Fab-IoT-Lab: Technological Expertise, Guidance and Prototyping Skills in a Single Place

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***Abstract*—Designing connected objects or introducing them in industry processes is complex because it requires many skills. These skills can be found in different places. Research labs are studying advanced topics and can provide focused expertise. Some projects offer a shared infrastructure to elaborate and test new products and algorithms. Some organizations provide guidance and technological advice. The Fab-IoT-Lab project brings all these skills and competencies in a single place so that entrepreneurs and industries can benefit from the strengths of these existing structures without sacrificing the high-level, multi-disciplinary point of view.**

***Index Terms*—Internet of Things, Prototypes, Research and development, Test facilities**

I. Introduction

At a fine-grained level, a smart thing can be defined as a composition of a sensor or actuator, a micro-controller, a communication module and a source of energy [1]. At a higher level, the Internet of Things (IoT) chain of value can be defined by its components: sensor and signal processing, communication, network integration, edge/cloud/fog computing and storage and data processing. Each part of these two definitions is the subject of academic research. Mastering each of these parts is a challenge because of the number of skills required.

On one side, University of Mons (UMONS) has a proven expertise in each of these fields. However, this expertise is scattered between multiple research labs and spread over many faculties.

On the other side, the structure of FabLab Mons, a fabrication lab (FabLab), allows people to make their ideas become tangible thanks to accessible digital manufacturing equipment and sharing skills and ideas with its user community.

Therefore, this paper presents the Fab-IoT-Lab project, setup jointly by UMONS and FabLab Mons. It describes how UMONS research labs provide advanced expertise. And it explains how FabLab Mons mission favors prototyping and how Fab-IoT-Lab mixes these to provide a single IoT counter for entrepreneurs and industries.

The project is strongly anchored locally. It presents existing initiatives that inspired Fab-IoT-Lab project such as wireless testbeds and an IoT guidance project that have been setup in the vicinity of Mons, Belgium.

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II. UMONS research labs and IoT

UMONS research is spread across hundred departments [2]. Many of them are contributing to IoT-related topics by studying either business applications and their impact or involved technologies.

Almost any department can bring expertise about IoT applications.

Here are some IoT-relevant topics that are studied in different department of UMONS:

- Smart cameras, movement recognition and virtual/augmented reality;
- energy harvesting and electronic sensors;
- wired and wireless communications;
- glass-fiber-based sensors;
- sensor networks routing;
- network-assisted location (outdoor and indoor);
- artificial intelligence (AI) and data processing.

III. Wireless communication testbeds

Creating a single wireless, communicating object is complex. However, making these objects communicate together in a world where many actors are exchanging information is a big challenge as well.

In order to do this, researchers and commercial companies are constantly creating new communication algorithms and improving existing ones. They simulate a lot of the environment behavior and disturbances using algorithms, but they still need a real-life experimentation to validate and fine-tune their changes.

As setting up labs big enough to recreate real-life conditions is very expensive, organizations are looking for a way to share these infrastructures. This paper describes two initiatives which propose shared, IoT-specific, wireless testbeds. Thanks to these tools, stakeholders can elaborate advanced technologies required by the Internet of tomorrow, both in the network and application layers.

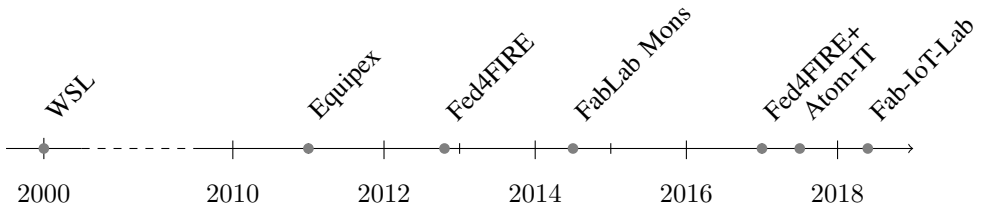

Fig. 1. Projects timeline

A. FIT IoT-LAB

In June 2010, the Ministry of Higher Education and Research of France launched a call for project named "equipex" in order to create some equipment of excellence [3]. The Future Internet Testing (FIT)[1] project was selected in January 2011, along with 52 other projects, and received a funding of 5.8 million euros to be spent over 9 years [4]. The program is conducted by multiple French actors: the computer science lab Paris 6 of University Pierre and Marie Curie (UPMC), the French National Center for Scientific Research (CNRS), Institut National de Recherche en Informatique et Automatique (INRIA) in Rennes, University of Strasbourg and Institut Mines-Télécom (IMT) in Paris.

The FIT IoT-LAB project aims to provide a facility collection to French stakeholders of the Internet so that they can experiment innovative solutions [5], [6].

It features hundreds of wireless nodes. Some of these nodes are attached to moving robots in order to move them during the experiment. The testbed facilities are voluntarily located in office building areas so that the usual radio-frequency disturbances (WiFi, bluetooth and mobile transmissions) influence the experiment randomly. This way, the experimental environment is as close to a real-life deployment environment as possible.

Many node types are available, most of which are equipped with a 802.15.4 PHY layer for communication. They operate in the 868 MHz or 2.4 GHz Industrial, Scientific and Medical (ISM) radio bands to avoid license requirements. Nodes with other technologies, for example, nodes with LoRa transmitters or custom radios, can be brought into the testbed by its users but this requires more logistics and is not so common.

The testbed provides multiple interfaces in order to automate the experiment, monitor the nodes and collect experimental data [7].

In order to simplify its user management, FIT IoT-Lab is part of a testbed federation called OneLab that provide single credentials valid for all the federated labs [8].

The FIT IoT-LAB project is now directed by the project team DNET and involves the project teams INRIA HIPERCOM, POPS, PLANETE and SWING.

The FIT IoT-LAB is targeted primarily at academic and industrial researchers. But everyone can reserve the testbed without charges. The only requirement is to cite the FIT IoT-LAB project when publishing any work.

[1]According to some sources, FIT could stand for Future Internet of Things.

B. w-iLab.t

In October 2012, the Fed4FIRE project started thanks to funding from the European Union [9]. In January 2017, Fed4FIRE+, its successor started and should last for 60 months. It is part of the Horizon 2020 program of the European Union and features a collaboration with the Swiss State Secretariat for Education, Research and Innovation.

w-iLab.t facilities, located in Ghent and Zwijnarde, in Belgium, are part of the Fed4FIRE+ project and provide a permanent testbed to facilitate experimental research on sensor networks, communication protocols, system design and applications. The project aims to offer access to openly available, accessible and reliable facilities to different Internet research communities; to establish a simple, powerful and cost-efficient experimental process; to improve trust in these facilities and to ensure the durability of these experimental infrastructures [10].

The w-iLab.t wireless testbeds feature 802.15.4, WiFi, LTE and cognitive radios. Various interactions with sensors connected to the nodes can be simulated as a part of the experiment.

Two facilities have been fitted with these nodes. The first one is located in an office building and thus reproduces real-life situations regarding RF disturbances. The second one is located in a pseudo-shielded building and provide a more industrial-like environment [11].

w-iLab.t is managed by IMEC iLab.t which is part of the IDLab Research group. The group involves 21 partners among which UPMC and INRIA, both already involved in the FIT IoT-LAB project [12].

The use of the w-iLab.t testbeds comes free of charge during the current phase. Requirements include citing the project when publishing results and filling a mandatory feedback form at the end of the experiment.

IV. Atom-IT: IoT guidance

Wallonia Space Logistics (WSL) was created by the Walloon Government in 2000 [13]. Originally focused on the spatial field, they now support all entrepreneurs that benefit from engineering techniques. The WSL is a startup advisory service that coaches people and companies with entrepreneurial projects in areas related to engineering science.

The Atom-IT project has been launched by the WSL in 2017 [14]. Atom-IT objective is to create and sustain a strong dynamic in the IoT and data science fields in Wallonia. The

project has also led to the creation of an IoT platform that is used during training sessions and to support the work of the Atom-IT team [15]. It primarily helps projects coming from private initiatives and the research.

The first goal of Atom-It is to organize experimentation sessions about IoT. A typical hands-on session lasts three hours and the goal is to discover the world of sensors, microprocessors and IoT networks. At the end of this session, the experimenter should have programmed an Arduino-like microcontroler and sent information to the IoT platform developed by the Atom-IT project team.

The second goal is about making working prototypes to reach a wide market. To do this, Atom-IT collaborates with the Labs [16] where micro-electronic, micro-system and software engineering companies can rent white rooms.

The third goal is about stimulating cooperations between companies active in the IoT and data science fields.

V. FabLab Mons [17]

The FabLabs mission is to provide access to tools, knowledge and financial resources in order to educate, innovate and invent using technology and digital manufacturing techniques to make (about) anything. They want to improve life around the world by democratizing digital manufacturing and education to technology [18].

A FabLab can be used to make (almost) everything as long as it doesn't harm anyone. Users need to learn how to become autonomous with the various pieces of equipment and have to share them with the other users. Every user is responsible for security, cleanliness and service continuity (maintenance, using the material stock responsibly and so on). Training sessions are proposed to develop this autonomy. The goal of sharing the space and equipment is also to promote ideas cross-pollination between the different users and projects.

The FabLabs are grouped in a global network, directed by the Fab Foundation. Fab Foundation is a US non-profit organization that was created by MIT's Center for Bits and Atoms lab [18]. FabLab Mons is a member of Fab Foundation and provides its services in the Mons area, Belgium.

FabLab Mons idea has been initiated in January 2013 by a bunch of passionate people. It has been created as a non-profit organization in June 2014 by École Supérieure des Arts de Mons (Arts au Carré, also spelled ARTS^2), Haute École en Hainaut (HEH), Maison du Design, Technocité, Transcultures and University of Mons (UMONS). FabLab Mons is managed by a board of directors provided with representatives from the founding organizations.

The first machines were bought thanks to a grant from Google and a loan from UMONS. ARTS^2, Technocampus and a private benefactor donated some equipment as well.

FabLab Mons has been created by actors coming from various horizons. But beyond their differences, they shared the same needs. This situation gave FabLab Mons a mix of many points of view which is very appreciated. Students and workers coming from FabLab Mons' founders are welcomed every working day. In May 2015, FabLab Mons opened its doors to the public. It is now open to everyone twice a week.

Beginners must follow an initial training session before being allowed to handle the main pieces of equipment. This session is organized twice a month [19].

Commercial activities are also accepted as long as they don't prevent access to the other users. Designs and processes developed within the FabLab can be protected or sold as the inventor see fit. But they must remain available to other users so that they can learn from these inventions.

VI. Fab-IoT-Lab

Fab-IoT-Lab project, which started in April 2018, is part of Digistorm, a 13-project portfolio funded by European Regional Development Fund (ERDF). It is the result of the collaboration between UMONS and FabLab Mons. This portfolio is steered by UMONS and focuses on cultural and creative industries. Together, these projects provide support to people during different phase of their product development. This support can take multiple forms such as the living lab that helps its users to co-create their product with their users, the opportunity to test new products in public spaces like museums, access to image recognition and augmented reality.

Fab-IoT-Lab target audience is wider than the one of portfolio. Fab-IoT-Lab helps existing and to-be entrepreneurs to prototype their IoT-related products and services. It also supports industries to migrate towards the Industrial Internet of Things paradigm.

While the first goal of Fab-IoT-Lab is to provide support to make IoT-related prototypes, the second goal is to improve competency and reach of FabLab Mons. It should help FabLab Mons to reach from the Mons area to the wider "Cœur du Hainaut" area, to acquire more competencies in IoT and electronics and to develop a strategy towards enterprises and to-be entrepreneurs.

Fab-IoT-Lab provides technological guidance about IoT prototyping by recommending technologies depending on the use case. It delivers prototyping services. This prototyping support is done either directly by a member of the project team, or by collaborating with one of the many experts working in the UMONS research labs. A permanent exhibition gathers several demonstrators that present IoT-specific technologies and some of their typical usages. This exhibition is fed by both the projects that are carried on by the team and other ones built specially for the exhibition.

A part of the European funding received by Fab-IoT-Lab project is reserved to finance prototypes. People and organizations that want to start an IoT project can thus take advantage of the competencies present at UMONS, but they can also receive money to buy the components required by their first prototype. This financial support then falls within the scope of the "de minimis" European rule about state aid [20].

VII. Conclusion

The Internet of Things is challenging for many reasons. One of them is that it requires many competencies.

Universities like UMONS are studying all the aspects related to IoT technologies and applications. The research labs each need to focus on a limited number of topics so that they can study them deeply enough. They can thus provide experts which have a deep knowledge in their own area of research.

Some projects like FIT IoT-Lab or w-iLab.t provide a wireless testing infrastructure so that academic and companies researchers can elaborate and improve their communication protocols and algorithms in an environment that reproduces real-life conditions as closely as possible.

A FabLab like FabLab Mons has a lot of experience in transforming ideas and concepts into tangible things. The equipment, knowledge and skills that are shared in a FabLab make it a very good place to initiate and iterate on a prototype. The diversity in education, occupation and area of interest inside FabLab Mons user community facilitates innovation.

UMONS and FabLab Mons created the Fab-IoT-Lab project to join the research labs expertise and the FabLab spirit in a single tool. This Fab-IoT-Lab team can thus provide guidance in both common and advanced prototyping. It brings the research results and experts closer to entrepreneurs and industries so that they can create innovative solutions. And it provides a single point of contact regarding IoT at UMONS.

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