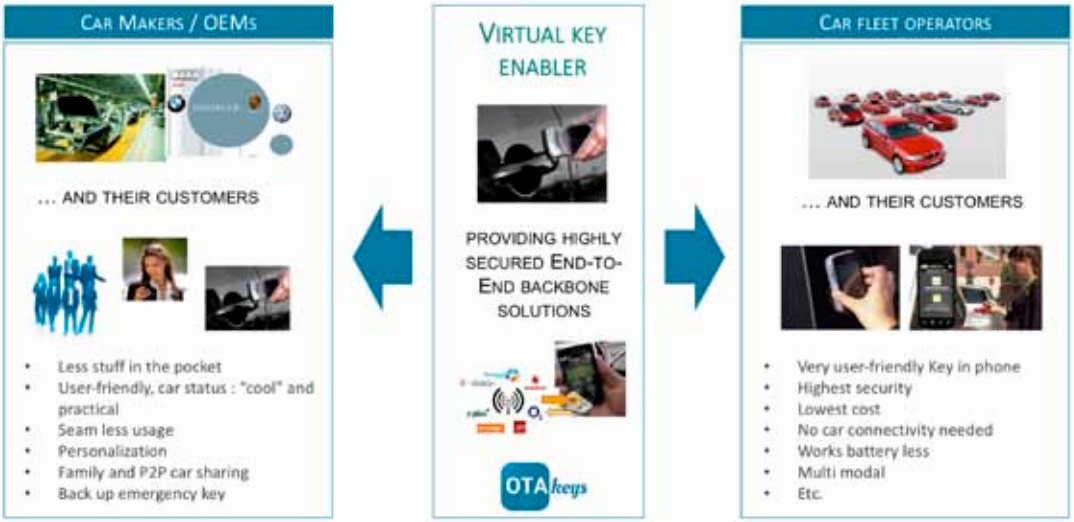


Figure 3. Virtual keys as an enabler for car-sharing

Thanks to an app, users can open and start cars equipped with the KeyzeeBox. A very lean way of sharing cars thanks to a very low investment, quick installation, low consumption, and no maintenance. The service is now a real market product and is quite successful

In order to meet market demand, including different segments (car makers and car fleet operators), OTAkeys has now developed a whole range of products & services.

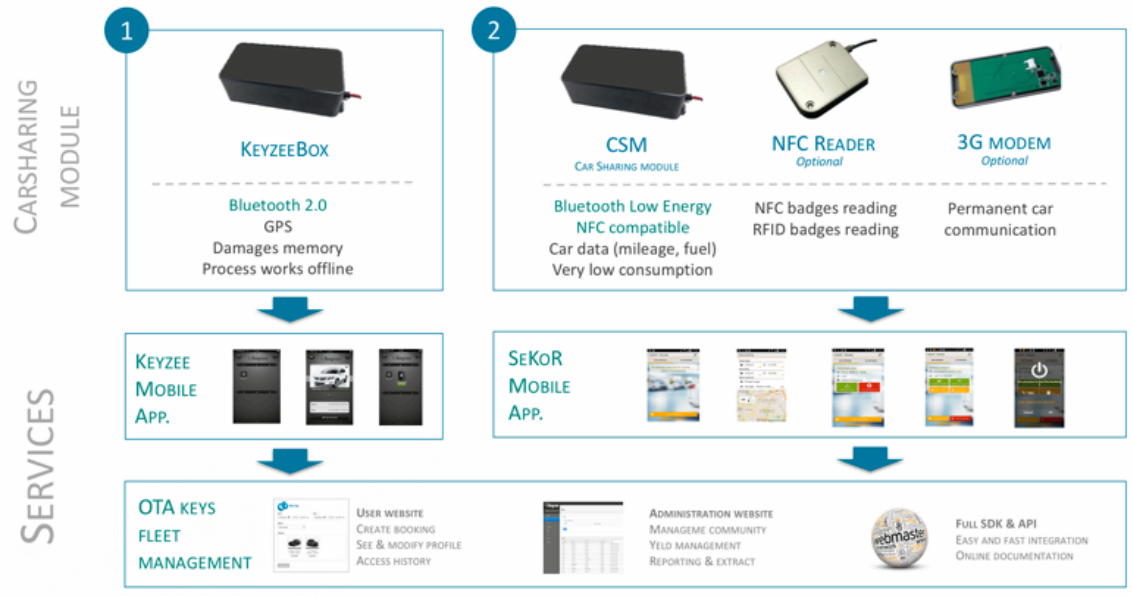


Figure 4. Product & Services range

4. Underlying magic: a breakthrough fast-prototyping approach

Productize offers a complete range of service to deliver better and faster to market product innovations: business consulting, technological expertise, and prototyping capabilities.

The agile product development approach allows the following benefits:

- Faster product design thanks to the iterative process and fast prototyping
- Cost-effective product development thanks to short spins and specific requirements
- Targeted product that fits market needs more efficiently, based on product testing and customer feedback

Thanks to Productize, D'Ieteren turned a costly business into a successful operation, that has lead to a joint-venture with Continental.

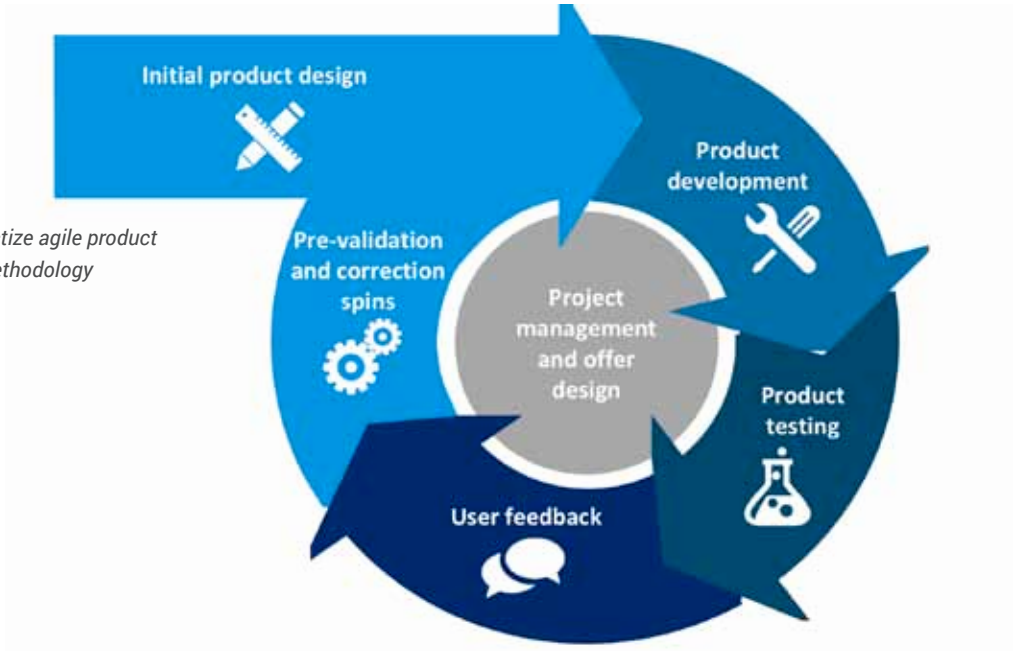
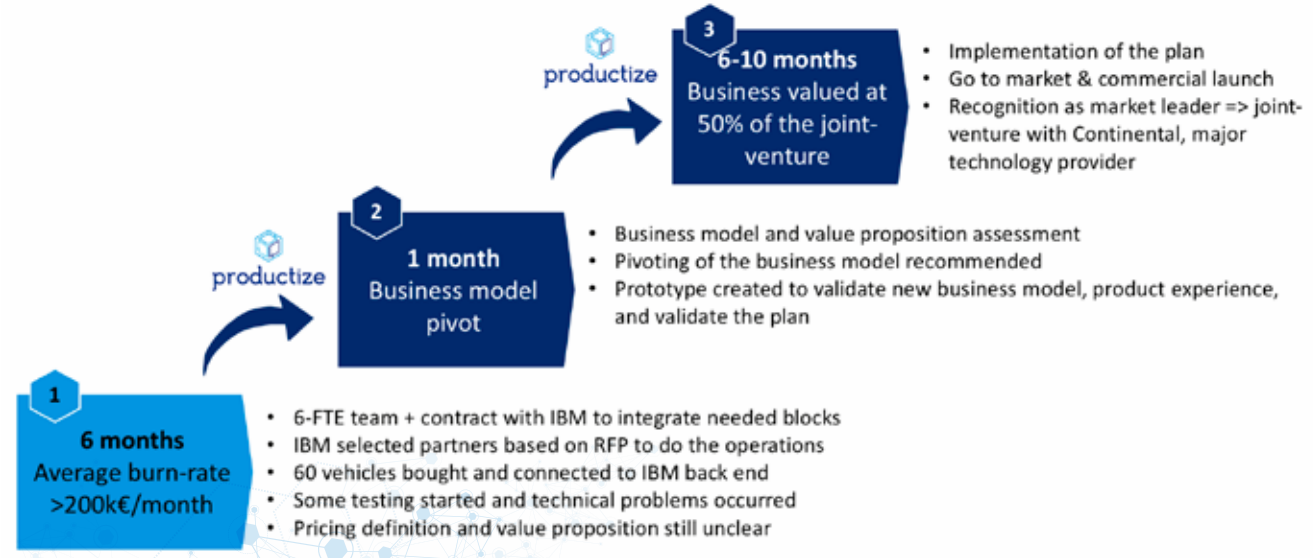


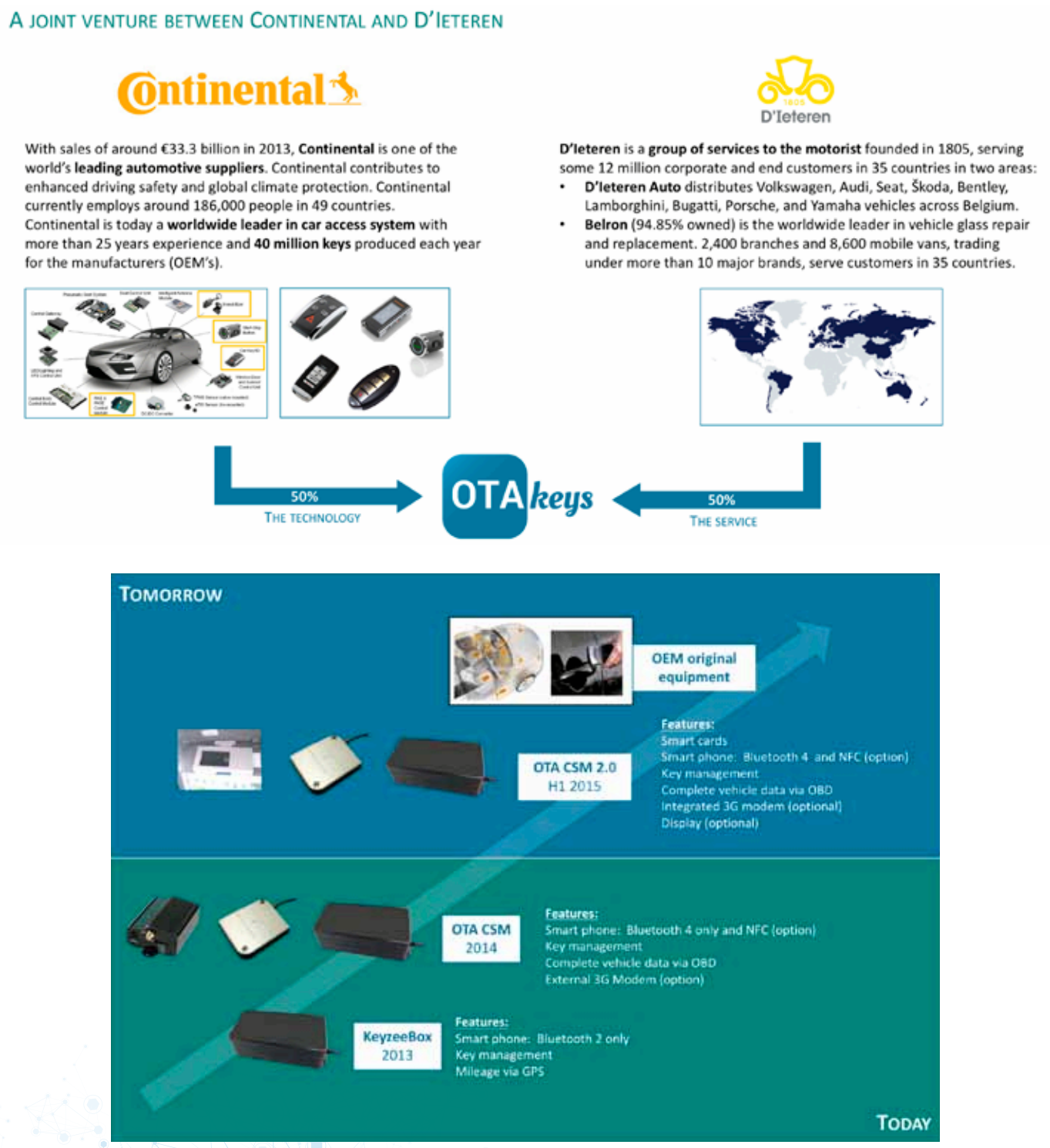
Figure 5. Productize agile product development methodology



5. Current status and forward outlook

D'Ieteren has now join forces with Continental as the technology provider for future products. Productize continues to help OTAkeys on a daily basis.

Figure 6. OTAkeys structure and products evolution



Connected vehicles

Device exploitation monitoring solution

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ABSTRACT: This document presents an innovative approach of developing and delivering an IoT solution of remote monitoring of operating parameters and exploitation conditions of a vehicle. Transition Technologies provided a retro-fit installation on an existing vehicle along with software solution based on rapid application development environment for IoT purposes. System block diagram was described with defined input/output interfaces along with a diagram of internal and external communications protocols. The proposed possible areas of applications include remote monitoring of special purposes vehicles. In conclusion the document summarises the distinctive features of the proposed system in relation to the existing solutions used for vehicle parameters registration.

KEY WORDS: Internet of Things, remote health usage monitoring system, product usage analytics, condition-based maintenance, usage and performance dashboard, real-time asset health monitoring.

DEVICE EXPLOITATION MONITORING SOLUTION

1. Problem

*Polish manufacturer of special purposes ground vehicles requested a pilot solution that would be able to respond to their needs in **achieving operational effectiveness** by **improving risk management** and **reducing product and service cost**. The needs are justified by following pain points:*

- High cost of spare parts
- Difficulties in spare parts availability (especially for older constructions)
- High cost of unexpected downtime
- High cost of service provided by qualified staff

The most important use-case for this value driver was **real-time asset** monitoring focused on **maximizing operational readiness** of the vehicles and their utilization rate by **minimizing the downtime** and **avoiding potential equipment failures.** Such a detailed monitoring of product usage (meaning critical equipment conditions and operating parameters) would then enable the manufacturer to **identify and prevent potential warranty compliance issues** and, in effect reduce warranty cost related to unjustified warranty claims.

The second business driver was related to **establish a strategic differentiation** by offering and IoT installation as a value-added kit mounted on vehicles depending on user requirements and enabling significant improvement of user experience in the area of user self-service, usage and performance dashboard and streamlining the development of operators' skillset and analysis of their performance.

In a long-term period (after the full, production deployment), the manufacturer wants to observe the improvements in following indicators:

- Reduced product failure rate (measured i.e. in MTBF)
- Improved failure resolution time, measured in MTTR
- Reduced warranty cost and increased service revenue or margin
- Increased service contract renewal rate

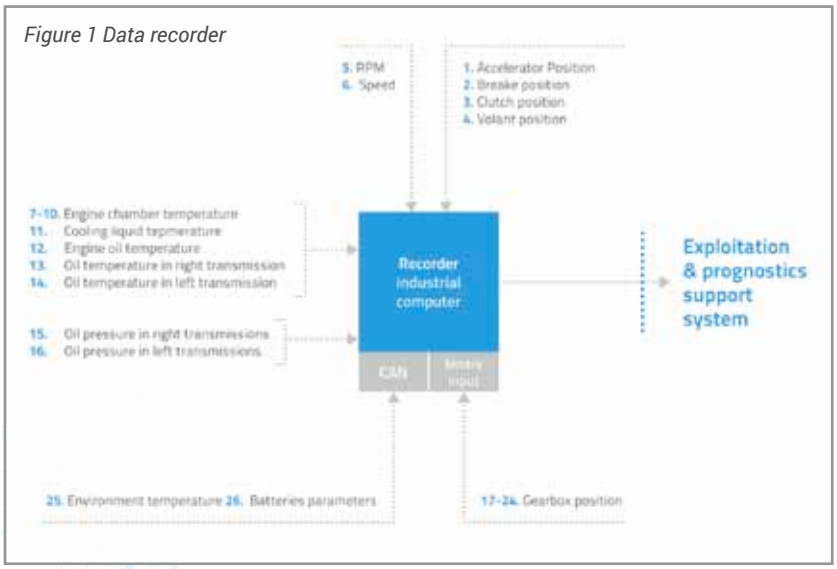
2. Solution

To validate the solution and technology, an existing vehicle was chosen to act as a test-bed for the pilot project. The concept of the solution assumes the use of existing diagnostic systems and enriching the installation with optional diagnostic sensors that communicate with a locally mounted data logger that acts as a «black box» acquiring and storing operational parameters, and communicating with the computer system on an ongoing basis, periodically or when one connects the vehicle to the network at a service station after the vehicle comes back to the depot.

Data acquisition

The system is responsible for registering the exploitation data using following components: new sensors which were enriching existing vehicle equipment, existing internal data bus and new on-board rugged industrial computer which archives the data locally and pushed them to the server according to chosen communication model. Among the measured values we can list: steering system components positions (brake, clutch, control column, gearbox), tensions, pressures, temperatures, liquid levels (coolants, fuel, oil), voltages, current, velocity, location and TBO (Time Between Overhaul) of selected components.

Figure 1 Data recorder



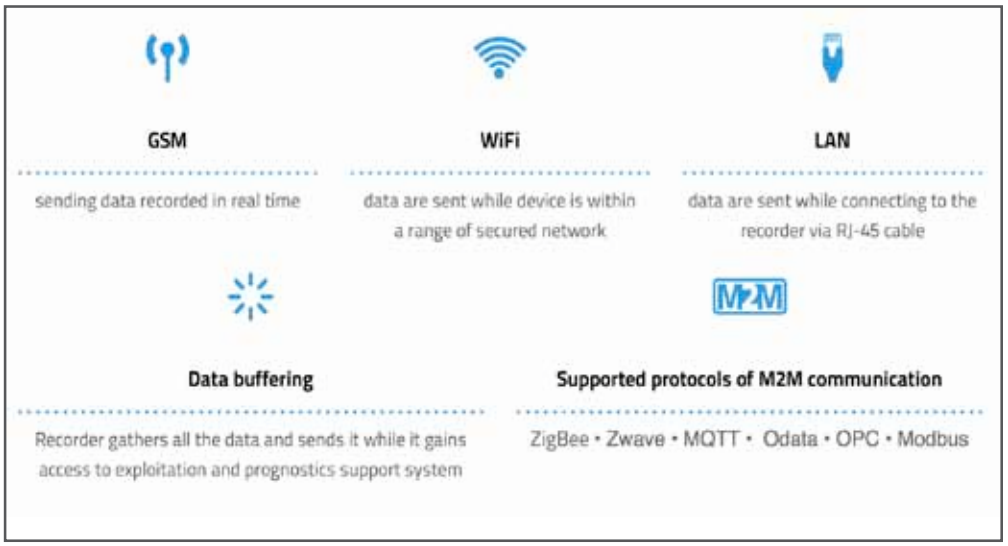
Hardware configurations

The system uses an on-board computer that meets EN50155 standard and featuring additional use features like:

- GPS with external antenna
- GSM modem with an external antenna
- Protection against surges on-board network of the vehicle
- Low power consumption
- Lack of moving parts

As for a retro-fit installation some of the sensors required a specific set of mechanical fasteners which were were delivered in cooperation with the vehicle manufacturer. The sensors, I/O and communication modules were integrated using MODBUS protocol. For the purposes of ensuring the continuity of data transmission and data security, the data recorder hardware along with its software component are configured to meet following communication requirements.

Figure 2. Communication requirements



Software configurations

Important part of the solution is the server-side component built on top of ThingWorx™ – a platform for rapid prototyping of IoT applications. It is responsible not only for accepting the vehicle data, storing it in a central repository but also for hosting the application for the end-users and at the same time for being a **web-based rapid development environment** for the value enabling application as the Device Exploitation and Monitoring Solution is by itself.

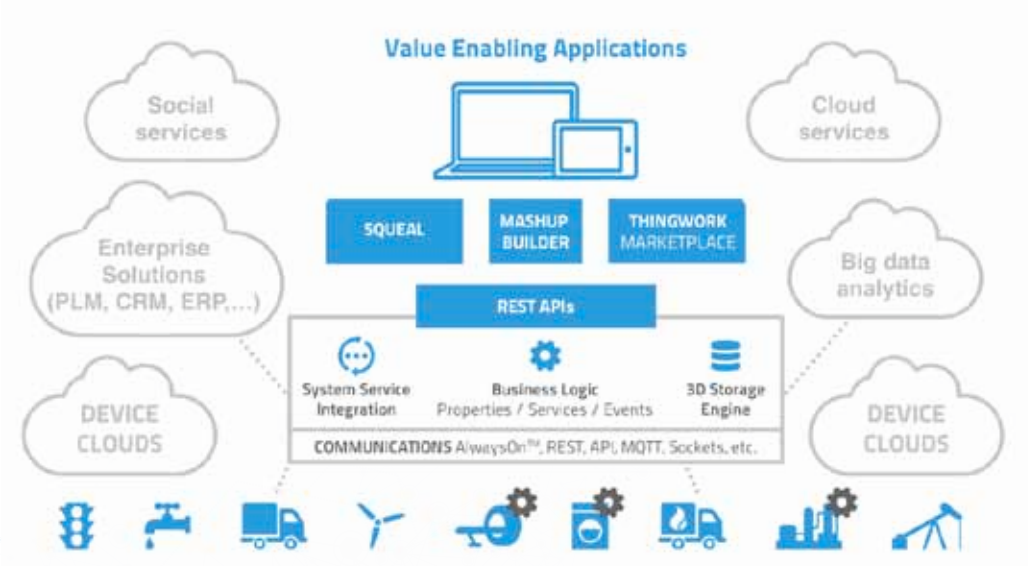


Figure 3. ThingWorx™ platform

DEVICE EXPLOITATION MONITORING SOLUTION

The solution defines three basic roles: regular user (i.e.: driver, dealer, fleet operator, field technician), administrator and developer. Regular user has an access to current and historical vehicle data, time-series visualizations along with the routes and exploitation style that can include not only values exceeding the thresholds but also more sophisticated indication of unauthorized manoeuvres leading to accelerated degradation of the vehicle or its subsystems. The administrator of a platform is primarily responsible for the optimization of the system and adapting it to the requirements of regular users. He regulates the access rights of users and manages their accounts. As his main tasks he configures application settings, and control application logs in the event of an unforeseen behaviour. He can also import and manage platform extensions that allow developers to further develop the solution and integrate the applications with 3rd party solutions and new hardware. The administrator can also freely import and export objects that are created by developers on different levels of application structure up to the entire application. Developer is a person in charge of building individual layers and application screens to allow the use of the solution by regular users. His main job is to create objects responsible for connection to a data sources which means creating a model of a vehicle / device and its equipment from which the data came from. He is also responsible for the design of the view layer, which enables accessing the data in an easy and transparent way.

3. Business model

From an ICT company and system integrator point of view, selected architecture and platform allow rapid IoT application development which radically reduces effort, time, cost and risk required to building and maintaining the solution and permits to focus on improving customer experience and inviting the customer into the process of frequent and incremental solution delivery. The application is very scalable and can be offered in a cloud model with a pay-per-use pricing which can be a combination of number of users, devices, data items, data storage or/and communication intensity. The alternative way is to deploy the solution at manufacture/dealer premises and charge the customer against number of vehicles/devices being monitored.

Regarding the market verticals, the solution seems to be a good fit not only for heavy industrial vehicles but also for transportation manufacturers, carriers, car rentals, car insurance companies or even for household appliances segment. Of course, the more complex devices are being monitored and the bigger cost of service/spare parts is being challenged – the biggest value and quicker ROI can be observed after deploying the solution.

Figure 5. Internet of Thing driving two levels of service transformation

From the customer point of view, the solution provides an opportunity to differentiate with a service offering that represent transformation from typical "service for product support" approach towards "service for profit and growth". Such a new approach allows to focus on maximizing service revenues from equipment utilization and long-term, predictable aftermarket services and extended warranties. It also enables new "servitization" business models which require moving away from the traditional one-off transactions towards the subscription model and long-term relationship with the client to offer him additional services and care.

4. Underlying magic

At the heart of the solution there is the ThingWorx™ platform that showcases its value in a few categories. The first is related to ubiquitous connectivity via rich set of scalable and embeddable set of API and SDK for connecting sensor, devices and equipment across any network topology and communication scenario, thanks to optimized and unified mechanism for time-series, structured and unstructured data with two-way interaction with data analytics. The platform provided also flexible storage and even-driven execution environment.

Second set of innovation areas is related to software development cycle and developer effectivity. With model-based development via web-based IDE we were able to dramatically reduce the time of software development and improve developer productivity who could spent their time on codeless creation of UI and collaborative workspaces. Such web-based mashup building that introduces "drag and drop" development lowers the entry barrier for IoT application development and invites domain specialists and subject matter expert to the delivery process.

The platform provides also search-based intelligence for search, query and analysis that puts the device data into a centre of solution and provides operational intelligence capabilities. The picture is completed with flexible deployment options ranging from cloud, through on-premise up to embedded use-cases.

5. Current status and future

We are after the pilot project verification when the solution demonstrated a qualitative leap in the management of vehicle exploitation and the maintenance of its equipment and components. Currently we are discussing the possibilities to scale the pilot among different product lines and develop it further towards tight integration of IoT, PLM (Product Lifecycle Management) and Big Data principles with a strong emphasis of digital-physical convergence that to Augmented Reality technology.

Figure 6. IoT and AR for digital-physical convergence

Figure 7. Next generation of the solution

The main conclusion that arises after the test trials is about the opportunity that opens up not only to the service department but also to other divisions within the organization such as sales, marketing, engineering department, process engineers or manufacturing. With seamless IoT data integration and digital-physical convergence, organizations can transform themselves into smart, connected enterprises improving risk management, optimizing operational performance and effectiveness and position themselves strategically on the market with new product/service offerings and new revenue streams.

Connected vehicles

Critical Challenges in the Connected Vehicle

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ABSTRACT: Vehicles are increasingly connected with their environment, resulting in numerous improvements for the driver like semi-autonomous or fully autonomous driving to avoid severe road accidents. Additional environment information helps to improve driving behaviour and to reduce fuel consumption. The permanent wireless access to the vehicles moreover opens up new business models, e.g. the remote software update to eliminate costly recalls, but also online services or the comfortable toll control. On the other hand any external access to the vehicle increases the risk of manipulations and cybercrime. Modern semiconductor solutions enable security systems that protect both personal data and life and limb of the road users.

In the future car-to-car (C2C) and car-to-infrastructure (C2I) communication will lead to an improvement of safety and efficiency in road traffic. For instance drivers can be warned of roadway damages or accidents on their routes. Remote diagnostics over the air interface could indicate necessary service measures at an early stage. However there is sensible information exchanged like position and speed. The integrity of these data must be protected. Up to now it is unsettled, to whom these data belong and if they are personal data which, as data protection law stands, face considerably more stringent regulations.

KEY WORDS: Connected car, C2C, C2I, remote diagnostics

1. Problem

Already today the car is a computer network. The system of the connected car allows communication in different directions and on different levels. There´s the on-board communication on one side, responsible for the information exchange between the control units like the instrument cluster and motor control or safety-relevant units like steering or braking systems inside the automobile. On the other hand the driver can benefit from congestion warning and accident prevention. And the cloud connection taps new possibilities like software updates in the field, remote diagnosis, eCall, payment systems, internet services, but also infotainment, traffic information and Apps.

Thus the future connected car resides within a «communication shell» with various possibilities, but also many interfaces and gateways for potential manipulations. Comprehensive security architecture inside the car and for the interfaces to the outside world is therefore required. A holistic approach taking into account both the aspects of safety and the information security is at the very beginning in the automotive industry so far. More than the already existing regulations to ensure the necessary safety following ISO 26262, dedicated hardware and software measures are needed to protect the corresponding data.

2. Solution

As a consequence of the increasingly connected car attacks can be carried out remotely without physical contact to the automobile. Trusted Platform Modules (TPM) help to protect communication with the outside. Such a TPM can e.g. be integrated into the communication control unit which frequently is connected with the infotainment system. By installing a secure connection to the servers of the manufacturer and checking the system integrity the TPM increases confidence in the communicating units. For example the TPM can be used to secure software updates on the road. Because the secrecy of the keys is of prime importance, the TPMs protect it through a security-certified key memory. Moreover the TPM has the advantage that it has security standards implemented with a proven track record such as used for card-based payments.

Secure on-board communication

Various demands characterize security solutions for on-board communication. They must be reliable, meet high real-time demands, be cost-effective and must be compatible with existing bus standards. Such systems must basically ensure protection from two threats:

- Installation of non-authorized hardware into the network, e.g. to increase performance;
- Targeted manipulation of existing ECUs, when the attacker successfully infiltrates the ECU to e.g. send messages through the bus or to manipulate them. The motivation for such attacks range from classical theft (immobiliser) to targeted attacks on life and limb of the passengers.

Modern microcontrollers like Infineon´s AURIXTM family contain a hardware security module that among other duties support the generation of authentication codes with a powerful random number generator in hardware.

Mobile networking with eCall

In the case of an accident, the eCall (emergency Call) system automatically transmits position and other relevant data to the rescue service. The provision of eCall will be obligatory in the EU from 2017. In an eCall the SIM (Subscriber Identification Modul) is the connecting element between the automotive and the telecommunications world. It must meet both the high quality demand of the automotive industry and the high security demands of the mobile network providers.

To increase flexibility and improve customer service for example when travelling in foreign countries, automotive OEMs will be able to change the cellular providers. With the introduction of this technology the security demands on the SIM are increased because mobile phone providers must transmit their secret access data into a SIM that has not been bought from them and thus is beyond their direct control. Therefore they request a security evaluation through independent third parties following the common criteria standard. This requires security controllers defined by GSMA (GSM Association, **www.gsma.com**) and ETSI (European Telecommunications Standards Institute, **www.etsi.org**).

Whereas eCall improves the fast treatment after the accident, the C2C communication guarantees safe and efficient road traffic. Protection of the private sphere of the driver and network integrity are important security requirements here. Security-certified security controllers like the SLI 97 family effectively protect in this application with cryptographic methods and key material.

Reliable authentication

The reliable authentication is a key aspect of automotive security systems. Most popular is the immobilizer as central part of theft protection. In this case authentication takes place between the ignition key and one or more ECUs in the vehicle. But inside the vehicle, too, authentication is deployed, for instance to protect components between ECUs to identify replacement of components that are unwanted by the manufacturer.

The immobiliser in the 90-s dramatically reduced car theft in Germany after its introduction, but meanwhile statistics stagnate or show a slow upward trend. This is partly due to inappropriate and obsolete encryption processes, but more and more missing secure key memories are the reason. A possible solution could be the deeper integration of the security system into the car electronics. For this purpose Infineon with its AURIX™ familiy offers 32-bit microcontrollers with integrated Hardware Security Modul (HSM). More than a powerful CPU with a special memory protected against access to store cryptographic keys and the unambiguous user identification, efficient encryption processes like AES-128 and a specific hardware for the generation of random numbers are needed.

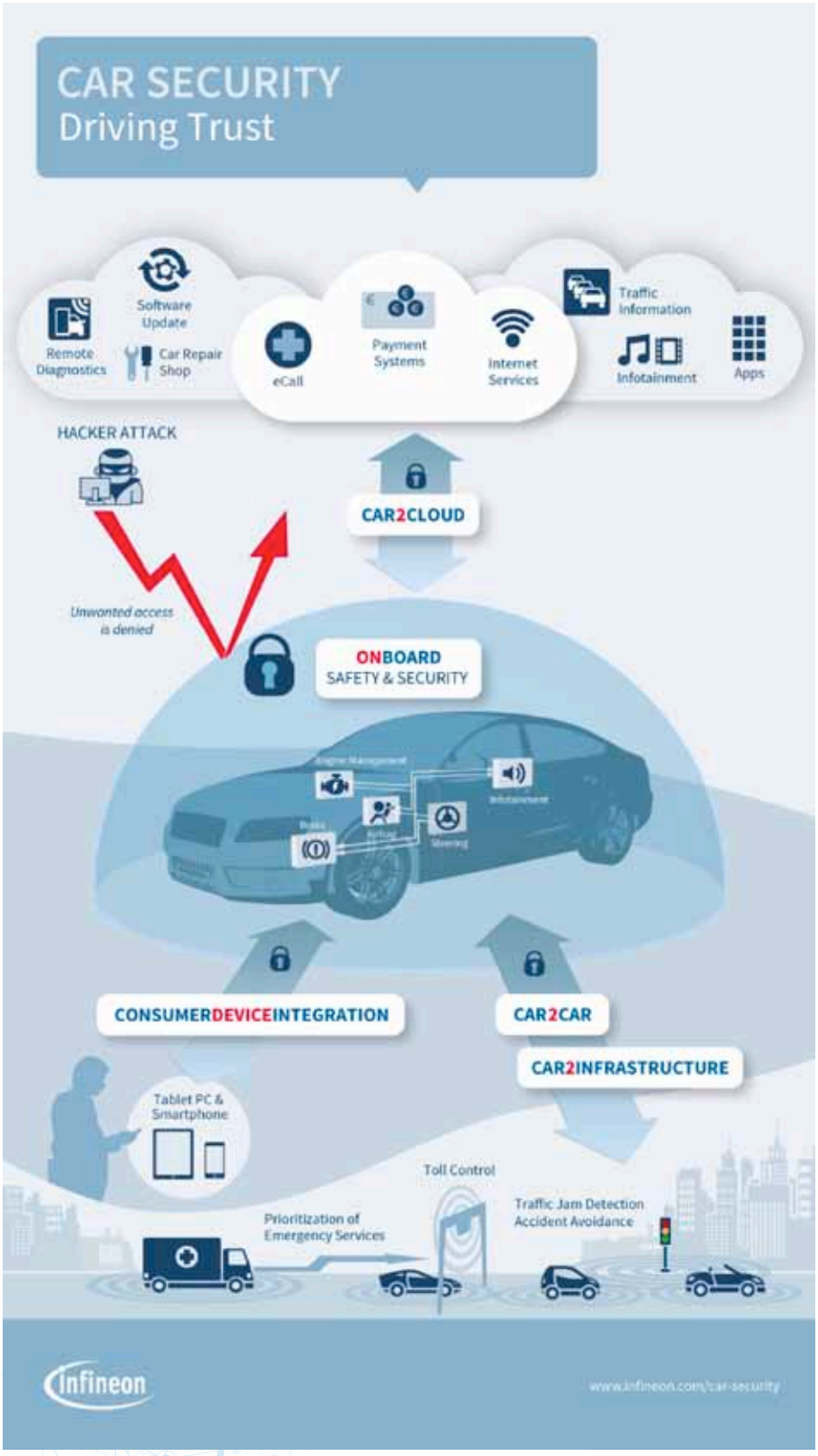
3. Conclusion

Electronics plays an important role to increase safety. Potential or real attacks of important safety components like brake or steering systems must be recognized and corrected autonomously to protect vehicle and passengers from damages. At the same time security plays an increasingly important role. Ever more connections of the vehicle with the environment is accompanied by an increased risk of cyber attacks on ECUs e.g. for motor and brakes. For this reason data integrity of all safety- and security-critical functions has to be protected. To this end already today Infineon provides powerful microcontrollers and discrete components.

There are several modern semiconductor solutions available for implementation of the necessary security functions in connected cars: powerful microcontrollers with special security modules, dedicated security controllers and TPM security elements. For instance the 32-bit microcontroller of the AURIX™ family offers special function blocks like «Security Hardware Extension» (SHE) or «Hardware Security Module» (HSM). The HSM for example through signature of messages or complete encryption takes over the secure communication with other microcontrollers. Additionally the HSM can be used to securely boot the microcontroller. Discrete hardware solutions such as security controllers or controllers with TPM functionality bring the proven expertise of the chip card area into the automotive world. So critical data, components and IP can be protected. Scalable products allow optimum compromises between level of security and cost. Risks are minimized through the use of standardized function blocks and components instead of proprietary solutions.

CRITICAL CHALLENGES IN THE CONNECTED VEHICLE

Connectivity exposes the car to the outside world which results in risks for cyber attacks. A universal security concept is hardly feasible. Therefore specific and effective security-solutions based on standards are needed as counteractive measures.



e-Health

Personalized Artificial Pancreas Device Systems

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ABSTRACT: Diabetes is the fifth leading cause of death in a majority of the developed countries and is becoming an increasingly larger issue in emerging regions as well. The International Diabetes Federation (IDF) estimates that 382 million people across the globe were diagnosed with diabetes in 2013. They project that by the year 2035[1], the disease is likely to impact 592 million people and will entail over US$500 billion in health expenditure annually.
Diabetic patients whose blood glucose levels are kept close to normal through suitable therapeutic measures face a lower risk of dangerous hypoglycaemic episodes and complications from diabetes, than less successfully treated patients. A precondition for this success is the close monitoring of blood glucose levels. Therefore, a great deal of research has been directed towards the development of sensors that permit near painless, continuous measurement of blood glucose levels.
This paper discusses the prevalence of diabetes globally, highlights the problems associated with the disease, and discusses the Artificial Pancreas Device System (APDS). The APDS is a solution that can help diabetic patients lead a better lifestyle by helping them to automatically control their blood glucose level. It achieves this by providing substitute endocrine functionality similar to that of healthy pancreas.

In this paper, we have focused on the patient specific artificial pancreas device that leverages artificial intelligence and high performance computing technology. The device uses an insulin pump which supplies the required doses of insulin to the body under closed loop control after receiving real time data from a continuous blood glucose sensor. The APDS technology is expected to not only monitor glucose levels in the body but also adjust the insulin dosage automatically to reduce high blood glucose levels (hyperglycemia). It can also minimize the incidence of low blood glucose (hypoglycemia) with little or no input from the patient.

KEY WORDS: Diabetes, APDS, Artificial Pancreas Device System, Insulin, Automate, Blood Glucose Meter (BGM)

[1] IDF Diabetes: Facts and Figures,2013 , http://www.idf.org/worlddiabetesday/toolkit/gp/facts-figures

PERSONALIZED ARTIFICIAL PANCREAS DEVICE SYSTEMS

1. Problem

Lack of awareness and high cost of treatment are the two main reasons of increased Diabetes in patients across the world. If unaddressed, this is likely to impact 593 million people by 2035[2]. There is an urgent need of effective daily treatment of diabetes, especially, in those cases where medical personnel are not present or patients have little knowledge of the disease

2. Solution

Diabetes is caused due to insulin deficiency or impaired effectiveness of insulin action, or both. It is broadly classified into three types: type 1, type 2, and gestational diabetes[3].Type 1 diabetes results from lack of insulin production in the human body and requires the person to inject insulin. Type 2 diabetes results from insulin resistance, a condition in which cells fail to use insulin properly, sometimes combined with an absolute insulin deficiency. Gestational diabetes occurs when pregnant women, who have never had diabetes before, are diagnosed with high level of glucose in their blood during the period. It may precede the development of type 2 diabetes. Some common causes of diabetes are hereditary traits, age, diet and obesity. Diabetes may also influence several severe complications such as heart disease, nerve damage, kidney failure, blindness, amputation, and so on.

As of 2013, the number of people affected with diabetes globally total 382 million. However, the more challenging part of this problem is the fact that around half of this population (175 million) is undiagnosed. Some countries in sub-Saharan Africa have an undiagnosed proportion of the population as high as 90 percent. Four out of five people with diabetes live in low and middle income countries. Moreover, half of the people succumbing to diabetes are under the age of 60. Just in the year 2013, about 5.1 million people died due to diabetes and $548 3 billion was spent on this condition[4].

[2] *IDF,IDF Diabetes atlas,2013, http://www.idf.org/sites/default/files/EN_6E_Atlas_Full_0.pdf*

[3] *IDF,world diabetes day,2013, http://www.idf.org/worlddiabetesday/toolkit/gp/what-is-diabetes*

[4] *IDF,IDF Diabetes atlas,2013, http://www.idf.org/sites/default/files/EN_6E_Atlas_Full_0.pdf*

[5] *IDF,IDF Diabetes atlas,2013, http://www.idf.org/sites/default/files/EN_6E_Atlas_Full_0.pdf*

3. Key Challenges in Diabetes Management

The following are the major causes that are contributing to the rise of this disease:

Lack of awareness

- 175 million (approximately 50%) people with diabetes are undiagnosed
- If unaddressed, the number of people affected by the disease is likely to rise beyond 592 million by 2035. 80 percent of these people are living in low and middle income countries where the epidemic is increasing at alarming rates[5].

Lack of affordable solutions

- Diabetes can be effectively managed. However, the expenditure involved in monitoring and controlling the blood glucose levels of diabetic patients runs into hundreds of dollars per month, making it an expensive affair for people suffering from it.
- Numerous scientific studies have found that health insurance inadequacies make it harder for people to manage their diabetes, often resulting in devastating consequences. Uninsured adults with diabetes are far less likely to receive needed care to effectively manage their disease, and those with health insurance face similar problems if the coverage is inadequate.

Lack of patient specific care

- A patient's glucose concentration may change dynamically depending mostly on his/her physical activities and nutrition, and therefore, the amount of insulin needed varies from time to time. A number of diseases may crop up, possibly resulting in life-threatening health conditions if the supply of insulin is untimely or inadequate, or fails for any reason.
- Till date, a common therapy for type 1diabetes is a series of three to five daily insulin injections. The quantities of insulin are based on regular glucose measurements by patients. Such a treatment lacks a reliable method of continuous monitoring, which may cause glucose concentration to reach beyond the permitted range due to control delay. This kind of therapy may not prevent glucose fluctuations occurring in patients.

4. Artificial Pancreas – A closed loop system

With the evident rise of diabetes amongst the world population, it becomes very critical to address the above challenges. The patient specific artificial pancreas is a solution that can help in effectively treating diabetes. This solution is designed as a continuous closed-loop control system needed for insulin infusion. The continuous control can be effective in the daily treatment of diabetes, especially, in those cases where medical personnel are not present or patients have little knowledge of the disease. Such an automatic control benefits patients and helps avoid the mistakes that can occur when using injections or even operations. The solution acts as an artificial pancreas, customized for each patient, helping them to automatically control their blood glucose levels.

A patient specific artificial pancreas solution:

- Supports automatic detection of blood sugar levels and injection of insulin in response to those levels. This ensures continuous monitoring and injection of the optimum amount of insulin and enables tight control of blood glucose level in patients suffering from diabetes.
- Prevents other diabetes related complications that can cause damage to organs such as eyes, kidneys, nerves, and heart, by maintaining optimum glucose levels.
- Helps patients drive complication-averting tight control, thus mitigating the serious dangers of hypoglycaemia (low blood glucose, most common during sleep)

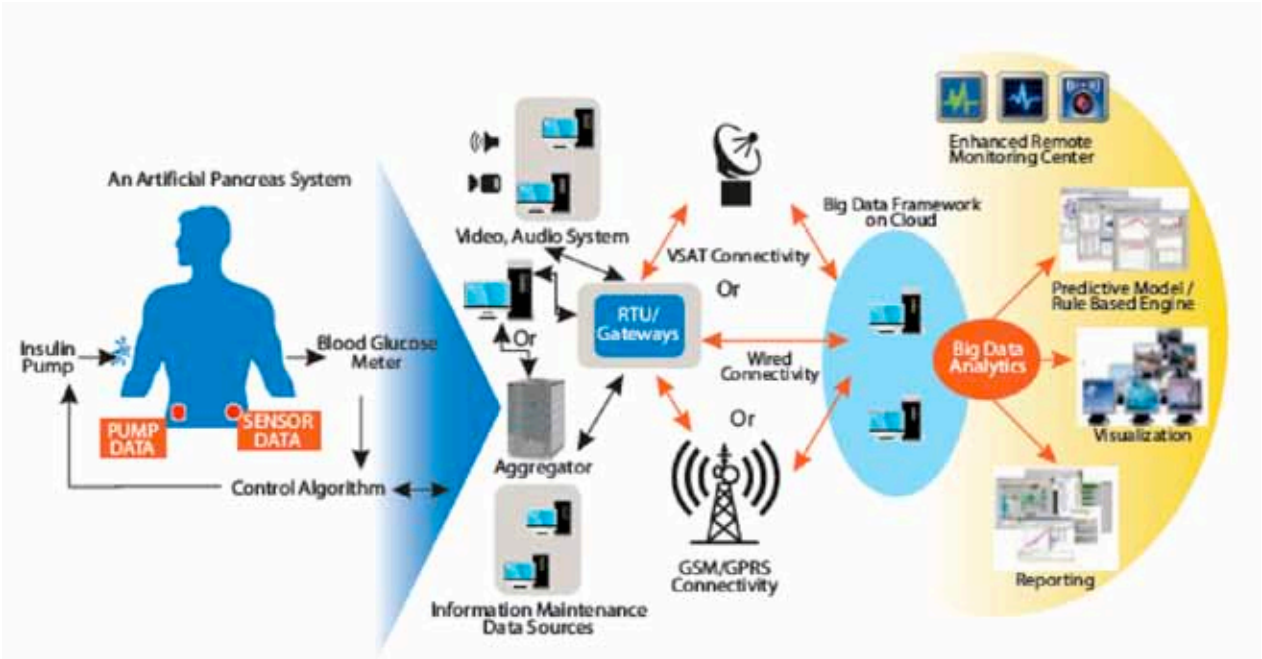

Fig 1: Artificial Pancreas System connect via Cloud to HPC for EBM

The APDS is a system of devices that closely mimics the glucose regulating function of a healthy pancreas. The device is designed for the 5 to 10 percent of diabetic patients diagnosed with type-1 diabetes where the body cannot produce insulin. However, the device also provides insulin to type 2 patients whenever required. The APDS consists of two types of devices already familiar to diabetes patients: a continuous glucose monitoring system (CGM) and an insulin infusion pump. A blood glucose device (such as a glucose meter) is used to calibrate the CGM. The CGM provides inputs to a computer controlled algorithm, which communicates with the HPC system through artificial intelligence, and uses this information to program the insulin pump. APDS is expected to not only monitor glucose levels in the body but also automatically adjust the insulin dosage to reduce high blood glucose levels (hyperglycaemia), and minimize the incidence of low blood glucose (hypoglycaemia) with little or no input from the patient.

5. Implementing an Artificial Pancreas Device System

To implement the continuous closed-loop control therapy, three primary components are needed: an implantable glucose sensor, a pump, and a control algorithm.

COMPONENTS	DESCRIPTION	KEY FEATURES
1	Blood Glucose Meter (BGM)	Instrument to check the blood glucose level of the patient at a preset periodic time and upon request. Sends this reading to Control Algorithm
2	Control Algorithm	Receives information from BGM. Based on the reading from BGM, calculates the setting for the Insulin Pump to improve patient's blood glucose level i.e. to get it within the recommended band. Sends these parameters to Insulin Pump.
3	Insulin Delivery Pump	Receives the programming information from the Control Algorithm. Programs the Insulin Pump to deliver insulin.

Model-based Control of Blood Glucose Concentration

The APDS should connect the glucose meter and the insulin pump wirelessly, creating an autonomous system that monitors and corrects blood sugar levels. No input from a patient or doctor should be necessary. The devices' data can be seen using a smartphone or tablet, making minute-by-minute analytics available.

An optimal insulin delivery system (see Figure 1) should consist of - a mathematical model for insulin as well as glucose dynamics in a patient, a control algorithm, and a method of adapting model parameters to the needs of a patient using CGM data collected over 72 hours. The mathematical model is the key component of this system and its accuracy will determine the success of the system. It should include patient specific parameters which can be estimated from the patient's CGM data for the last 72 hours. Once model parameters are determined for a particular patient, the optimal insulin and glucose profiles can be calculated with respect to time using optimal control theory. These profiles can be stored in a commercially available insulin pump or delivery device. The insulin delivery device can be programmed to deliver insulin automatically as per the stored dosage profile or it can suggest a dosage to the patient, allowing them to opt for a different dosage, if required.

In recent years, significant effort has been made in the development of glucose control algorithms. Recent reports indicate that model based predictive control (MPC) algorithms can successfully tackle constraints posed by several biomedical control problems. They are used not only for blood glucose concentration control in diabetic patients, but also for mean arterial pressure and cardiac output control during anaesthesia.

The development of control algorithms could lead to safer, more reliable and robust APDSs. For instance, adding redundancies in the control algorithm can help the institute system checks and prevent dosing errors. In the absence of fast-acting insulin, a control algorithm may need to address the variability of insulin absorption. In addition, algorithms that allow variations between patients by incorporating additional physiologic measures, such as physical activity, could lead to the more precise control of blood glucose.

Leveraging High Performance Computing for Evidence Based Medicine

Opportunities exist to harness High Power Computing (HPC) to process the data outed from CGM as well as the Artificial Pancreas solution and stored on Cloud. Analytic on this data can help in the use of medicine and insulin delivery that has been proven to provide desired results in patients with a similar profile. This data can be aggregated for a small hospital or a nation with public healthcare systems and can be pooled from multiple sources to make more informed decisions for better patient outcomes. This Evidence Based Medicine may have better acceptance than the current methods as real-time analysis and feedback from the HPC system to patients can improve patient outcomes, reduce recovery time, lower overall cost of treatment as well as improve the wellness of healthy subject.

6. Breakthrough Benefits of Artificial Pancreas

The introduction of APDS will likely improve disease management through more precise measurement of personal health status and involvement of patients in their health care process. Further, it will contribute to a knowledge based society, and accelerate the establishment of standards for personal health care systems for diabetes.

Some of the benefits likely to accrue from the APDS include

- Constant monitoring of blood sugar in diabetic people and automatic supply of insulin as needed. This enables tight control of blood glucose level which is not possible in conventional diabetes therapies.
- Optimum balance of blood glucose and insulin in patients can prevent the occurrence of other diabetes related disorders such as kidney failure, cardiac arrest and so on.
- Reduce cases of still birth and mortality rates among pregnant women with type-1 diabetes.

The various stakeholders in the diabetes management system, who can benefit from APDS:

Patients: Patients suffering from type 1 diabetes can gain access to secure, safe and personalized health systems, resulting in reduced hospitalization without compromising on the quality of health care. The CGM product in this solution can be used by patients suffering from type 2 diabetes. During times of fluctuating glucose levels, this device can help patients with the right information to enable them to make informed decisions on their treatment.

Original Equipment Manufacturers (OEMs): Developing products used in this solution with open interfaces will improve the interoperability of devices required to grow the market and lower the cost of this solution. Also, OEMs may build one or more products or even the complete solution and focus on the market segment of their choice.

Public Healthcare Systems: Data gathered from this solution can be used to learn about the patients' response to medicine and provide evidence based treatment. Aggregating such data over a large population can help advance the science of diabetes management. Public Health Systems can integrate this data with patient electronic health records; share the data over Cloud with researchers, who in turn can analyse this valuable data to learn more about diabetic patients.

7. Conclusion

Insulin therapy is the most common treatment for diabetes. Type 1 or insulin dependent diabetes can be managed by taking insulin injections or by delivering insulin periodically using a pump through a tiny catheter inserted under the skin. The problem with manual insulin delivery techniques is that patients have to estimate how much insulin they will need based on their food intake and physical activity or lifestyle. High dosage of insulin can result n low blood sugar levels (hypoglycaemia), which can cause unconsciousness and even lead to the death of the patient in some cases. On the other hand, too little insulin leads to high blood sugar levels (hyperglycaemia), which a cause serious complications such as heart ailments and kidney and eye problems over time.

An artificial pancreas devise system can potentially solve these problems by automating the entire process, wherein he computer algorithms decide the amount of insulin to be given to the patient at a given moment. The artificial pancreas holds the promise of freedom from multiple daily finger pricks and injections, with a potential bonus of tighter control over a significant portion of the diabetes disease continuum.

The APDS is however not yet well established. The continuous glucose monitoring system, for example, has several drawbacks such as low reliability, high cost, daily calibration and frequent replacement of sensors. Similarly, model based control systems too need to be tested extensively with actual patient data. In view of this, the need to develop accurate and inexpensive CGM systems and representative mathematical models that can mimic insulin and glucose dynamics in diabetic patients in order to enhance the capabilities of an APDS has assumed importance. Stakeholders across the government and business sectors are working on getting this part of the puzzle right in order to make the APDS a safe and effective reality in the very near future.

8. Company

Tata Consultancy Services (TCS)

Tata Consultancy Services is an IT services, consulting and business solutions organization that delivers real results to global business, ensuring a level of certainty no other firm can match. TCS offers a consulting-led, integrated portfolio of IT and IT-enabled infrastructure, engineering and assurance services. This is delivered through its unique Global Network Delivery Model™, recognized as the benchmark of excellence in software development. A part of the Tata Group, India's largest industrial conglomerate, TCS has a global footprint and is listed on the National Stock Exchange and Bombay Stock Exchange in India.

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Ashok is accountable for growth of Emerging Business – Internet of Things and Industrie 4.0, for Engineering and Industrial Services as well as for creating value-based solutions and services for clients across automotive, aerospace, hitech, telecom, pharmaceutical, medical devices, industrial machinery, consumer packaged goods, utilities, oil and gas, and resources

With an experience of over 20 years, his expertise spans across multiple medical and pharmaceutical domain areas including new product development, product lifecycle management, manufacturing operations management, R&D and quality, regulatory and product sustenance.

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Saptarshi has more than 9 years of experience in the medical devices and diagnostics industry. He has worked as a product development engineer throughout his career at Tata Consultancy Services (TCS), with TCS' clients including various medical device majors across North America and Europe. His specialties include Class II and Class III surgical device development, risk management, and post market surveillance. Saptarshi holds a bachelor's degree in Production Engineering from Jadavpur University

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Principal Scientist, TCS

Venkat currently leads the particle science and nanotechnology research programs at the Tata Research Development and Design Centre (TRDDC). Venkat has extensive experience in developing and implementing industrial research projects on process modelling, simulation and optimization, predictive data analytics, and process development, scale-up and design. His current areas of interest are nanoparticle synthesis in aerosol flame reactors, production of nanoparticles through high energy milling, and drug delivery systems. Venkat has a Master's degree in Chemical Engineering from the Indian Institute of Technology, Kanpur and a Ph.D. in Earth and Environmental Engineering from Columbia University, New York. Venkat is currently an AICTE-INAE Distinguished Visiting Professor at IIT Kanpur.

Shantanu Maheshwari

Shantanu works with the Process Engineering Innovation Lab at the TRDCC. Since joining TCS, he has worked on modelling of drug delivery systems and nanoparticle production through high energy milling. With a Bachelor's degree in Chemical Engineering from BITS Pilani, Goa, Shantanu went on to complete his Master's in Chemical Engineering from the Indian Institute of Science, Bengaluru.

Environment

Intelligent access management At household waste recycling centres

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ABSTRACT: The ACTAIS® Waste system is specifically designed for the intelligent management of access to household waste recycling centres, thus allowing the managing body to comply with relevant EU directives related to waste statistics collection and reporting. The system monitors persons and companies through their Identity Document, Smartcard or vehicle number plate, among other methods. After being identified at the entrance point, the user, through a touch screen, describes the type and quantity of waste he will leave at the recycling centre. In this way, the type of waste and the deposited amount can be easily determined at the various recycling centres owned by the managing body. This system is currently in operation at three household recycling centres managed by Gijon's urban waste collection company (EMULSA).

KEY WORDS: Household Waste Recycling Centres, Waste, Access Control, Recycling, Smartcard, ACTAIS.

INTELLIGENT ACCESS MANAGEMENT AT HOUSEHOLD WASTE RECYCLING CENTRES

1. Background

The implementation of EU policies requires comparable and reliable statistical information about the economic, social and environmental situation in the EU and its components at national and regional level. Statistics are also indispensable for Europe to be understood by the general public and for citizens to take part in the democratic process and debate about the present and future of the EU.

In this context, EU regulations have substantially increased the array of implementation measures on environmental policy, thereby making it **essential to improve the supervision of waste**, as it is stated in:

- Regulation (EC) No 2150/2002 of the European Parliament and of the Council of 25 November 2002 on waste statistics. *"The objective of the Waste Statistics Regulation (WStatR) is to ensure better monitoring of effective implementation of Community policy on waste management with regular, comparable, current and representative data on the generation, recycling, reuse and disposal of waste".*
- Regulation (EU) No 99/2013 of the European Parliament and of the Council of 15 January 2013 on the European statistical programme 2013-17. *"Objective 3.3.2: Provide environmental statistics to support the policy-making process of the Union. The objective will be implemented by a set of key environmental statistics on resources, such as on waste and recycling, […] at national and where possible regional level, […] to support mitigation and adaptation actions and policies at all relevant levels from local to Union level".*

Furthermore Eurostat has set up the **Environmental Data Centre on Waste** "*to process and disseminate waste data in the most effective way. The aim of the centre is to supply the information needed for EU environmental policies and to use the available institutional resources as effectively as possible*".

Finally, and linked with the current **smart city revolution**, it is worth mentioning that the application of **new IT solutions for all areas of waste management** will substantially improve the statistical context, increasing automatization, control, transparency and reporting.

2. Project Description

Within the new regulatory and strategic framework mentioned above, the Municipal Company for Urban Environment of Gijon (EMULSA) included, as a part of its investment plan, the modernization of three household waste recycling centres in the area of Gijon (Principality of Asturias). The aim was to improve the service offered by these free municipal facilities, while encouraging both the public use of such facilities and the sorting of deposited waste.

Ecocomputer S.L. was awarded the project due to the innovative solution proposed: ACTAIS® Waste. The development of this IT system would allow EMULSA a substantial improvement in the operation of both access control and waste data management at the three recycling centres.

EMULSA invested €44,000 into this project. ACTAIS® Waste system is in operation at the three recycling centres from March 2014. ACTAIS® Waste system identifies private users by means of their Gijon's Citizen Card, and business users by a personalised card issued by EMULSA.

Figure 1. Access control at the EMULSA household waste recycling centres.

3. Process

Users are identified at the entrance of the recycling centre by placing their Gijon Municipal Citizen's Card (or EMULSA-issued card) close to the ACTAIS® Station, a touch-screen kiosk. The user must then state through the touch-screen the type of waste and the amount of each type to be deposited.

Other facilities can be configured to allow the user to access through other methods:

- Electronic National Identity Document
- SmartCard (in Smart Cities)
- Eco Card
- Card issued by the managing company of the recycling centre
- Vehicle number plate registration
- Other methods of identification

Figure 2. ACTAIS® Station

After card recognition, the use of the touch screen is very intuitive because the user follows an icon menu that will guide him/her through different defined types of waste and amounts to be deposited.

Figure 3. Screen shots of the ACTAIS® Waste touch screen

Once the waste information is entered into the system, and automatically validated, the barrier is disengaged and access to the household waste recycling centre is granted.

Figure 4. Access granted

Finally, a record is generated, which provides EMULSA with a set of comparable and reliable data that can help to improve the service and the required statistics reporting.

Furthermore, unidentified users (no card), can be authenticated by their vehicle number plate recognition. They can be provided a limited number of deposits.

Figure 5. Vehicle number plate recognition module

4. Results

Deposit monitoring

EMULSA can use ACTAIS® Waste to generate statistics on the access to the facility and on the deposited waste. The system provides a description of the type and amounts of waste deposited at the various recycling centres run by the city council or managing body. The amounts can be expressed in units, weight and volume. Daily limits can be set for a recycling centre or for a group of such centres.

Figure 6. Generation of access and waste statistics

Furthermore, operators of the facility can also monitor the data, entered by users accessing the recycling centre, from their mobile device (Smartphone, tablet, etc.) by means of the ACTAIS® Waste Mobile application.

Figure 7. ACTAIS® Waste Mobile application

Recycling incentive campaigns

Another major benefit of installing the ACTAIS® Waste system is the ability to set up information and reward campaigns, with the aim of encouraging recycling and the public use of Gijon's recycling centres.

In this way, the most active users, for example, could be rewarded with cash, prizes (tickets, etc.) or exchangeable eco-points, depending on the type and/or quantity of waste they deposit.

The system would allow users to receive an SMS or email, every time they use the recycling centre, in which they are informed of their accumulated points. There would also be a website available for users to check on their accumulated bonuses and the individual data recorded at the recycling centre.

5. Conclusions

Installing ACTAIS® Waste system, as currently operational at the household waste recycling centres of EMULSA, would provide the managing company with the following benefits:

1. Generation of statistics on users and waste deposited.
2. Space optimisation for waste containers.
3. Greater flexibility in managing waste.
4. Mobile monitoring and supervision by operators.
5. Enhancement in transparency of waste information.
6. A tool for encouraging user recycling.

6. Acknowledgements

Ecocomputer S.L would like to thank EMULSA for its collaboration in developing this project and its commitment towards innovation.

7. Company

Ecocomputer S.L. is a technology firm based in Spain. Founded in 1999, it is specialized in the design and development of IT solutions for security, transport, and health industries.

Ecocomputer S.L. offers a wide range of products, based on own technology, resulting from years of evolution and adaptation to meet the client´s needs. Within "Security" business area, Ecocomputer S.L. is highly skilled and experienced in the implementation of advanced systems (hardware and software) for Access Control and Time Attendance for all kind of facilities (e.g. Ports, Household Recycling Centres, Logistic Centres).

In Ecocomputer S.L. we maintain a clear commitment to innovation, so that we develop a continuous innovation strategy, participating in National and European R&D projects, and aiming to achieve maximum competitiveness and international excellence. In that framework we are members of the Spanish Platform for Industrial Safety (PESI), Spanish Railways Technological Platform (PTFE), SmartLiving Platform, and Alliance for the Internet of Things Innovation (AIOTI).

Ecocomputer S.L. carries out a continuous investment in the development of new products and services, aiming more robust and powerful tools. We are a flexible company that will address and solve client demands in a highly professional and competitive manner. We seek to meet the specific and often unique needs of our clients because we understand that our tools should adapt to our customers and not vice versa.

Ecocomputer S.L. main technology interest areas include: Security (Access Control and Time Attendance); Transport; Pharma and Healthcare; Predictive maintenance; Smart Cities.

Juan Carlos Rodriguez
Managing Director, Ecocomputer SL

Electrical Engineer (6-year degree) from Polytechnic School of Engineering (University of Oviedo) and IBM Master in Enterprise IT systems.

9 years of experience in international environment as IT consultant (LAN, Support, SAP Warehousing and Data Migration). Since 2005, Managing Director at Ecocomputer S.L., where he leads the Business Development Department and the R&D activities.

Energy

A new approach to an IoT energy based analysis

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ABSTRACT: Modern technological plants are complex. Even for highly educated users and expert technicians, understanding their functioning is a difficult task to achieve. Unfortunately, this knowledge is important for fine tuning them and help the final user to get the best performance out of their plants, maximizing the costly investments in them.

Power plants make no exception. With the wide spreading of renewable energy production systems often coupled with advanced technologies like energy storage systems, heating pumps and domotic systems, tools that helps in understanding what is going “under the hood” in a simple way are more and more needed.

Ecogriddy provides an IoT based solution that merge the power of a real time and predictive energy analytic with the easiness of a consumer oriented app.

A NEW APPROACH TO AN IOT ENERGY BASED ANALYSIS

1. Problem:

During 2014 and 2015 a lot of different SMEs came to us to express their interest in using better their renewable power plants. Most of them stressed about maximizing the usage of the energy produced. Others were more focused about power consumption audits. Ecogriddy has been founded by engineers with a long field experience, so its team started to analyse deeply some of the cases that have been presented to us. Moreover we led a set of interviews with managers of SMEs with renewable energy plants installed on their sites, technical installers, ESCOs. A common trait we discovered between them is the difficulties that the interviewed people are facing in order to manage their expensive plants in an effective and efficient way. Most surprisingly to us, many of the interviewed people have a monitoring/supervising system in place. They rarely use it, or they don't use it at all. The reason? Those controlling systems are far too complicated to be used by non-technical people. Most of them don't understand what's happening on their plants.

Plant users have to take informed decisions on costly activities (like production strategies or logistic choices) based on important variables they don't understand fully (like energy production rate / consumption / forecasts).

*There is a real and costly **problem to solve:** to make users aware on how their "green sourced" electrical subsystems are working, performing and interacting with other subsystems and external factors (like weather, human activities etc.).*

2. Solution:

Ecogriddy solves the problem with an IoT approach that integrates monitoring hardware, a network stack, a cloud based predictive analytics, a data storage and a consumer oriented web interface.

The technicalities and all the diagnostic information are still there, if the user or, more likely, the technician asks for them, but they are available only on request and on a low level view. The system interacts with the user in a streamlined way, teaching her/him how the plant is working, giving emphasis to the events and the interactions that really matter.

Everything is there to maximize the usefulness of the plant, getting the most from the investment in it.

3. Business model:

Since we are still in the early beta-test, our business model is still subject to changes. One of the most promising scenario is based on a Software-as-a-Service approach combined with a one-time fee that covers hardware and installation costs. The solution is priced according to a monthly fee which depends on plant size. This business model fits also the customers' expectations, because it's becoming a common trend in the services market. We have a working prototype (see the section "Current Status ...") on a 1.6 MWp solar plant that serves Trentino Trasporti's logistical site. They will buy our solution in 2016 and we are closing several contracts by the end of 2015 based on yearly subscription model and hardware price paid upfront.

Our customers are SMEs with green power generators on their production sites, plant installers that resell our solution to their customers, system integrators and energy advisors which use our platform as a design/audit tool.

4. Underlying magic

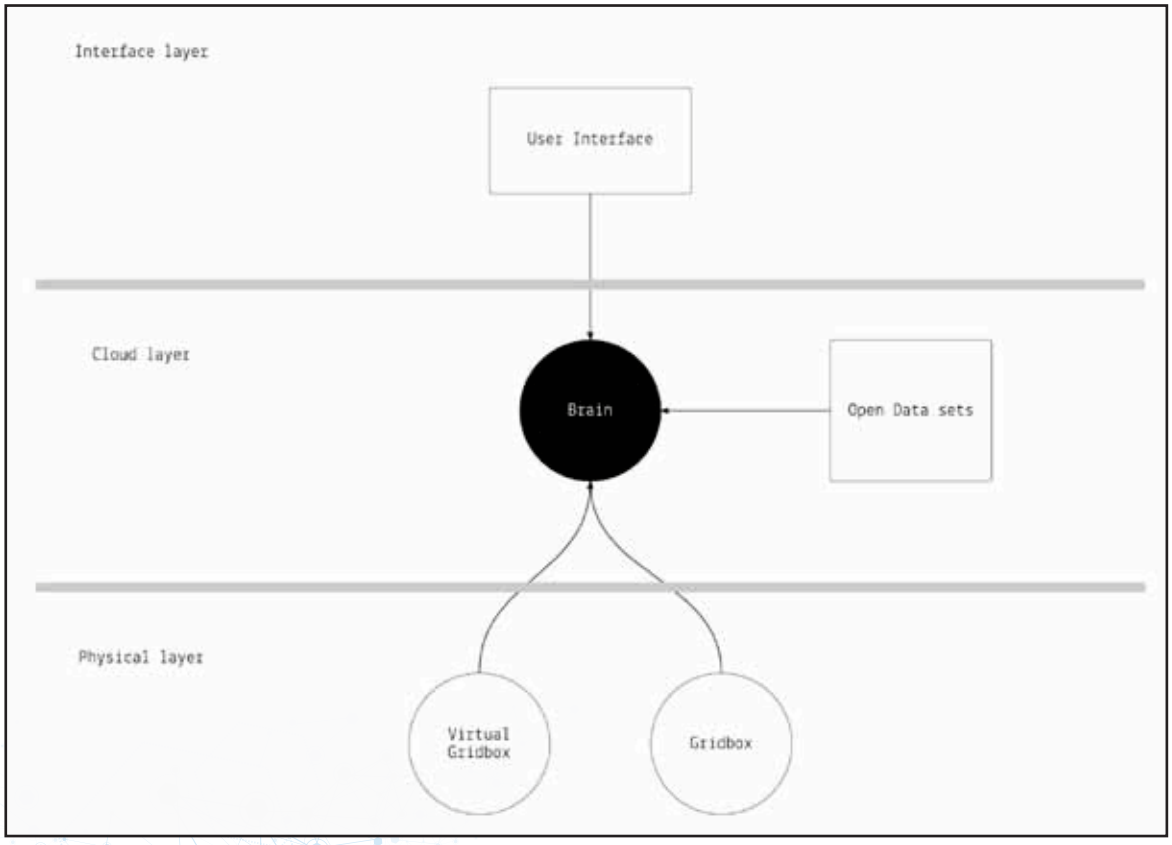
Technology:

Our product is built on 3 layers interconnected in a classical IoT architecture:

- a physical layer that consists in monitoring hardware (industrial grade). It's modular and it exchanges data through industry standard protocols like MODBUS, 4-20 mA, OneWire. The data are gathered by a gateway and transferred to the next layer. The gateway has been nicknamed "Gridbox" which can be either a physical object or a virtual object (software adapter).
- A cloud layer, which collects, analyzes and elaborates further the data received by the Gridboxes and by other contextual sources. Opendata play an important role in providing datasets for this contextual sources. This cloud layer has been nicknamed "The Brain" because it makes sense out of raw data, reacts dynamically to several situations that can occur on the plant and responds from inputs that are provided by the user. It is built on proprietary algorithms developed by Ecogriddy team of engineers and developers. It is also powered by several Fiware Generic Enablers and other open source technologies. The Brain can act in real-time and has a predictive engine integrated in it.
- An interface layer that allows the users to interact with the plant and to learn from it. At the moment this interface is web-based and responsive, but there are plans to develop also native mobile apps on Android and IOS. The user experience happens in this layer and is an important part of the product. The principles that have inspired its design and a description of its main features will be presented in the "Visual language" section.

Scalability, modularity, resiliency, compliance to open standards and edge computing capabilities are keystones of our architectural design. We believe that an IoT approach can give a substantial improvement to the state of the art in monitoring solutions: it can reduce operational cost and multiply the possibilities of an hardware setup thanks to a continuous development that can improve the hardware compatibility and potentials over the time.

A cloud-based approach is fundamental also to provide zero-day security fixes and to improve the User Experience over the time, keeping the product fresh and up to date.



A NEW APPROACH TO AN IOT ENERGY BASED ANALYSIS

A visual language:

The representations management, for the acquisition, processing and transmission of knowledge is essential for our relationship with the world.

We need another map. We need to represent data in a new way to understand our world.

We can easily record and store data from things. We can sense positions, weights, temperatures, etc. This data are even easy to transfer anywhere with little effort.

The technology that senses “anything” in real time can be seen as a nervous system. No doubt about that. We can aggregate and process these big data and serve them exactly when we need them.

The first design solution that we found immediately useful is the fusion of notifications with charts. As you can see this charts made of two curves is provided with a round blinking element.

This is the first step of a complex process. Charts and notifications are a good tool to represent information and to analyse it. 90% of data are referable to a given value in a specific time: time series.

A timeline is made of significant milestones. A time series is nothing less than a path.

We are reading a map with a street which is developing second after second. So we can represent crossroads, curves, highways, straights and so on.

People are interested only in some key patterns. “The system is working”, “peak detection”, “stable growth”, “wave shape, etc.

Those key patterns are our words and we can start a new language now.

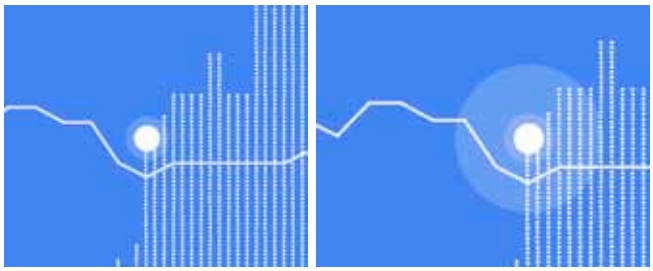
One of the first design problems we faced was the representation of kW and kWh. One is a value that measures power and the other measures energy. So the first is like a speedometer and the other like an odometer. Kilowatts matter for real time performance of the plant. We decided to represent this value with dotted lines. Kilowatts are precarious. They have a meaning only while you read them.

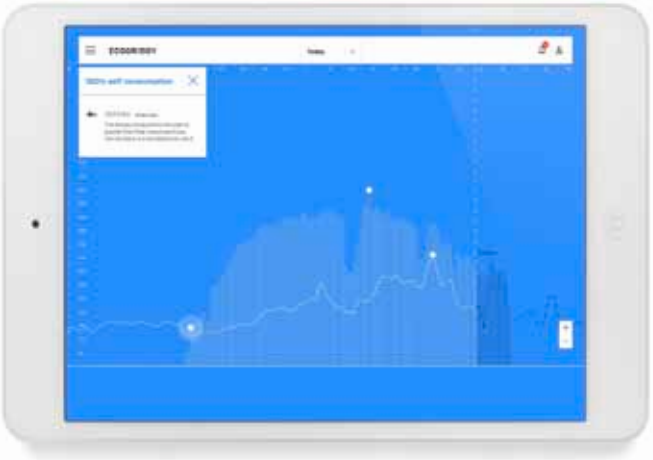
To represent kWh we changed dotted lines into more compact point lines: continuous lines.

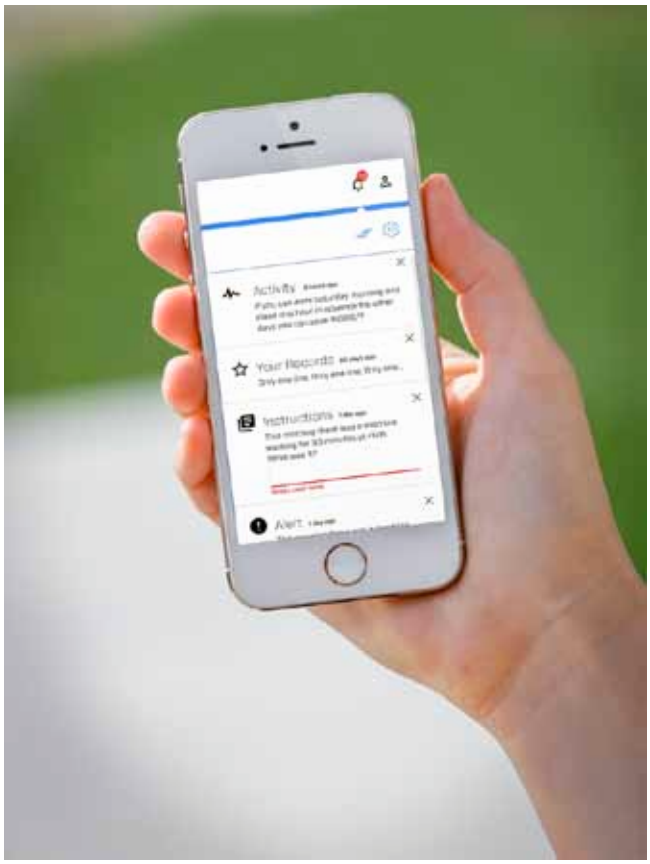
This values and records are useful for billing information. So they need to be clear, precise and reliable. We are expecting feedbacks from users for this choice.

Another important design solution is the regard for graphs proportions. Every histogram has a shape. Stretching this shape while zooming it change the meaning of this shape. Every time you are forced to change the reference points you lose coherence. This is fine for a mathematician. But if you need to build a visual language you need to be consistent.

We don’t want to stretch our charts as we do not stretch types to force them into pages.







5. Current status, accomplishments to date, timeline

Current Status:

The product has a working implementation on an operational environment (TRL 7). It's monitoring a 1,6 MWp photovoltaic plant that is located on Trentino Trasporti logistical site. The hosting company is the public transportation company in the Autonomous Province of Trento and has provided us both the access to their plants and the feedback from their personnel, both technical and not.
The tester is enthusiast of our overall solution, it has been very active during product development with a constant and focused feedback activity. It will be one of our first customers, since it's willing to buy the final product as soon as it will be available on the market.
The team is pushing hard to advance the TRL of the product with a targeted launch to market set by the beginning of 2016. Ecogriddy is closing several contracts before the end of 2015 based on the prototype, effectively pre-selling the product.

Accomplishments to date:

Ecogriddy roots lay in the engineering/design consulting sector. The founders have worked as freelancers and advisors, each one of them for more than 10 years.
Ecogriddy has been incubated in one of the first cleantech incubators in Europe (Progetto Manifattura - www.progetto-manifattura.it).
Subsequently we have achieved several important milestones:

- our product, at an early prototype stage, has been selected among the 10 finalists of 2014 EICT Labs Idea Challenge - Smart Energy Systems. (**https://goo.gl/LG0sUt**)
- selected by FINODEX Fiware Accelerator and secured 50k € in equity free funding. (**http://goo.gl/vZayWS**)
- selected to partecipate to the 1st Fiware Investement Forum (**https://goo.gl/8CbxK3**).

Currently Ecogriddy is part of EIT Digital Business Development Accelerator (BDA).

Timeline

- 2013: Incorporated
- May 2013 - April 2014 : Incubated in Progetto Manifattura
- Oct 2014 - Finalist @ EITICT Labs Idea Challenge 2014 – SES
- Nov 2014 - Selected among 20 best applications for @ Rockstart Smart Energy Selection Days
- Nov 2014 - Selected among best proposals for @ Startup Energy Reykjavik
- Feb 2015 - Selected for Finodex (Phase 1,2,3) - 50k € equity free funding.
- Aug 2015 - First test installation on Trentino Trasporti Logistic site.
- End 2015 - First contracts signed
- 1st Qt. 2016 - Market Launch & APIs release
- 2nd Qt. 2016 - Mobile Apps (Android & IOS)

6. Biography

Luca Silvestri: is the founder and CEO of Ecogriddy. Civil engineer with 15 years of professional experience. Before starting Ecogriddy he worked as a freelance engineer and as consultant for several SMEs. He lives in Trento.

Ivan Favalezza: Lead designer at Ecogriddy.
He is a multiform designer. Expert in typography and interactive environments. He is an Aiap member and he worked with some of the best designers in Italy, for museums, cultural associations, publishers and startups. Serial entrepreneur, he lives and works between Trento and Verona.

Transport

Tecnoport 2025 - Future Technological PORT

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1. Problem

Freight transport is one of the bussiness with more presence in the world, being crucial to the economy of a country. The fact that the traffic volume is so high makes it a complex problem involving many different actors: from the cargo owner to the insurance company, including also intermediate administrative entities. Therefore a system that provides information of the containers in transit would provide significant added value to logistics systems.

Road transport has always been the most prevalent in the movement of freight. However, road congestion and the increasing necessity to find more sustainable modes of transport have encouraged governments to promote multimodality as an alternative. From the supplier, the freight is transported using multiple modes (rail, ship and truck) without cargo handling to its final destination. Multimodality combines the cost effectiveness of railways or ships with the flexibility of trucks. However, multimodal transport has several difficulties to overcome to become viable. One of them is a high fixed cost, which explains why multimodality is not suitable for trips shorter than a certain minimum distance, which could be extended if drayage operations were improved.

Optimizing the management of freight is one of the main targets of multimodal transport. Independently from the selected transport mode, it is important to monitor the exact location and status of the merchandise in order to ensure its efficient management, and, at the same time, that goods are not damaged or their quality is not impaired (it is especially important in the case of perishable goods). Additionally, securing the contents of containers has strong health and safety implications, since the illegal manipulation of their contents could be the support of illegal traffic (drugs or weapons).

A variety of goods tracking systems have recently arrived to the market, although its market penetration is still low. They are usually intended for road transport. The most common tracking systems use RFID tags attached to boxes, pallets or containers, which are read in certain checkpoints along the way. These solutions, though do not require batteries in the tracked element, are limited by the necessity of deploying tag readers in selected checkpoints, with all the drawbacks inherent to such a situation. More recent solutions offer GPS tracking (despite its high power consumption) attached to a communication terminal (GPRS/GSM or satellite), with widespread need for a SIM card.

Besides the location of the containers it is also of interest to monitor their cargo. R.J. Craddock and E.V. Stansfield, in «Smart container sensor fusion», 2005, raised the desirability of measuring certain variables within the container, such as

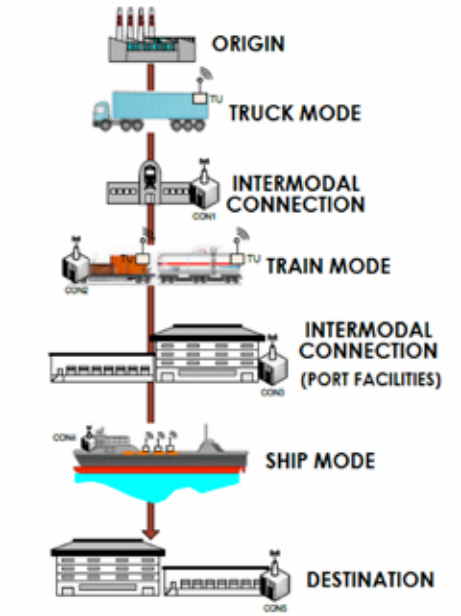


Figure 1. Scheme of multimodal transport

temperature and humidity, also including intrusion detection, special monitoring of dangerous goods or biological systems, and early detection of leakage of gas or liquid.

Only very recently some solutions have appeared which are based on a set of sensors (including door opening detectors, temperature and humidity sensors, accelerometers, etc.) connected by a wireless network (Bluetooth or ZigBee type) to GSM/GPRS or satellite terminals, allowing cargo tracking in real time in almost any part in the world. As for communication technologies, those solutions based on local networks are rare; they mainly use the 2.4GHz band, which implies communication problems when there is a high concentration of containers. One of the most complete examples of these systems is the one called Trecs (which stands for tamper-resistant embedded controllers) developed by Maersk and IBM in 2005, (Harris, I., Wang, Y., Wang, H., 2015, "ICT in multimodal transport and technological trends: Unleashing potential for the future", in: Int. J. Production Economics 159, 88–103). Also to mention the Smart Container Management (Smart-CM) project (Julia Carn. "Smart Container Management: Creating Value from Real-Time Container Security Device Data"), 2011, financed by the 7th Framework Programme with the participation of companies such as Globaltrack and Raytheon. A demonstration with 24 containers in three logistics companies (COSCO, DHL and Kuehne + Nagel) was conducted in 2010-2011, monitoring information for 42 trips between Europe and Asia by ship, rail and road.

Unfortunately these global solutions hardly reached the market, as they are usually based on closed systems and terminals, with proprietary interfaces, providing the services for cargo tracking at a high cost, only suitable for high-valued cargo.

Figure 2. Partial view of the container yard in the "Batan" dock at the Port of Seville

2. Solution

The TECNOPORT2025 project is an initiative of the Port Authority of Seville (APS), which is the only inland seaport in Spain; the waterway from Seville to the coast is part of the TENT European Transport Network with the name of Guadalquivir EuroWay E.60.20. The Port of Seville is an important logistics hub that serves a population of over one million people and maintains a leadership position in some logistic corridors such as the Madrid-Seville-Canary Islands one, which will be the scenario for the demonstration of the project. TECNOPORT2025 is being co-funded by the European Commission by means of the ERDF (European Region Development Funds), under the Pre-commercial Public Procurement model aiming the "Port of Future".

The Port Authority of Seville (PAS) launched this project in 2014, with the leadership of the University of Seville in collaboration with five leading European companies in their respective fields: Telefónica, Thales, Portel, Isotrol and ServiPort.

TECNOPORT2025 is conceived as an initiative to enhance existing physical infrastructure by means of exhaustive use of the information and communication technologies (ICTs), in order to optimize their exploitation with the long term objetive of increased growth, while ensuring environmental sustainability, and maintaining a leadership position in some key logistic corridors like the Madrid-Sevilla-Canary Islands one.

To this end, an innovative infrastructure for some key enabling technologies (such as a heterogeneous communication network and a platform for service integration) are being deployed, and three subprojects are being carried out, each one targeted to an area of particular interest to the activity of the Port of Seville: "Container Unitized Tracking System" - CUTS (focused in container tracking), "Ferro Port System" - FPS (focused in railway traffic operation), and "e-River information and optimization" - eRIO (focused in sensor monitoring and enhanced navigation in the Guadalquivir River).

This paper is mainly focused on CUTS sub-project, whose objective is to develop an open platform for geolocation and for remote monitoring and control of containers and their cargo, giving an answer to the problem of optimization of freight management. CUTS is a system for remote monitoring and control of containers that integrates data coming from sensors located in the containers themselves and the necessary supplementary information, providing an open environment for the exploitation of these capabilities. CUTS solution transforms the container into an active element of the multimodal corridor, almost comparable to a store asset, increasing the capacity of management of supply chains.

CUTS Functionalities

The proposed system will provide the following functionalities:

- Geolocation: To determine the geographic position of a container and its presence/absence in bounded enclosures.
- Monitoring: To receive readings from sensors installed in containers in transit: both, periodic readings and alarms triggered by events, in almost real time.
- Actuation: To send commands to equipment installed in container traffic in near real time.
- Additional information: To include information on containers and cargo in transit from various systems.
- Services: To facilitate the development of applications. For example, for the management of transportation plans, for alarm management, for «geofencing» applications, etc.

Beneficiaries and Benefits of CUTS

The main beneficiaries of the CUTS system are those responsible for the transportation of goods in containers in multimodal corridors (distributors, producers, etc., or specialized agents which operate on behalf of them). In addition, the system will develop new services that will create value for some other actors involved in the Port activity or in the logistic system.

Following Muñuzuri et al., Impacts of a tracking and tracing system for containers in a port-based supply chain. In: Proceedings of ICIEOM-CIO-IIIE (2015), the expected supply chain impacts of the system could be grouped in 6 categories: visibility, security, reliability, timeliness, cost, and efficiency, as it is shown in Table I.

CATEGORY	REQUIREMENT DESCRIPTION
VISIBILITY	• Transparency and visibility on terminal shipping processes • Earlier information on hinterland transport • Visibility during recovery processes from anomalies (reactive) • Traceability of empty containers for better repositioning strategies • Enablers of exception management • Accuracy of position of container in terminal area
SECURITY	• Opening of container only once/as less as possible • Fight counterfeiting • Reduce theft • Avoid cargo damage (liability issue) by knowing the sensitivity of the commodity
RELIABILITY	• Decrease lead time variability and capture deviations within margins
TIMELINESS	• Reducing total door-to-door time, minimising idle time • Reduce dwell time at terminals by improved availability of information to different actors thus contributing to better process planning • For some users, waiting time can be functional • Enabling companies to go intermodal by reducing complexity and solving interoperability issues • Contribution to e-freight and IoT visions to become a reality
COST	• Reducing total door-to-door cost
EFFICIENCY	• Reducing administrative burden/single window offering, one stop-shop-service • Pre-announcement of hinterland operators to improve terminal efficiency • Value added services from platform: automatic document generation from users

Table 1. CUTS project impacts on the supply chain

3. Business Model

Compared to conventional tracking systems, this solution is conceived as a public service with open architecture and interfaces, where different suppliers will design communication terminals and sensors according to the user needs. The Port Authority will maintain the network infrastructure and will provide services and APIs to the logistic operators and to the different stakeholders in the logistic chain, so that can take benefit from this infrastructure.

The results of the CUTS project will be offered in a public call for tenders, oriented to global ICT companies. The business model relies on four pillars:

- Sensors and communication terminals, which will be offered by different providers based on open interfaces. These low cost terminals will be owned by logistics operators, offered to their customers, as part of their service. Optionally cargo owners could be interested in some specific sensors to be attached to the communication terminals.
- Communication infrastructure, consisting on the backbone (wireless sensor networks, concentrators and gateways) required to collect data coming from data container terminals. This low-cost infrastructure will be maintained in the Port facilities, intermediate warehouses and transport modes (trucks, trains and ships). This is a low cost infrastructure that will be used by ports, warehouses and transport companies which will pay for its use, making them more competitive, especially for higher-valued merchandise.
- Central servers, in charge of storing container location and sensing data, offering basic CUTS services to logistics operators, cargo owners and transport companies, depending on selected user profiles. These servers will be maintained by a global ICT company. Access to server data will be charged to every user.
- Third-party advanced applications will be built on top of basic services, either by the global ICT company or by the corresponding users, according to their capabilities and requirements.

This is a revolutionary model for this kind of services, which are usually provided in a centralized way by a single company with closed, proprietary devices, infrastructure and applications.

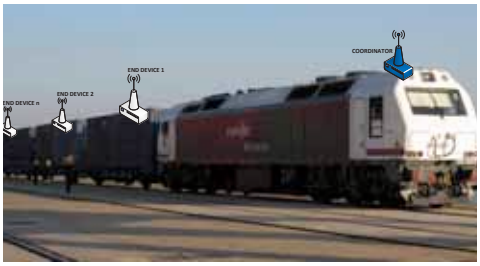
4. Underlying Magic

The network infrastructure is based on the recent IEEE 802.15.4g standard, and it adapts to every stage in the multimodal chain. In the distribution of goods, several transportation modes can apply. Every mode has specific conditions to trace the cargo. The transportation of a container in a truck is much simpler than in others because there is only one container to track at a time, thus deploying a complex Wireless Sensor Network is not necessary, the container has one end device which will be connected to the coordinator terminal in the truck cabin. In the case of a ship or a train, they transport several containers (from only one to several thousands), then a WSN can be deployed to locate every container. In this scenario 3 different modes are identified:

- Train and trucks moving the cargo from the origin to the port,
- Ships travelling between different ports
- Train and trucks that deliver the container to the final destination.

Figure 3. Network architecture in main scenarios

a) Network deployed in a truck: one end device in a container



b) Network deployed in a cargo train

c) Network deployed in a cargo ship

d) Network covering most of the Port of Seville facilities

There are four ways of acquiring the information for container traceability depending on the scenario: trucks, ships, trains and port. Figure 3 depicts the network architecture in every case, being the last two (ships and port) the most challenging ones in terms of technology performances and complexity of the solution.

The Madrid-Sevilla-Canary Islands corridor will be the logistic corridor where this system will be applied for the first time, with Seville port as the strategic point.

Once the cargo arrives to the port, the CUTS system is able to trace containers in the port facilities. It manages every critical piece of information about the goods, and provides alarms and notifications, such as an open door, a significant change in the optimal temperature, humidity, etc. Moreover, the system monitors the amount of time the container is stored in the port facilities, which is very important for the management of the containers in a big port, for calculating the costs of container storing, and to check the delivery time for perishable goods.

Subsystems

Wireless Terminal Nodes

In order to achieve the network development a node based on an Atmel microcontroller and a Texas Instruments transceiver in the subGHz band have been chosen.

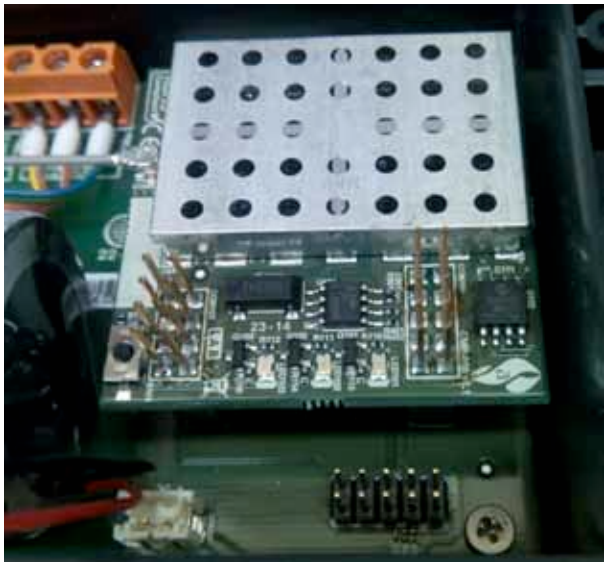


Figure 4. Designed wireless terminal node

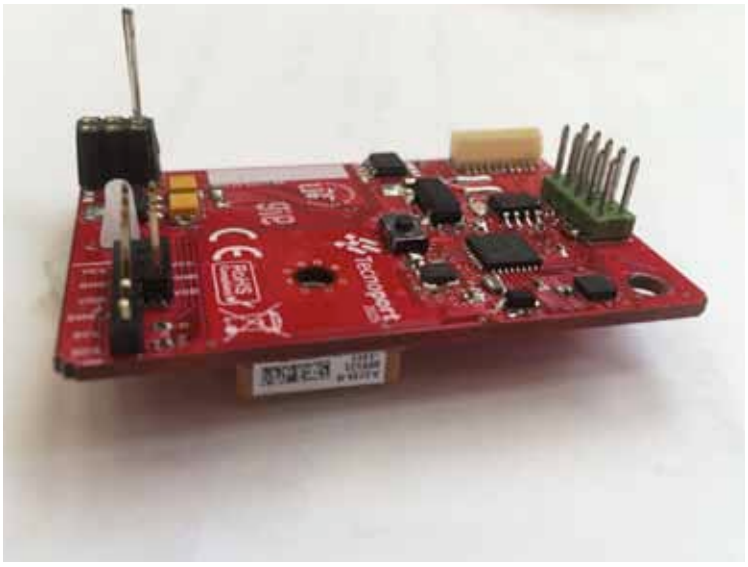


Figure 5. Sensor Interface board with GPS

This node consists of two boards, one of them with open interfaces dedicated to data acquisition, and the other one dedicated to manage wireless communications.

Wireless Network Basic Topologies

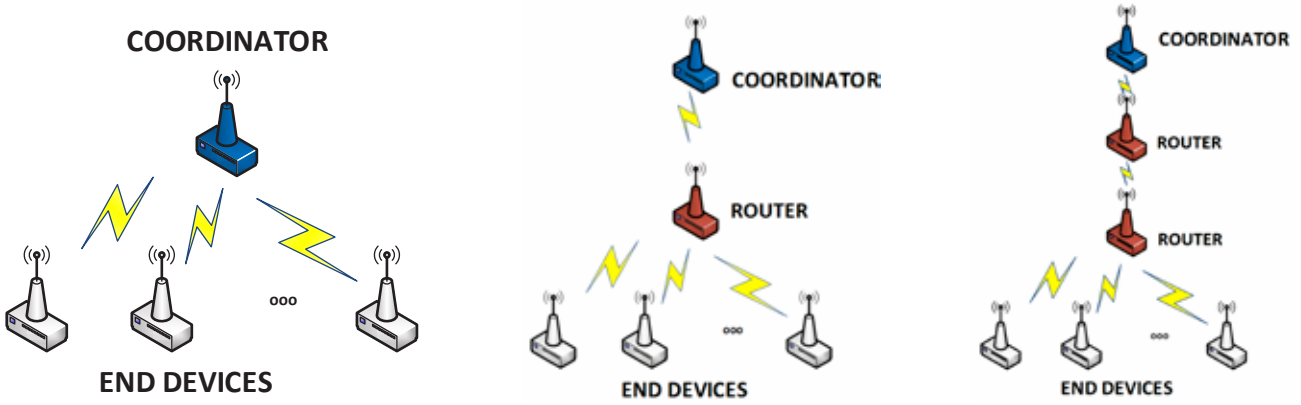
Two kinds of networks will be implemented regarding the different scenarios explained in previous sections.

The first network, the system on a cargo ship or train, consists of a coordinator with a number of end devices connected directly to it. In this network, all the end devices attached to the containers can be connected to the coordinator located in the bridge ship. The coordinator sets an 802.15.4 superframe, giving slots to a determined number of end devices, which can transmit their data to the coordinator in the assigned slot. The truck network is a particular case of this network where only an end device applies.

The star network has been designed as a synchronous beaconed network with 256 slots. Thus, in 5 minutes of superframe period, 256 end devices have a dedicated slot, avoiding collisions. Every node sends a 25 bytes frame every hour or every assigned slot if an event occurred. The latency of the network depends on the total number of end devices. When the number of end devices is higher than 256 devices the latency increases in 5 minutes steps each 256 extra end devices. This latency is enough to locate the containers and to monitor typical variables in it. Network programming is based on STK600, where a Transceiver Abstraction Layer (TAL) has been designed, to make the design independent on hardware.

For the network deployed in the port facilities, it is necessary to know the area to cover. Usually port facilities have an extensive area to cover. Although a star-network is the optimal solution, it is possible that coverage is not ensured in this way. For this purpose up to 3 levels of routers could be necessary, which can cover distances in a radio of 10km for a typical communication link passing through several building walls.

Figure 6. Basic Wireless Network Topologies



a) Star Network *b) 1-Level Tree Network* *c) 2-Level Tree Network*

Integration platform and services

Integration platform

TECNOPORT2025 requires an integration platform that collects the information coming from the sensor network deployed in the in the different means of transport (trucks, trains, etc.), stores them in a distributed database and serves them to the different services and applications used in the project. To this end, and innovative platform based FIWARE has been chosen, FIWARE has been pushed by the European Commission in the Future Internet initiative.

FIWARE is an open cloud-based infrastructure for cost-effective creation and delivery of Future Internet applications and services based on the Internet of the Thing (IoT) paradigm. The API specification of FIWARE is open and royalty- free, driven by the development of an open source reference implementation which accelerates the availability of commercial products and services based on FIWARE technologies.

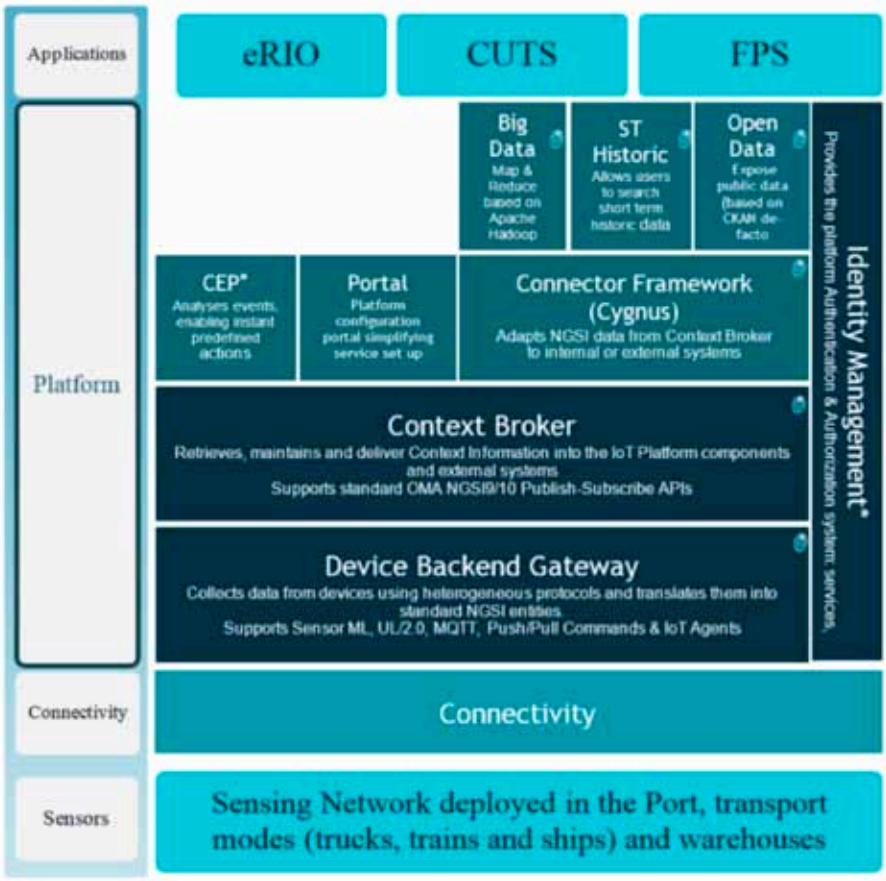


Figure 7. Architecture of the Integration Platform based on FIWARE

Services

CUTS has been designed to provided open interfaces for third-party applications, so that only a reduced catalog of services has been considered for CUTS in the TECNOPORT2025 project. Among them we select two of the most significant ones:

Geofencing

A service derived from geolocation is geofencing, consisting of detecting the position of a container outside a real or virtual enclosure defined by the geographic coordinates of its perimeter. When this situation occurs, an alarm is generated and reported to all those actors who may suffer injury, or who need to reschedule their operations, in the case of transport delays.

Planning of port operations

Since the CUTS system knows with high accuracy the position of the containers, as well as the location of the transport mode that carries it, an algorithm has been implemented that prioritizes the inputs and outputs of the containers in the port so that the overall port operations is optimized.

The aim of this service is to minimize transition times of containers in transit by the port facilities so that effective transport times are reduced in favor of a better service.

To this end the system collects the following input information:

- Estimated time of arrival at the port of different modes of transportation (trains and ships).
- Time required for output of different modes of transportation (trains and ships)
- Information on container transfers between modes.

and provides the following output information:

- Suggested priority for the entrance to the river of different ships, with dock allocation.
- Suggested priority list for the entrance of trains to the container terminal, with track allocation.

A user-friendly interface has been developed for viewing container tracking, with different user profiles (cargo owner, container owner, carrier, etc.).

5. Current Status

Each designed networks has been successfully tested in the laboratory and also in an outdoor scenario.

Additionally, tests in field have been performed in the Seville port facilities. Placing a coordinator in a 20 meters high street-light, coverage is ensured in the container storage area. Even in the case of measurements inside containers or surrounded containers, results indicates that the WSN network proposed for the solution is suitable in this scenario.

In a short time a fully functional system will be implemented in the Port of Seville port. According to the tests results the system will be running with hundreds of end devices attached to the containers.

A novel automatic, autonomous and low-cost solution for distribution chain, including intermodal connections has been developed. This WSN solution combined with an open platform provides the location of containers along the distribution chain, including the intermodal connections.

Finally with all data acquired by the different coordinators, the system offers to the stakeholders of the process add-values services focused on their needs.

Smart Campus

Open IoT Smart Campus

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ABSTRACT: The successful implementation of a Smart City solution is achieved thanks not only to a careful planning and design, but also thanks to the engagement of final users, in order to successfully identify and satisfy their needs. This paper presents the CEI Montegancedo Open IoT Smart Campus project, which has been conceived as a holistic solution to improve the quality of life and comfort of the campus staff, i.e. satisfying their different needs and demands. The project is divided in four different solutions: an outdoor smart lighting system, a greenhouse monitoring and control system, a building energy management system and a home smart system. Lessons learned during the project serve to illustrate how the interaction between final users and solution providers is essential to accomplish a successful implementation.

KEY WORDS: IoT, Smart Campus, Smart Lighting, Energy Efficiency.

1. Introduction

One of the most widely used definitions for a Smart City is outlined by Bakici et al. (2013), who defines smart cities as "cities that utilize information and communications technologies with the aim to increase the life quality of their inhabitants while providing sustainable development". This definition shows that ICT plays a key role in adapting a city to the contemporary needs of its citizens. Many ICT-based systems have been proposed and tested in order to solve a wide variety of issues and problems within cities, such as traffic management, air quality improvement, public illumination optimization, efficient infrastructures, energy use, etc. (Domingo et al. 2013). However, the conception and implementation of most of those systems have been primarily focused in the use of high-innovative technical solutions rather than in solving a real problem demanded by the citizenship (Skouby & Lynggaard 2014).

In this paper, we present the CEI Montegancedo Open IoT Smart Campus project, which has been conceived as a holistic solution to improve the quality of life and comfort of the campus staff, i.e. satisfying their different needs and demands. The project is divided in four different solutions. The first one has been driven by the insecurity and accident prone situations caused by the low luminosity on sidewalks: an outdoor smart lighting system which controls illumination in function of luminosity level and motion detection. Secondly, motivated by the huge amount of energy consumed at the Centre for Plant Biotechnology and Genomics, an energy monitoring and management system has been developed, which includes a full equipped growing module. Thirdly, in order to reduce energy consumption and discrepancies surged around rooms temperature, a building energy management system to control HVAC (Heating Ventilating and Air Conditioning) and set temperature in function of indoor temperature, humidity, luminosity and presence sensing (among others) has been deployed. Finally, trying to increase users' awareness and encourage the introduction of smart metering and control technologies into the residential market, a home energy management system has been developed and tested. The four systems have been successfully implemented, achieving high energy consumption reductions, satisfying as well problems and needs demanded by the campus users. All the pilots are technologically based on the BatNet solution, a 6loWPAN (IPv6 over Low power Wireless Personal Area Networks) based sensor and actuator network designed and developed by CeDInt-UPM researchers that provides wireless connectivity between physical systems and the internet (Caffarel et al. 2013).

2. Open IoT Solution

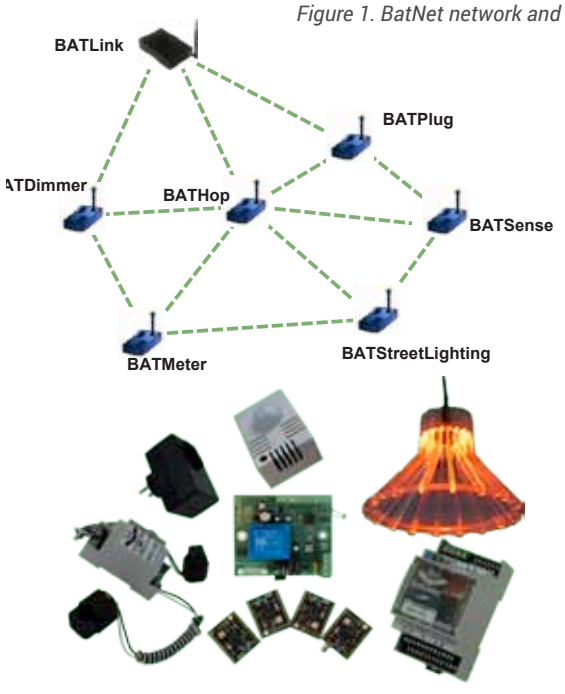
CeDInt solution for Open IoT comprises a sensor network (BatNet) and a management platform in Cloud (BatMP).

BatNet

BatNet connectivity is based on a network of nodes with mesh topology that communicate through a Std. IEEE802.15.4 Physical Layer under a 6LowPAN over IPv6 to implement Link and Network Layers. The Transport Layer is UDP and the Application Layer is based on CoAP (Constrained Application Protocol). Information encryption is done accordingly with AES-128.

The mesh topology has auto-configurable and auto-routing capabilities. Connection to Internet is done through a border router that can group up to 200 nodes. The implementation has been done using Open Hardware, resulting in a modular and inexpensive design. The devices firmware is Contiki OS.

Figure 1. BatNet network and devices



The strength of this solution relies on a robust communication network where connectivity among nodes is guaranteed. Nodes are plug-and-play, so, the deployment of the network infrastructure is easy to do. Nodes are designed using a modular architecture in such a way that different sensors and actuators can be easily integrated in nodes, obtaining different types of nodes IPv6 compatible.

BatMP

BatMP is a software platform or middleware designed for the monitoring and management of infrastructures and for the provision of services within a Smart City.

This gateway establishes a service oriented architecture which assures the system's scalability and follows the OSGi (Open Services Gateway initiative) specification. This way, BatMP offers a simple and well defined method to expose and invoke these services, which makes the interaction between different proprietary systems or third parties easier.

One of the aims of BatMP is to offer a set of APIs so future developers could use these APIs to create different kinds of applications which can run on this platform and several drivers for the existing or new technologies. Every BatMP gateway is connected with a central server where all the measures from the electronic devices connected to this gateway are stored. The applications developed over BatMP will have access to data of a certain client which are store don the central server, so these data can be visualized and used to make intelligent decisions, through a series of rules or algorithms, with respect to the way those electronic devices act. In the next figure the structure of BatMP gateway and the central server is shown.

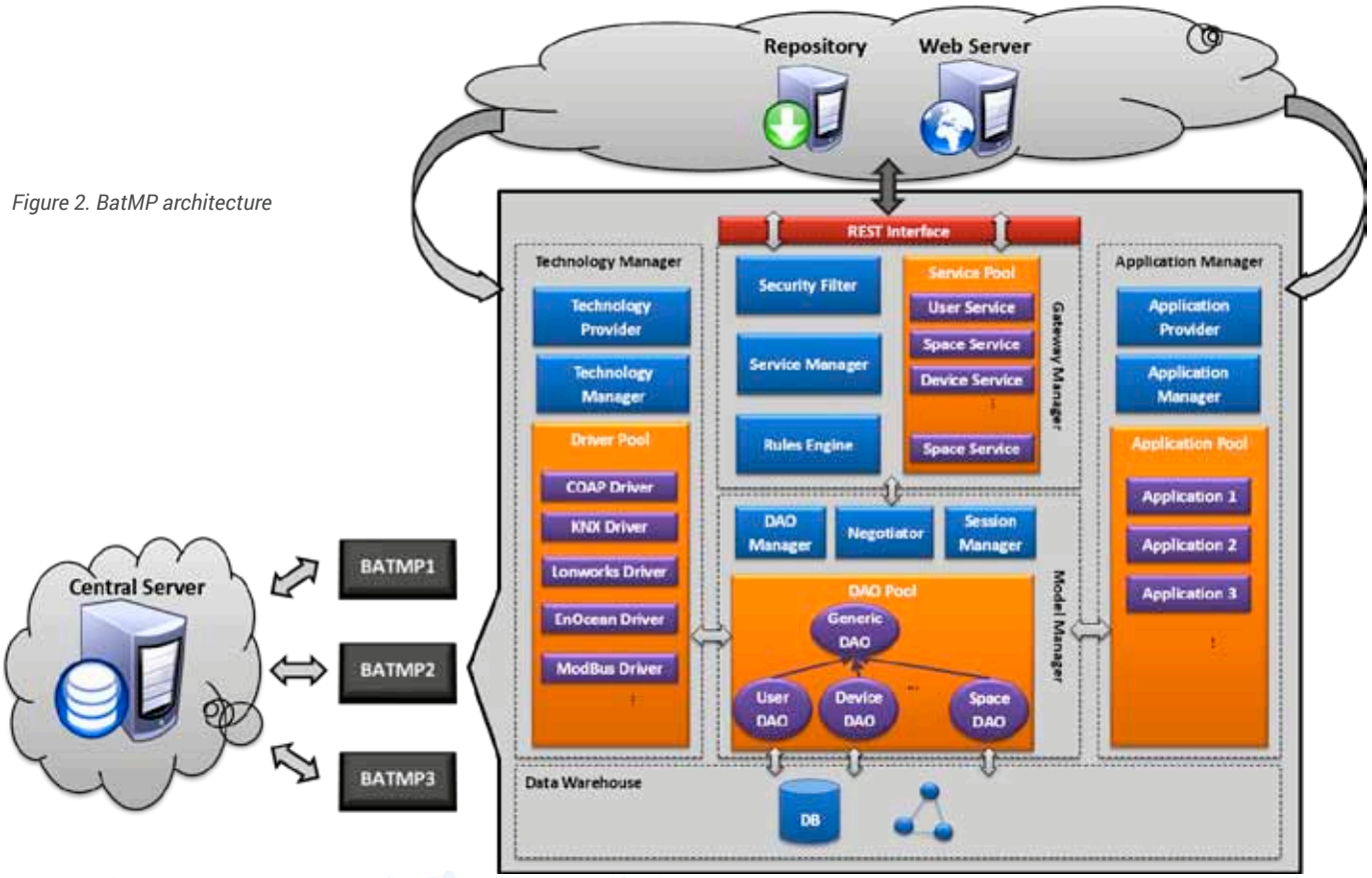


Figure 2. BatMP architecture

The design of BatMP satisfies the following objectives:

- Multiprotocol: the system is able to interact with devices from the different technologies (6LoWPAN, Zigbee, EnOcean, X-10, Lonworks, etc.).
- Service Oriented: lower layers of the platform related to the operating capacity of the system will be transparent for the service developer.
- Multiplatform: the gateway is completely functional in any operating system where it can be executed.
- Secure: only the authorized users are allowed to access the system. Several access profiles are defined. Users must authenticate themselves in a secure way against the central server so they can have access to the data stored.
- Extensible design: the system design is adaptable to future hardware and software requirements, such as new functionalities or modifications.
- IP Connectivity: the system uses the protocol TCP/IP to allow access to the services and as a way of communication between different remote systems. It also uses the software architecture style REST as a means to perform that communication.
- Hot plugging of services: the system is able to install remotely, start, stop, update, and uninstall new services without requiring a reboot.
- Hot plugging of devices: the system is able to manage the connection of new devices without rebooting or disconnecting the gateway.

3. Smart Campus pilots implementation

Smart Street Lighting pilot

Low luminosity on the sidewalks within the campus was the cause of insecurity at sunsets and nights. The previous lighting system was old, prone to breakdown and with a tedious maintenance. Considering that situation, it has been replaced with a new one in order to satisfy the following goals: improve illumination quality and decrease light pollution; reduce energy consumption; provide remote control and ease maintenance.

In the design phase, the first decision was to use light emitting diode (LED) luminaires, a more energy efficient illumination source than traditional ones as high-pressure sodium (HPS) or mercury-vapor lamps. Besides, LED lamps allow an easy fine control or dimming. Among available commercial luminaries, we have selected a plain model which illuminates just the ground, avoiding light pollution.

In order to reduce energy consumption, we have developed a control system which regulates the illumination level using luminosity and motion sensors. The system optimizes energy consumption, as it only illuminates when it is needed and as much as it is needed. That is, it just turns on when the luminosity is below a defined level, maintaining the illumination at a low - but sufficient - level, and rises this level when someone is approaching. An electronic device, called BatStreetLighting (BSL), which includes all the previous capabilities, has been designed, developed and installed in each lamppost (Fig.3).

Figure 3. Installed LED luminaire with the BSL and nodes communication detail

The BLS integrates a light sensor and multiple motion sensors (two or three, depending on the lamppost location), so that the street light is switched on only when needed and with the exact required level. Through a wireless communication interface based on IEEE802.15.4 and 6LoWPAN technologies, streetlights can be easily connected to internet and externally controlled, defining every street light as an IoT node. Besides, direct communication between street lights is feasible, allowing management optimization and minimizing equipment failures.

The system is supervised by a management platform which stores information from BSLs and offers monitoring and control applications.

The system has been installed in 69 street lamps, increasing the security, reducing light pollution and achieving an energy consumption reduction of 85%. The system has been working for a year and a half with no breakdowns so far (Perandones et al. 2014).

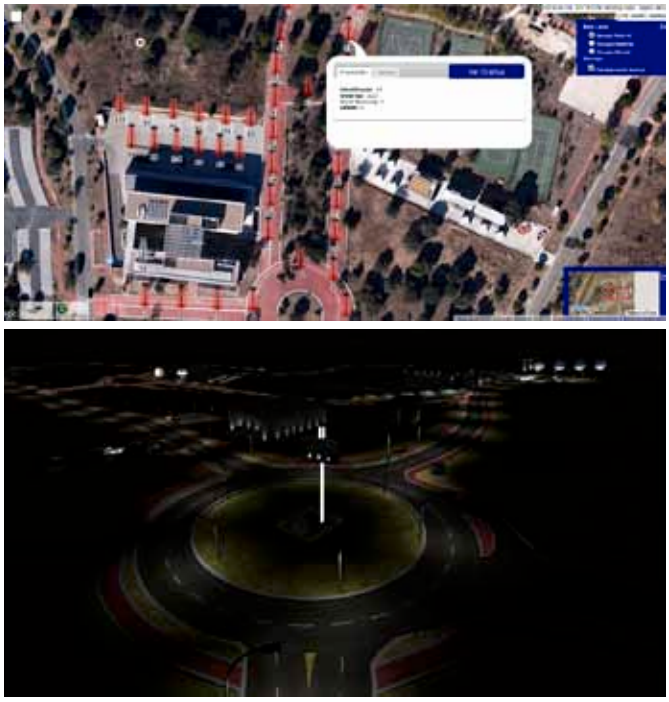


Figure 4. Management application

GreenLabs pilot

The Centre for Plant Biotechnology and Genomics (CBGP) is a research centre at the Montegancedo Campus. Besides an office building, there is a facility with numerous and diverse artificial grow chambers and machines and several greenhouses. Machines and systems within this facility have a massive energy consumption. CBGP and campus staff were interested in identifying each system consumption, as first step to achieve a reduction of the whole consumption. Regarding illumination technology, greenhouses are traditionally equipped with HPS lamps that cannot be adapted to the plants illumination cycles and emit a high amount of heat (Fig. 5).

Figure 5. GreenLabs previous HPS lamps and new LEDlamps

In order to analyse energy consumption, we monitor the facilities electrical lines as disaggregated as possible, installing smart meters at the panel boards. The previous lamps in one of the greenhouse modules have been replaced by controllable LED lamps. Apart from being more efficient, our goal was to test the effect caused by this kind of light in the growth of plants.

The BatMeter is a smart meter device capable of measuring power consumption of up to 6 electrical lines in real time. It continuously measures line voltage and current and calculates instant power, energy and other electrical parameters. Data is sent via wireless communications to a router connected to the internet. Through a monitoring application, consumptions can be analysed based both on instant and historical data.

The LED lamps installed at the greenhouse module are controlled by a device called BatDimmer, which regulates the illumination level. Besides, luminosity, temperature and humidity are measured at different areas of the module thanks to the BatSense, an ambient multi-sensor device. An ad-hoc application has been developed, where illumination level can be set manually or automatically, obeying a predefined schedule.

Figure 6. Greenhouse module and water-resistant enclosure for the BatSense

Smart Building pilot

The Research Centre for Smart Buildings and Energy Efficiency (CeDInt) is a multi-disciplinary R&D centre comprising different facilities. Although built recently (2005), energy consumption is huge, especially that corresponding to HVAC and illumination. In order to reduce energy consumption, HVAC and illumination systems control needed to be improved.

Some control solutions have been developed for this purpose. Controlling HVAC system, for instance, has been a challenge, since each person behaves differently to temperature variations. Taking this into account, a new control mechanism has been designed. It adapts the temperature set point in function of ambient parameters (both indoor and outdoor), the users' preferences (it learns from the user interaction with the HVAC controls) and building energy strategies.

BatSense devices equipped with illumination, temperature, humidity and presence sensors have been installed all around the building. On the other hand, as in the pilot described in section 3, disaggregated power consumption can be monitored with a new BatMeter device, capable of measuring up to 18 lines at the same time (Fig. 7).

For now, the new HVAC mechanism is being probed, testing different algorithms and managing diverse sets of input parameters. Besides, the monitoring and starting analysis of consumption and ambient data has helped to reduce energy consumption by improving awareness of building users.

Figure 7. BatMeter device installed at panel board and BatMeter frontal view

Smart Home pilot

Although the energy management systems are being increasingly integrated in buildings and other public infrastructures, the residential market appears to be reluctant to embrace this kind of solutions. Main causes are the cost, installation difficulties and the integration with other systems.

In order to increase users' awareness and attract more residential users, a new solution, called BatHome (Fig. 8) has been designed and developed. BatHome consists on a BatMeter device to monitor the overall home energy consumption (and when possible, separated lines dedicated to different uses as illumination, loads, etc.) and three BatPlug devices, capable of measuring power consumption of an individual electrical equipment and of turning it ON/OFF remotely. All devices are wireless linked to a gateway which is connected to the internet router. A web application (Fig. 9) allows the remote monitoring and control of the appliances connected to the BatPlugs.

BatHome system has been delivered to 20 test users, who have used them for three months now and have provided technicians with interesting feedback.

Figure 8. BatHome kit

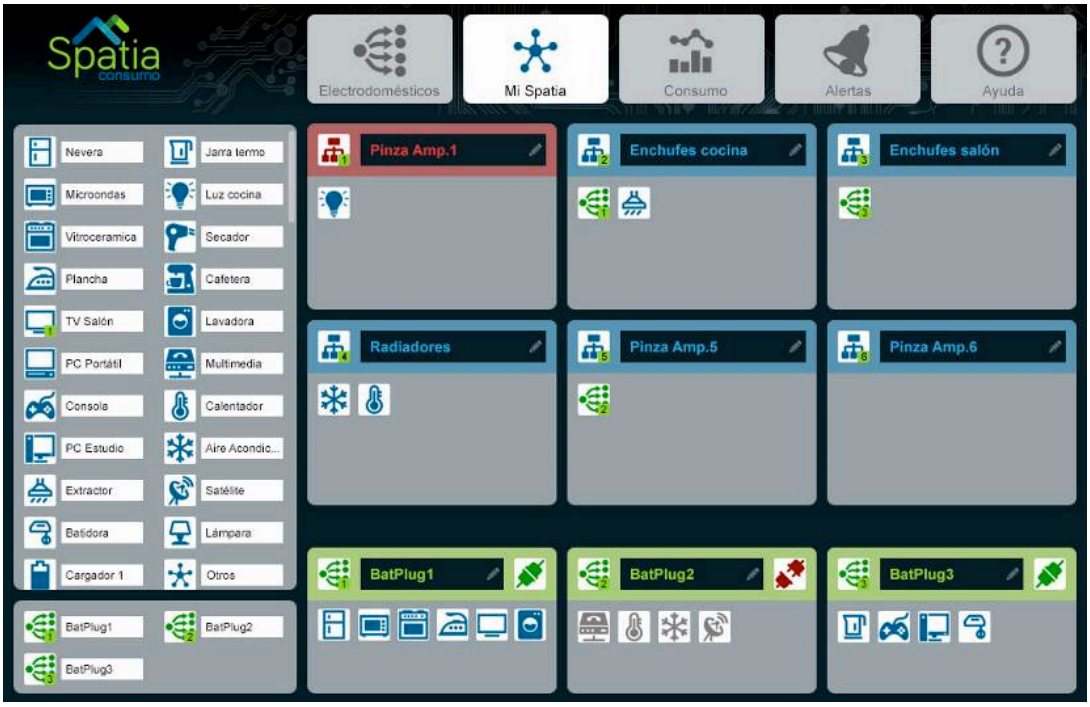


Figure 9. BatHome web application

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5. Biography

Prof. Asunción Santamaría is PhD in Telecommunications Engineering (PhD Special Award 1993/1994) and professor at the UPM Telecommunications School since 1994. She has participated in more than 60 R&D projects (leading 30 of them), several of them belonging to the European Commission ESPRIT and ICT programs and to the European Space Agency. She is author or co-author of more than 25 scientific papers and books and more than 45 conference papers on wireless networks and ICT-based systems for energy efficiency. She is an IEEE Communications Society Member and has been member of Technical Reviewers Staff of IEEE and ASTED journals and conferences and member of Technical Reviewers Committee of Spanish National R&D Programs. From 2005, she is the director of CeDInt-UPM, where she created the Energy efficiency research group, which she also leads. She represents the UPM in the Energy Efficiency Buildings Association (E2BA) and has been appointed by the EC to participate as an expert in Energy Efficiency on behalf of the European Universities Association. She has also an intense activity training young researchers: she is currently performing as PhD supervisor in 3 PhDs. She is responsible of the Internet of Things and Big Data area in the Master of City Sciences of the UPM.

Ms. Rocío Martínez, achieved her master degree in Telecommunications in 2008. She is currently working as technical coordinator of the Energy Efficiency and Smart Environments Research Area at CeDInt-UPM, where she has participated in the definition and development of more than 20 R&D projects on Energy Efficiency and Smart Environments since 2008. She has worked on European Projects at UPM from 7th FP and worked as researcher in Isdefe (Systems Engineering for the Defence of Spain). She is MC Member of the Transport and Urban Development COST Action TU1204 - People Friendly Cities in a Data Rich World. Participation in national and international committees and associations: AIOTI, AENOR (AEN_CTN 178 Digital Cities, AEN_CTN71_GT7_Sensor Networks), CENELEC, CEDOM, ASIMELEC and in national and international technology platforms and associations: EnerTIC, eNEM, eMOBILITY, Future Internet Association, Energy Efficiency in Buildings Association.

Mr. Guillermo del Campo, achieved his master degree in Telecommunications in 2008 and his master in Communications Technologies and Systems in 2010. He is currently finishing his PhD in the Visible Light Communications filed and working as researcher of the Energy Efficiency and Smart Environments Research Area and the Communications Group at CeDInt-UPM, where he has participated in more than 10 R&D projects on Energy Efficiency and Smart Environments since 2009. Participation in national and international committees and associations: AENOR AEN_CTN71_GT7_Sensor Networks, EnerTIC, IEEE IoT

Smart Infrastructures

IoT-based monitoring and management approach for smart infrastructures

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ABSTRACT: OdinS (http://www.odins.es) is a technology SME founded by Researchers of the University of Murcia in August 2014. OdinS works in the IPv6 fields of Internet of Things, Big Data and Security. This company has developed an IoT based platform for managing and monitoring smart infrastructures. In this document, two successful stories are presented validating such platform. The first one consists in the management and monitoring of a bank branch with the goal of reducing the energy consumed by the facility, while the other one dealt with the management of a cropland where wireless sensors gather different environmental and soil parameters for the prosecution of optimizing the water resources as well as obtaining the highest quality in the barley planted.

KEY WORDS: Internet of Things, Smart Infrastructures, management, monitoring.

IOT-BASED MONITORING AND MANAGEMENT APPROACH FOR SMART INFRASTRUCTURES

1. Problem

During the last years a spectacular growing of the cities has been produced, being such that by 2050 more than six billion people are expected to live in cities and surrounded areas (Habitat 2010). Such amount of people concentrated in cities means a great challenge for the latter ones in terms of providing autonomous and efficient services assuring their sustainability. In particular, challenges such as water supply, public transport, healthcare, education, security and power supply have already been identified as mid-term targets.

So far, the current trend of the market regarding the energy management of infrastructures is that of focusing its interests on energy efficiency in the stage of system design, but only in limit or extreme conditions. In addition, low or no interest has received the exploitation and maintenance of these systems. Another interesting behavior of these companies is they only design and deploy the systems but they do not hold responsible for their operation (at least from the energy point of view). So, after the deployment the owner ends up being the person in charge of this system who owns neither the knowledge nor means to proceed properly.

From the point of view of the customer, he is only aware about the initial cost of the system, i.e. the price of the devices, their implantation and maintenance costs. Nevertheless, he is not aware about the cost of the system to be operative, i.e. its daily consumption. Besides, he is neither aware of different optimization alternatives by which this initial cost could be rapidly amortized. All these premises have made customers to acquire the cheaper choice which usually cannot provide an efficient approach regarding the management of energy consumption.

On the other hand, there exist other kind of infrastructures like refineries, transport, water, etc. or large growing areas which also need a solution for their monitoring and management.

In the latter ones, owners are more and more aware of how precious is a resource such as water. For this reason, they are more and more interested in efficient solutions that are able to monitor the environmental conditions of croplands (humidity, temperature, soil conditions, etc.) so as to know the proper moment to water them keeping always the highest quality of their products. In this context IoT also provides

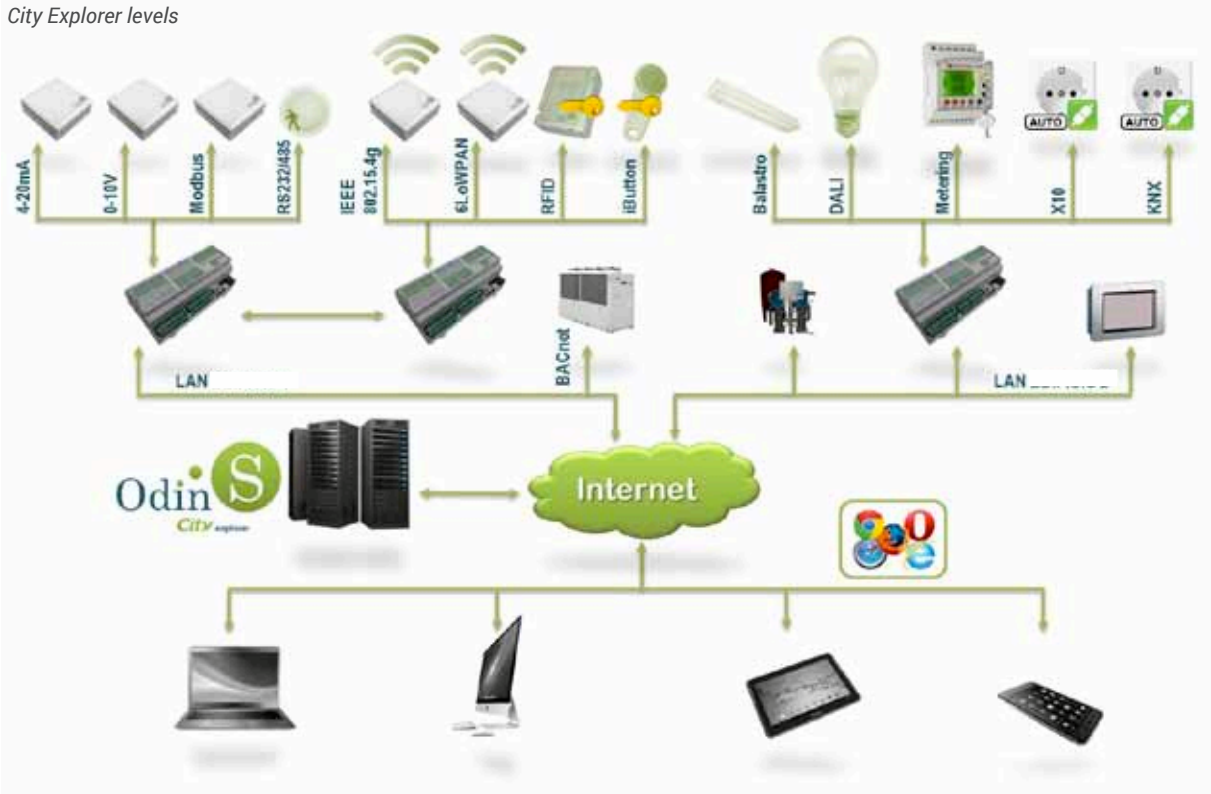
2. Solution

In this context, thanks to the great advance in integration and development of Intelligent Computation Systems which are based on Information and Communications Technologies (ICT) (Jones 2011), and the widespread deployment of sensors and actuators the paradigm of Internet of Things (IoT) promotes (Perera et al., 2013), there exists a great opportunity to develop applications which allow a smarter and more efficient performance of the services provided in cities. IoT allows the interaction among smart objects and the effective integration of real information and knowledge in the digital world. Smart objects are equipped with the abilities of sensing and interacting which allow them to capture real world information with a level of detail never obtained before. This technology is the cornerstone of efficient energy management systems.

Despite this technology enables the development of new management systems pursuing energy efficiency, other elements are also required so as to provide such a system. These systems need to rely on a smart management platform that permits both monitoring and controlling the different components of the system (sensors and actuators). Actually, energy efficiency is only reached thanks to the interaction among different actors and entities. They allow the platform to monitor real time information, to obtain feedback of the carried out actions, to take control measurements, to design saving strategies, etc.

IOT-BASED MONITORING AND MANAGEMENT APPROACH FOR SMART INFRASTRUCTURES

Figure 1. City Explorer levels



OdinS has successfully applied the aforementioned technologies developing a holistic platform based on IoT called CityExplorer and whose levels are depicted in Figure 1. In this document we describe two different success stories of the application of this platform for managing and monitoring smart infrastructures to two different scenarios. The first one is a deployment inside a bank office where the objective is that of making easier its management as well as pursuing the energy efficiency obtaining notable reduction of the energy consumed of the facility. The second application of these technologies consists in a radically different scenario, in particular monitoring a field crop pursuing the optimization of the irrigation process so as to waste the minimum amount of water needed to maximize the production of high quality barley in this field crop. In the following sections we give more details about these two deployments.

Deployment in bank office

Figure 2. Bank office floor

Let us firstly specify the targets for the customers for this facility. From their point of view an efficient management system must be responsible for providing the most comfortable conditions for their daily work avoiding the workers and users of the facility to manually correct these aspects. On the other hand, the efficiency must also be related to the awareness of the energy consumed by the office reducing it as much as possible keeping always the optimal comfort conditions for the people inside it.

Bearing these aims in mind, we firstly installed a power meter device so as to obtain information about the energy consumption of the office during a month approximately. This information was later on used to know whether our IoT based efficient management platform provides a significant improvement or not as well as quantify this enhancement.
The next step consisted in deploying sensors, control actuators such as heating/cooling (HVAC) systems and lighting appliances as well as the aforementioned IoT based platform that is able to tune the work comfort conditions through the control actuators according to the information received from the sensors of the office.

Agricultural scenario. Cropland

In this case, the specific infrastructure consists of a cropland belonging to the ITAP (Instituto Técnico Agrónomo Provincial) of Albacete region. In particular, this specific cropland consists of a circle area where barley has been planted. It also has an irrigation system based on a center-pivot with a radius of about 400 meters. This way, a tube rotates around the central pivot and the water flows through this tube towards several sprinklers in order to irrigate the whole cropland.

We deployed a wireless sensor network (WSN) comprised of three low-power and low-cost sensors (P1, P2 and P3) in the cropland in April 2013. The deployment focuses on the measuring of soil conditions during the irrigation operations. So, the monitoring locations were carefully selected to achieve this objective

Figure 3. Location of deployment scenario

Figure 3 shows the selected locations for the deployed sensors and for the central node (DatalogV1) which is placed in the base of the pivot (around 200 meters). In this area, an existing phone infrastructure enables the communication among the central node and the platform based on IoT located far away this area.

3. Underlying magic

Our base automation platform is based on the City explorer solution, whose main components were presented in detail in (Zamora-Izquierdo et al., 2010). City explorer gathers information from sensors and actuators deployed in the infrastructure, and it is responsible for monitoring the established parameters received through the deployed sensors. Thus, the platform is able to monitor environmental parameters, detecting anomalies (such as fire and flooding among others), and it is able to take actions dealing with key efficiency requirements, such as saving power or water consumption. The versatility of this platform is proved thanks to its application to the previously commented and radically different scenarios.

Details for the bank office deployment

The main difference between the two scenarios consists of the components connected to the platform. For the bank office deployment, one of its main components is the network of Home Automation Module (HAM). Each HAM module comprises an embedded system connected to all the appliances, sensors and actuators of various spaces of the building. These devices centralize the intelligence of each space, controlling the configuration of the installed devices. Additionally, the platform offers management and monitoring facilities through a connection with HAMs. Sensors and actuators can be self-configured and controlled remotely through the Internet, enabling a variety of monitoring and control applications. User interaction with the system is carried out through the control panels installed in the building, or a user restricted access to the platform view through Internet.

On the other hand, our intelligent management subsystem for comfort and energy efficiency uses a combination of techniques based on behavior-centred mechanisms and computational intelligence for auto-adapting its operation (Callaghan et al., 2004). This way, it is necessary to consider the data provided directly by users through their interaction with the system, since they can change the comfort conditions provided them automatically and, consequently, the system can learn and auto-adjust according to such changes. This subsystem is integrated in the back office part of the City explorer platform. Decisions taken by this module are reflected on the actuators deployed in the building, such as the heating/cooling units and electric lights. We base our energy performance model of buildings on the CEN standard EN 15251 (EN 2006), which specifies the design criteria to be used for dimensioning the energy system in buildings, establishing and defining the main input parameters for estimating building energy requirements and evaluating the indoor environment. In addition, our comfort management mechanism is based on the models for predicting the comfort response of building occupants described in (Berglund 1978). Thus, taking into account all these criteria, we define the input data of our system, which are shown in Figure 4.

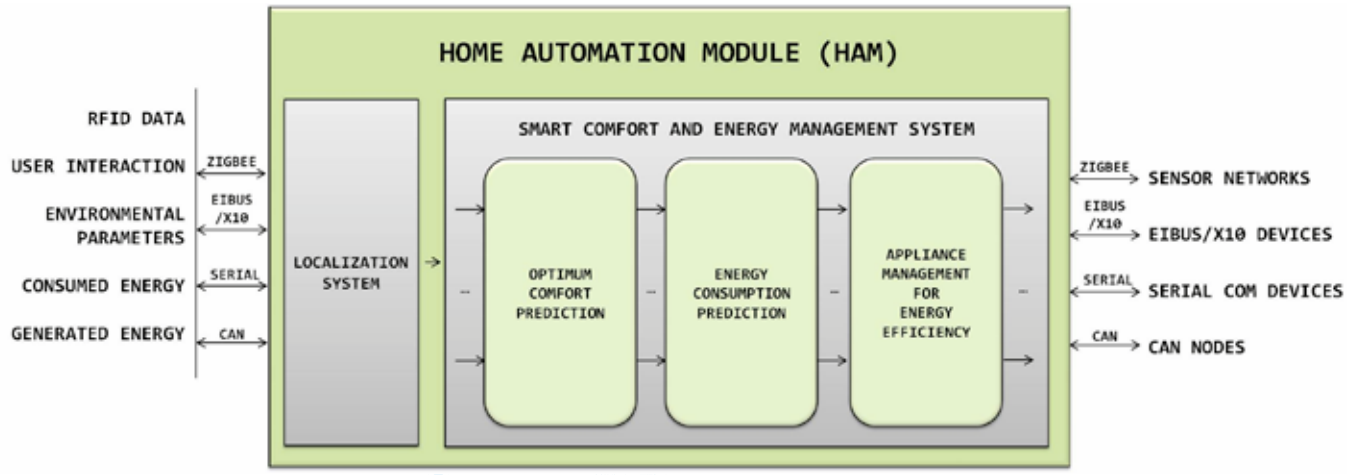


Figure 4. Home automation module (HAM) schema

Details for the barley crop

The selected instrumentation is a key element to ensure the accuracy and autonomy of the irrigation system. The monitoring task achieved by the deployed sensors is a periodical operation which requires a high consumption of the power resources because it implies the use of different elements like measuring the water potential of the plants and transmitting wirelessly this information to the central node. Therefore, this consumption depends on its measuring time and its supply voltage.

We incorporated to our sensor, Figure 5, device a solid state electrical resistance sensor named Watermark from Irrometer to measure the water potential of plants as well as a SDI-12 sensor called Hydraprobe-II from Stevens to measure multiple soil parameters.

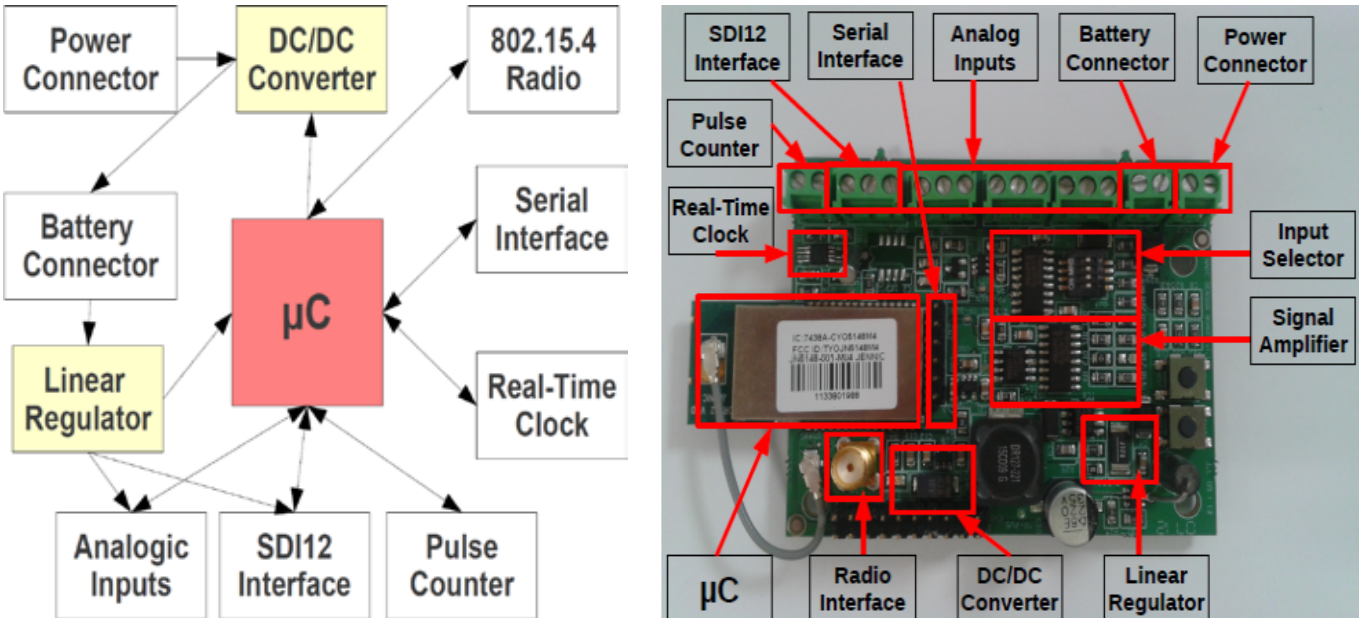


Figure 5. Two different views of the selected sensor

So, the communication architecture required for monitoring this field crop comprises our sensor devices (which incorporate different sensors as commented above), a central node (DataLogV1) and the platform based on IoT. The central node is responsible for delivering the gathered information from the sensors to the platform acting therefore as a gateway. This central node owns different features compared to the other deployed sensor devices. It comprises a low-powered microcontroller, a GPRS module and a large persistent memory. It is also equipped with a wireless interface and two combined power sources, a 12V and 7A battery which is recharged by a solar panel, so as to guarantee the network autonomy. Finally, wireless communication between the sensor devices is periodically done through CoAP, 6LoWPAN and 802.15.4.

4. Current status

In both scenarios our platform based on IoT obtained a successful behavior making the management and monitoring easier for both infrastructures. This success can be proved by the results we are presenting next.

For the bank branch, our platform provided not only management but also energy efficiency. Taking a look at Figure 6, we can see the correlation of the energy consumed by the bank facility with respect to the maximum temperature reached for each day. The left one corresponds to the information obtained before the deployment of our platform, while the right one corresponds to the period managed by our platform. The latter one obtains a correlation index of 0.67 while the left one only 0.4. The closer this correlation index to 1 is, the more related the data are.

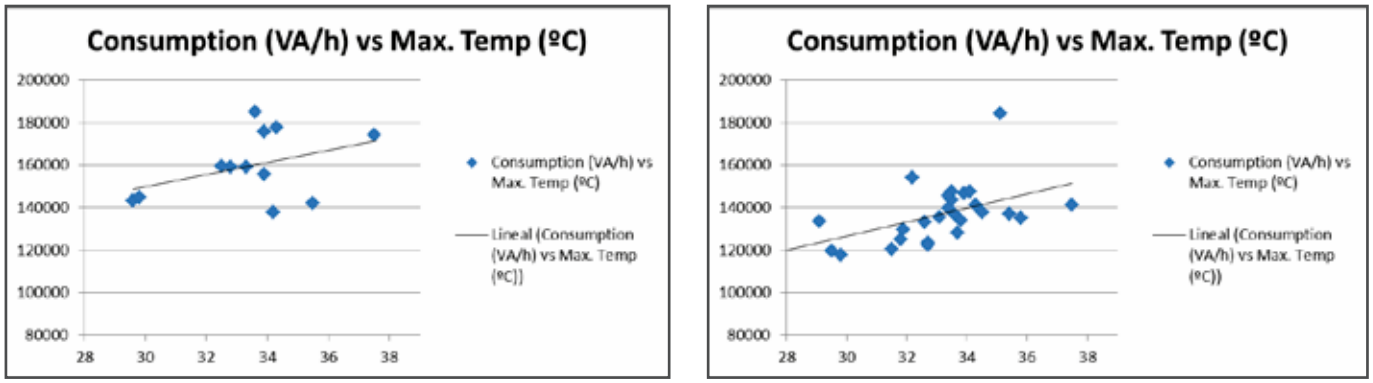


Figure 6. Correlation between consumption and max. temperature before and after deploying our platform

In addition, Figure 7 shows both consumption and maximum temperature in the same graph. The lowest values corresponds to the period of time where the bank branch is closed. Ignoring these values we can observe how the left side of the graphs present a higher consumpion rate than the right side.

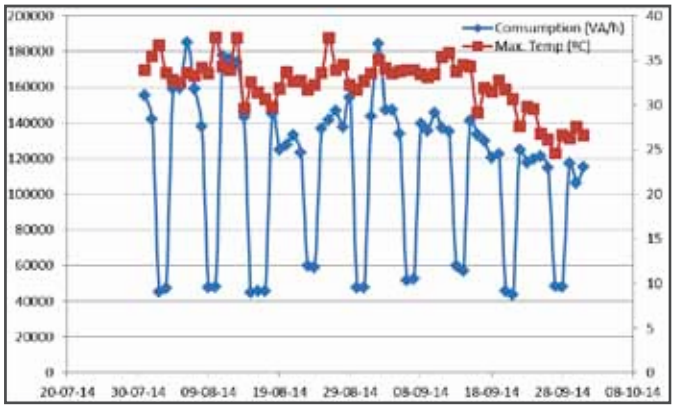


Figure 7. Energy consumed by the bank branch and max. temp. reached each day

This gap has been calculated obtaining a reduction of 18.28% of the consumed energy proving the benefit of using our platform based on IoT.

Regarding the agricultural scenario, our platform is able to gather the information transmitted wirelessly by the sensors deployed in the field crop. Actually, the following graphs corresponding to Figure 8 shows the information related to humidity and conductivity measured by the deployed sensors.

This information has been analyzed by agronomic engineers to estimate the amount of water needed to irrigate the field crop in order to make a more efficient irrigation process by using, in a next iteration, this platform wasting the minimum amount of water as well as obtaining the highest quality in the barley planted.

These two heterogeneous scenarios proved the success of the platform based on IoT by OdinS, as well as its communication model being a suited platform for managing and monitoring smart infrastructures.

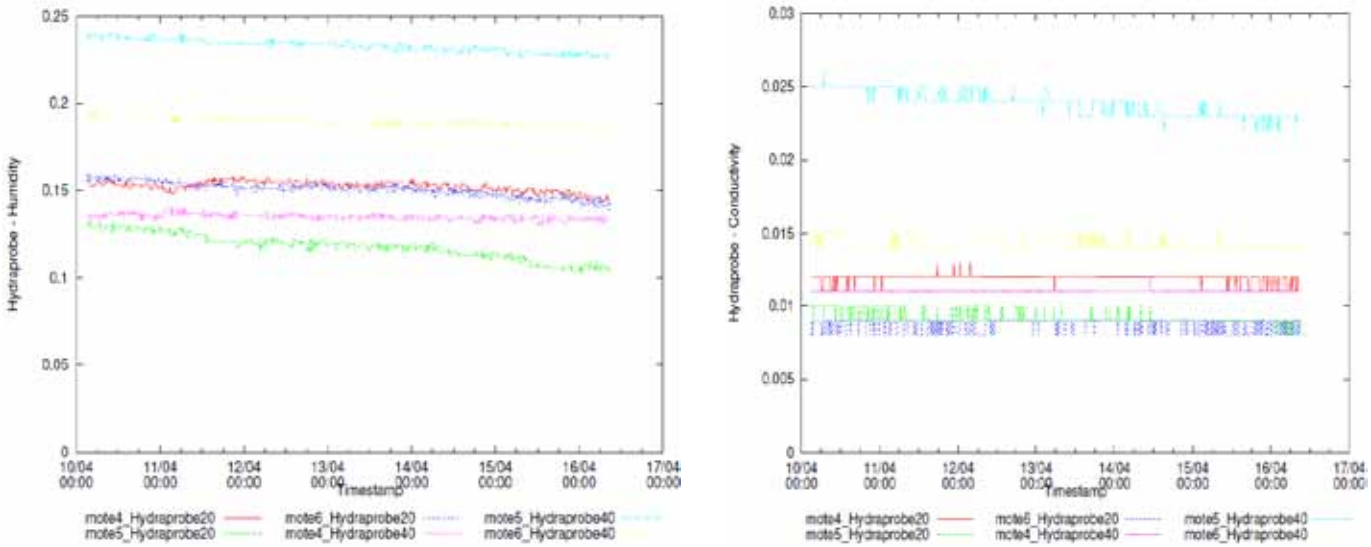


Figure 8. Humidity and conductivity information gathered by the deployed sensors

5. Acknowledgments

This work has been partially sponsored by European Commission through the FP7-SMARTIE-609062 project

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SERIES 3

NOVEMBER 2015

Editor : **Philippe Cousin**

This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no 609024

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