# A First Step Toward an IoT Network Dedicated to The Sustainable Developement of a Territory.

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***Abstract*—Digital technologies are one of the keys to bring solutions to the current ecological transition issues, and Internet of Things are even more inevitable in our everyday life. The objective of the study and the experiment presented in this paper is a first step of the Grasse territory to try to find out the concrete answer to the question of which gain could provide the IoT to a territory and under which conditions. This paper describes the overall approach that the Grasse territory actors follow to establish an IoT network serving the citizens, companies, institutions, elected representatives, etc.: what are the steps towards such deployment and what are the key interests. The technical realization is then presented to demonstrate the current development of this network and platform. After the first setting-up of the platform, the next steps are especially to involve more people, to address more use cases and to extend the network technically. The feedbacks of the usage of the platform are essential to the initial purpose: the sustainable development of a Territory.**

***Index Terms*—Internet of Things; Sustainable development; LoRa; Smart Territory**

## I. CONTEXT

### A. The territory of the Grasse area

The city of Grasse is located in the south-east of France, about 20 km to the north of the French Riviera. It defines with its neighboring cities an agglomeration community that brings together 23 towns and 100k inhabitants. This community is located outside the large attractive economic poles constituted by the Nice metropolitan area and the technopole of Sophia Antipolis. Rather urban in the south, near the coastline, but without really benefiting from its touristic attraction, it is, in the north, strongly marked by a rural identity with nearly 80% of its surface located in rural and mountain area.

This territory faces heterogeneous development challenges. In the "City" part (towns of Grasse, Mouans-Sartoux, Peymeinade, La Roquette-sur-Siagne), issues are those of urban and peri-urban areas related to mobility and in particular the commuting, the precariousness of a growing part of the population, and the sustainable food and waste management. The challenges to cope with in the rural part are depopulation and lost of attractiveness but also adaptation of agricultural production to climate change.

Faced with these complex and systemic development issues, an approach based on sustainable development seems the most appropriate.

### B. An approach in terms of sustainable development

Our approach to sustainability is rooted by Amartya Sen [1]. He introduced the concept of capability which expresses the freedom of an individual to choose and guide his own life according to what he considers worth to be lived. Sen defines the Sustainable Development as the way to improve the capabilities of the current generation without compromising the strengthening of the capabilities of the future generations.

This necessarily takes into account the material resources and opportunities of each one, but also its abilities to convert them, directly or indirectly, in well-being. This allows Amartya Sen to propose a concept of Sustainable Development that goes beyond the concept of needs to catch the one of freedoms [2]: *Human freedoms include the fulfilment of needs, but also the liberty to define and pursue our own goals, objectives and commitments, no matter how they link with our own particular needs. Human beings are reflective creatures and are able to reason about and decide what they would like to happen, rather than being compellingly led by their own needs—biological or social. A fuller concept of sustainability has to aim at sustaining human freedoms, rather than only at our ability to fulfil our felt needs*. Sen insists [3] on the importance of considering that each individual must be able to participate in the decisions that affect him. The question of governance is thus necessarily oriented towards dialogue and deliberation, which implies the need to develop democracy and citizen participation.

Thus, the question arises of organizing the group to allow everyone to participate in the deliberations and to access the material and immaterial resources that one needs, to education, to health, or more broadly to all areas of development listed in the Sustainable Development Goals, published in 2015 by the United Nations [4].

In this sense, being part of a sustainable development approach consists in aiming at the ideal of a fair distribution and increase of the individual capabilities, taking into account the future generations. Sustainable development becomes this mode of development that combines, in a systemic way, the search for social justice, economic efficiency, environmental sustainability and the development of individual and collective capacities to participate in the decisions that affect us.

The mission of the CICS Tetris[1] is to deploy sustainable development, as it has been described, in the territory of the Grasse area. The experimentation in a research-action approach is one of the used methods [5]: prototypes or experimental environments are built, then some targeted activities for awareness towards different types of actors (institutions, elected representatives, citizens, companies) in order to bring out collective projects, thought for the sustainable development of the territory.

### *C. Digital technologies and the IoT for the sustainable developement*

The digital transition presented as inevitable is part of the ecological transition issues in terms of the environmental and social impacts, in the same time it can bring solutions through Green IT or IT for Green. The digitization traces its path in our daily lives while we do not really know where we want it to go; the ecological transition knows where it wants to go but is still seeking its way. The sustainable development as the digital technologies are recognized to be cross-disciplinary, impacting all activities of society; they would benefit from being put in synergy.

Improvements in semi-conductors technologies lead to costs reduction and improved integration of computing power and wireless networks. This contributes to the pervasivity of digital technologies and brings us to the Internet of Things era, predicted by some authors [6].

From a Sustainable Development point of view, it has been proven that the collection of field-related data is improving the decision making process [7]. This is especially true if they are cross-referenced with other data sources, as provided by some administrations in the open-data movement for example.

From this analysis comes naturally the idea to experiment the IoT technologies as a potential solution provider to the Sustainable Developement of a territory. The approach described in this article, aims at testing IoT use cases that could provide sustainable solutions to the issues the Grasse area is facing. This is also meant to be a test-bed for other areas facing similar issues.

Moreover, as we have seen, it is of importance for the Sustainable Development to provide means to people to deliberate on the issues of their living area. The collection and publication of such data contributes to this aim. However, as some authors have pointed out [8], to be efficient, the boundaries between the R&D communities and the decision making processes have to be managed. In particular, a “mediation” process, should be put in place by some third-party entities.

Our experiment started in January 2017. We then stated that we want to:

- Allow various actors of the concerned areas to develop skills and help them to experiment, to understand what can be gained and what to be concerned about;
- Deploy 3 LoraWAN gateways;
- Deploy some sensors to experiment how to gather data about the environment, the mobility and the agriculture;
- Deploy a technical infrastructure for the data storage, analysis and publication.

We hope at providing some answers to the question of which gain could provide the IoT to a territory and under which conditions. How is this compatible from the sustainable Development point of view ? How this would contribute to a digital citizenship ?

## II. OVERALL APPROACH

To put in place such an approach, we have to act simultaneously on two subjects: the technical infrastructure and the implication of the actors of the territory.

### *A. Finding the actors*

First of all, we need to find people with varied profiles who have the capacity to act in the area and who are interested in the process. Our goal was to find representatives from different population groups, such as younf people, elected officials, farmers or community service managers.

The interest of a cooperative attached to a territory is that it has developed a network of actors that can serve as a basis for that. The problem is that the levels of information on such a subject are very variable from one person to another. We had to take this into account and offer some easy to access timeslots to upgrade the knowledge of our partners.

We therefore started our experiment by proposing to the members of our network a briefing on an innovative project in which they would be invited to participate. At these meetings, we offered a long introduction to the technology of the Internet of Things and its potential use cases. We then invited our interlocutors to share their daily issues and we tried to think with them of use cases adapted to their needs. We then proposed to implement some prototypes, so that we can together evaluate whether the IoT could provide concrete answers. These meetings were attended by various city representatives, local government officers, farmers, high school students as well as a few handymen attending the TETRIS Fablab.

### *B. The sustainable development point of view*

During these discussions, people expressed some concerns and it became rapidly clear that the approach to adopt with these technologies needs to follow various guidelines:

- no top-down approach but focus on collaborative proposals;
- transparency about collected data and their usages;
- educational support for everyone.

Moreover, the Sustainable Developement approach we described also pushes the idea to contributing to the public debate and collective decisions.

All of this leads to the idea of a “brainy territory”, which became equipped to be better understood and mastered by everyone, in order to promote the collective intelligence of people.

[1] http://scic-tetris.org/

### C. Use cases

The use cases we built with the actors are listed hereafter.

*1) Quality of the environement for everyday life:* Being able to have an independant measure of the quality of the environement seems to be a concern for all the actors. A part of them is even ready to contribute to these measurements by wearing some detectors or just put one in their car or in their garden.

People are concerned about indoor and outdoor air quality, noise and pollution. They are less concerned about water quality since the distribution network is well organized and provide good quality water. Moreover, in our area the air quality is a concern because Grasse industrial activities are historically organized around perfumes and flavours.

The foreseen applications are related to the possibility of using these published data to initiate some public debates, or to provide users with real time data to help them optimize their paths in the city.

*2) Adaptation to climate change:* The effect of climate change are becoming apparent on the human activities. On our area, we identified two use cases for which the IoT could help to build an answer.

The first one is the potatoes cultivation for which effects of climate change has already been studied by [9]. They show that it is of importance to implement some adaptation strategies, otherwise some productivity loss around 30% (in France) are likely.

Growers told us that this cultivation is based on precise watering plans, developed year by year by the farmer for his farm location. These watering plans must be adapted as fast as the climate is changing. It is a very challenging issue. The IoT could help this adaptation by providing measurements of soil moisture and temperature at various depths.

The second use case is linked to the issue of water management. Our area did not receive water for several month during the summer of 2017. This is quite unusual, and the city representatives we talked to were quite concerned by the water availability. Some local government officers suggested us to see how the IoT technologies combined to our Sustainable Development approach could help to manage water resources. We are thereby considering applications that help to show to everyone water stocks and consumptions, in the respect of private life, in order to bring individual and collective awareness, create debate and collectively build solutions (which will hopefully be more easily accepted than a coercitive top-down approach).

*3) Resolving conflicts of use on certain forest area:* The surveillance of farm animals is an issue that was mentionned several times in our briefings. The problem as it first arose is a conflict over the use of forest plots between a farmer and a hunting community. The first needs a fence to hold his animals in a well-defined perimeter, while the others need to be able to circulate freely.

Real-time geolocation of animals, possibly coupled with a virtual barrier system, could make fencing unnecessary. Allowing both to constrain and locate animals without hindering the movement of hunters.

*4) Circular economy:* Sustainable waste management is one of our big challenges in the near future. The circular economy aims at increasing the efficiency of the production and consumption by implementing a closed loop pattern where wastes are becoming resources. In this approach, it is of great importance to master the waste collection process to separate the various materials.

The idea here would be to explore how the data collection permitted by IoT could stimulate good sorting behaviours and to help modelling flow of waste in the city. This could be, for example, coupled to local energy generation management - methanation of organic waste for example.

### D. Deploying the Technical Infrastructures

Finally, we had to work on the deployment of the technical infrastructures. For this experiment we needed to deploy our gateways on various sites, allowing to address all the use cases we wanted to experiment with. We also needed an internet-connected server to run all the needed software components.

We asked the various cities representatives interested to participate in the experiment. They all helped us to find some spots, mostly on public buildings, with electricity and internet access. The server was installed in the data center of the agglomeration community administration.

## III. REALISATION

### A. Technical Architecture of the IoT Network

The technical realisation of such an IoT network is constrainted by many factors, for example, the acceptance of the public and local authorities, the evolutivity and the openness of the platform for new stakeholders, the privacy of collected data, the annual budget for the network operation and maintenance. With the experience of IoT network deployment in several European projects, the key components to realise the network are the follows:

- LoRaWAN wireless telecommmunication network technology. LoRaWAN is a Low Power Wide Area Network (LPWAN) specification intended for wireless battery operated Things in a regional, national or global network. The technology is extremely low power consumption that the battery life is considerably extended. The specification is maintained by the lora alliance which is an open, non-profit association, and it provides seamless interoperability among smart things and puts many considerations on the security aspect.
- FIWARE Context Broker. It is one of the FIWARE generic enablers (GE) maintained by the FIWARE community[2]. It presents the data in OMA NGSI data model and provides a set of REST API. Evolution of that interface specification is under work with the ETSI Industry Specification Group on Context Information Management [10].

[2]https://www.fiware.org/

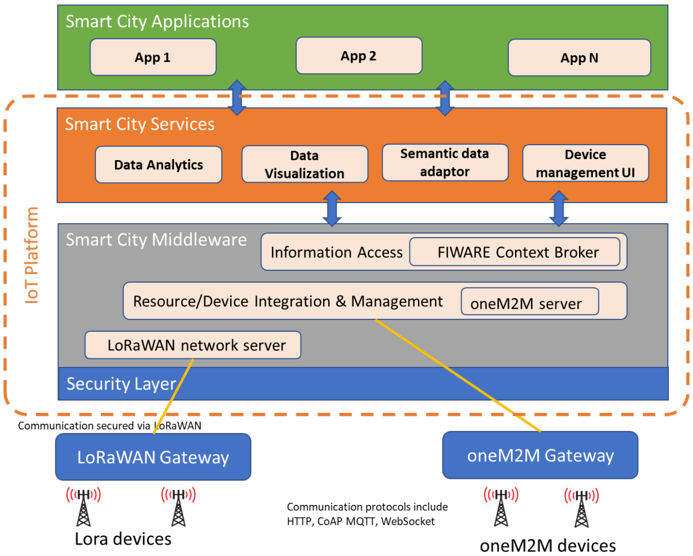


Fig. 1. Architecture of the IoT network

- oneM2M server and gateway. oneM2M[3] is a global standardization body well recognized in the IoT domain. The oneM2M server is responsible of IoT resource management and provides a set of REST API for accessing the resources. It supports most of the connectivity technologies on the market. It provides some general services such as device management, pub/sub, security,e tc.
- ElasticSearch data collection and analytics. ElasticSearch is a search engine well reputed for its performance in big data. It is modular and has other components such as Kibana for data visualization, logstach for data collection pipeline.

Note: all the key components above have at least one open source implementation so that the development and maintenance of the network and platform are in full control of the technical team.

The actual logical architecture of the IoT network consists of 4 layers, namely: Field domain, Middleware, Service and Application layer.

- Field domain. This is the lowest layer which consists of devices deployed in the field and the gateways that link them to the core platform. In this layer, we distinguish two types of devices/gateways. LoRaWAN devices and gateways providing long range communication at a low bit rate and with low power among things. oneM2M devices and gateways which cover the use cases needing wider bandwidth and which LoRaWAN cannot provide.
- Middleware. This layer is responsible for Data brokerage and information access. Data input from the field domain layer are collected, prepared to be consumed by the higher layer. The LoRaWAN network server is actually the data broker of LoRaWAN devices. It pushes the data to the oneM2M server for resource and device integration and management. The FIWARE context Broker is in charge of presenting and providing interface for platforms information to be consumed by higher level services. The Middleware layer comes with a Security layer which protects the data from the field domain from being modified in the middle or exposed to an illegal party.
- Service. This layer provides common services to Smart City applications. For the time being, 4 services are available: i) Data analytics. This service provides interfaces for Smart City applications to execute predefined basic analytic operations, such as daily average of measurement value, as well as interfaces for executing customized analytics; ii) Data visualization. It is a graphical dash board for users to visualize the resources on the IoT Platform that he or she is authorized to access. This includes for example route path of city vehicles fleet; iii) Semantic data adaptor. This component annotates the data from the IoT platform with a specific ontology to be sent to a semantic database (triple store) for further semantic interoperability or advanced data analytics; iv) Device Management UI. It is a graphical facility for device vendors to register and deploy the devices, and manage the devices already deployed. The interface builds upon the H2020 FIESTA ontology[11] to automatize sensors registration and payload transfer to the upper layers.
- Application. Smart City Applications are to be designed and developed upon the IoT network. In Figure 1, no concrete examples are shown, however we can forsee that an application such as "Green transportation" in the use case in II-C1 aiming to monitor the noise and air pollution status in the city in order to trigger necessary actions to encourage citizens to use public transportation as a function of the level of pollution.

### B. *Implementation and Deployment of the IoT network*

On the server side, the software components are configured regarding to the API documentations to interface to each other correctly. The deployment of the server (see Figure 1) uses docker platform in order to automate the configurations and upgrade of single component or service. The service is hosted by a local infrastructure provider.

On the field domain, deployed gateways implement the LoRaWAN protocol and act as packet forwarders to the LoRaWAN network server. The gateways are made from off the shelves multi-canal commercial one as well as custom built using open-source developments and low cost hardware such as RapberryPI. These low cost gateways come with the limit of reduced number of devices which can be connected (100) and incompatibility with the over the air LoRaWAN provisioning method (OTAA). In addition, some regions in the country side are in moutain areas with deep valley, rising the complexity of radio network deployment. In these cases, development and use of LoRa repeaters is being considered.

The deployed devices are mostly community made, building upon RFM95 or Microchip RN2483 LoRa chips together with

[3]http://onem2m.org/

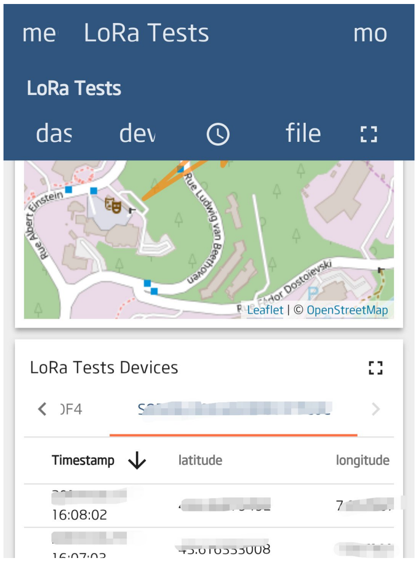


Fig. 2. Device monitoring GUI of the IoT network

Arduino like platforms. Coupling with GPS allows for fleet tracking scenarios.

### C. Test of the network connectivity and data visualization

After the deployment of the devices, gateways and server, several tests of the connectivities have been performed to validate the network by measuring the signal strength with a mobile LoRa device at different position regarding to the gateway. The test data have been collected in the server and presented on the GUI of the IoT platform (one example is shown in Figure 2). The long range aspect of the LoRa technology has been demonstrated during the tests, especially:

- With the gateway installed on the roof of a 2-floor building in the proximity of Grasse, the signal is received 15.4km away in Theoule (a small city at the coast), shown in Figure 3;
- With another gateway installed on in the proximity of Grasse, the signal from a LoRa device embedded in a cattle collar is received from a distance of 5.5km, shown in Figure 4.

## IV. CONCLUSION & PERSPECTIVES

The first phase of this project consisted in creating a small community composed by people with different backgrounds and interests, all involved in the same territory. Some workshops and meetings were organized to understand collectively what could be some useful use cases to implement.

At this stage we remains with :

- a small community made of people with different backgrounds and interests, all involved in the same territory;
- a list of use cases oriented through the sustainable development of the territory;
- one gateway deployed connected to a server, with the full stack of software wich has been validated.

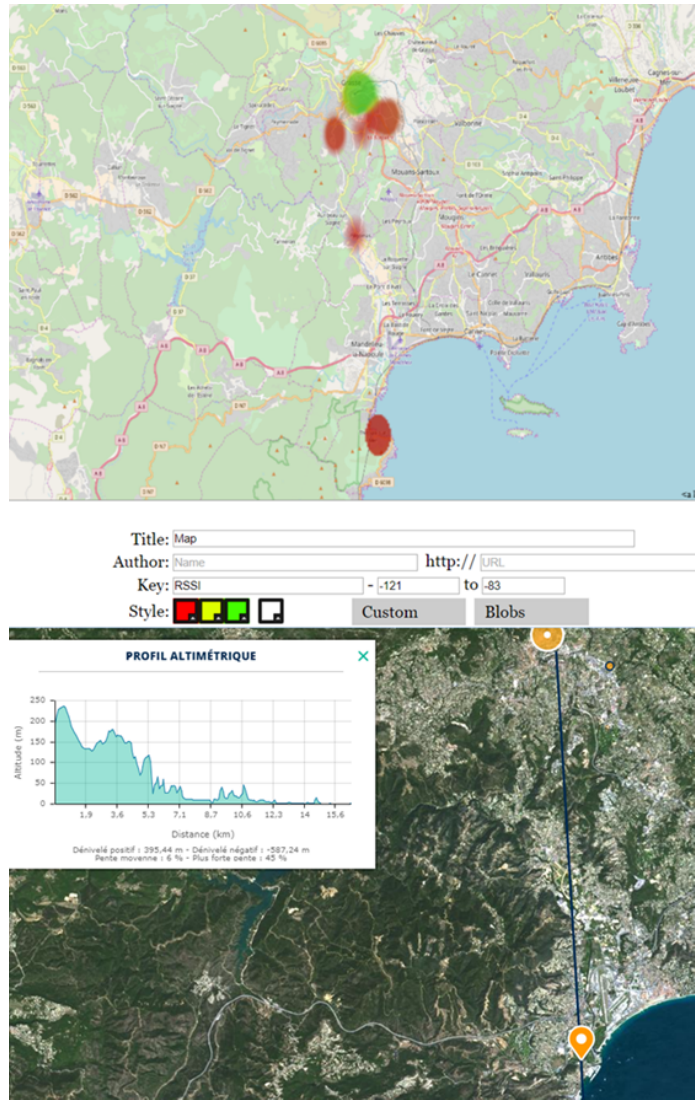


Fig. 3. Test LoRa: Signal received from 15.4km

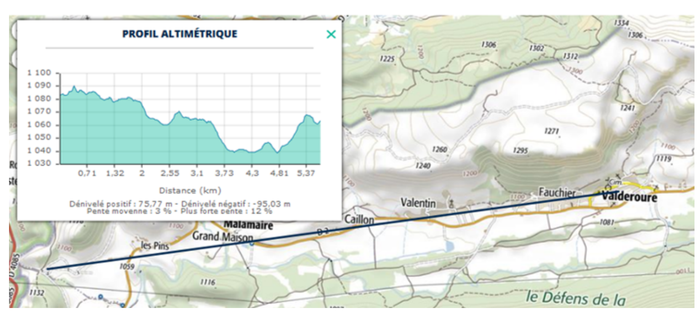


Fig. 4. Test LoRa: Signal received from 5.5km

We are now ready to enter the next phase of this project for which the objective is to deploy the sensors and start collecting data for a subset of the use cases (air quality, soil moisture for agriculture) in various areas. For this, we need first to be able to produce locally, in the Fablab of Tetris, a reasonable number of sensors needed for these use cases. This implies to work on a more efficient production process. We also need to deploy two or three additionnal gateways. This will allow us to start gathering data and process them.

The expected outcome is to understand how the IoT can help to improve the transition throught the sustainable development and how to monitor it, maybe by contributing to a kind of *territorial observatory of the ecological transition* aimed at collecting and processing territorial data to measure how a given territory is moving toward its sustainable development.

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## References

[1] A. Sen, "Development as freedom (1999)," *Roberts, JT, Hite, AB & Chorev, N. The Globalization and Development Reader: Perspectives on Development and Global Change*, vol. 2, pp. 525–547, 2014.

[2] "The ends and means of sustainability," *Journal of Human Development and Capabilities*, vol. 14, no. 1, 2013.

[3] A. Sen, *The idea of justice*. Harvard University Press, 2011.

[4] "Transforming our world: the 2030 agenda for sustainable development," *Seventieth United Nations General Assembly, New York*, vol. 25, 2015.

[5] P. Chemla, G. Fontaine, and V. Têtu, "La recherche comme accélérateur du pouvoir transformatif des initiatives locales? Le cas du Pôle Territorial de Coopération Economique TETRIS (Transition Ecologique Territoriale par la Recherche et l'Innovation Sociale) en Pays de Grasse," 5ime colloque international du CRISES, 6 et 7 avril 2017, Montral, Québec, 2017.

[6] F. Mattern and C. Floerkemeier, "From the internet of computers to the internet of things," in *From active data management to event-based systems and more*. Springer, 2010, pp. 242–259.

[7] S. Fang, L. Da Xu, Y. Zhu, J. Ahati, H. Pei, J. Yan, and Z. Liu, "An integrated system for regional environmental monitoring and management based on internet of things," *IEEE Transactions on Industrial Informatics*, vol. 10, no. 2, pp. 1596–1605, 2014.

[8] D. W. Cash, W. C. Clark, F. Alcock, N. M. Dickson, N. Eckley, D. H. Guston, J. Jäger, and R. B. Mitchell, "Knowledge systems for sustainable development," *Proceedings of the national academy of sciences*, vol. 100, no. 14, pp. 8086–8091, 2003.

[9] R. J. Hijmans, "The effect of climate change on global potato production," *American journal of potato research*, vol. 80, no. 4, pp. 271–279, 2003.

[10] Industry specification group cross-cutting context information management. [Online]. Available: https://portal.etsi.org/tb.aspx?tbid=854&SubTB=854

[11] R. Agarwal, D. G. Fernandez, T. Elsaleh, A. Gyrard, J. Lanza, L. Sanchez, N. Georgantas, and V. Issarny, "Unified iot ontology to enable interoperability and federation of testbeds," in *2016 IEEE 3rd World Forum on Internet of Things (WF-IoT)*, Dec 2016, pp. 70–75.