AROUND THE WORLD OF IOT

In this column we plan to take a tour around different physical locations in the world with the objective of highlighting the peculiarities of the trendiest IoT-related applications in selected regions. Thus, the "IoT World" will certainly be physical, but traveling around it shall also expose to the readers how different application domains have been addressed, with particular attention to business sustainability.

Fostering IoT Solutions for Sustainable Development in Africa

by Raffaele Giaffreda and Abdur Rahim
Fondazione Bruno Kessler

The first leg of our journey takes us to the African continent, in particular to the Sub-Saharan countries. In this developing part of the world there are many initiatives led by many non-governmental organizations (NGOs), as well as public and private organizations with humanitarian objectives. They all have in common an interest and commitment toward accelerating the speed at which African countries can develop due to innovation and new technologies that improve peoples' lives while sustaining the economy.

The EU took part in this via the Joint Africa-EU Strategy; agreed upon as far back as December 2007, it is an overarching long-term framework for Africa-EU relations. The Strategy was adopted with a number of actions, one of which resulted more recently in funding opportunities for joint projects within the H2020 Horizon framework program.

In this article we place our magnifying glass over two related projects: **WAZIUP** and **WAZIHUB**. WAZIUP, which started in 2016 and finished recently, laid the foundations for the implementation of an Internet of Things (IoT)-based open platform, mostly based on existing assets, which were the result of previously funded EU collaborations and were immersed in the African context. WAZIHUB started in 2018 and aims to exploit these assets through integration with home-grown innovation-related activities.

This column is organized in two sections: first, highlighting the lessons learned with specific reference to technology deployment, and second, illustrating the paths taken to foster home-grown innovation in the context of the presented EU-Africa projects.

"Project execution exposed us to many deployment challenges" explains Abdur Rahim, the project coordinator of both initiatives as the first phase nears its conclusion. *"Through WAZIUP we implemented a low-cost infrastructure for deploying IoT in developing countries. Considering 70 percent of the world's population live in developing countries, working to address real daily life problems in these contexts is quite stimulating. Rather than keeping it in the labs of participating partners, we deployed it in real application domains, common across many African countries' rural areas, such as livestock farming, precision agriculture, logistics and storage as well as fresh water management."*

The WAZIUP project proposes a do-it-yourself (DIY) approach to problem solving, providing a list of hardware and IoT components to be used as well as tutorials to empower the locals to easily and quickly create solutions to the problems they face in their daily activities. Due to its low cost and wide coverage, IoT allows unique opportunities for social inclusion and innovation.

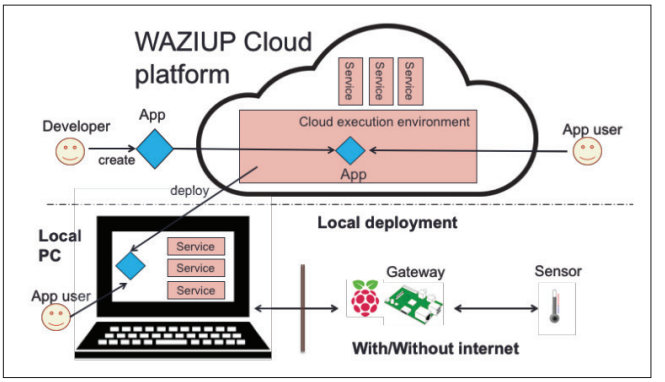

FIGURE 1. Containerized platform for standalone deployments.

"For WAZIUP, we shared through Github the integration software package as well as a collection of supporting material, such as different types of tutorials, videos. We provided step-by-step guidelines on how one can assemble full IoT solutions with locally available hardware. To date these online tools have reached 100K people both within and outside Africa," adds Abdur Rahim.

On the hardware front, Arduinos (for connecting sensors to a widely available microprocessor) and Raspberry Pis (for implementing cheap IoT gateways) have been proposed together with LoRa (long-range, low-cost, and energy-efficient communication technology).

"Besides the need for cost-effective solutions (people's average daily earnings is about 2 Euros, which demands for low-cost and affordable technology), another major hurdle against adoption is the internet infrastructure: WAZIUP's main focus is on rural applications and many of the targeted regions don't have internet connectivity. Thanks to LoRa, we could access the sensors deployed in the fields within a 10Km radius from the gateway. In order to push the data back to the WAZIUP cloud we used a 3G router where this was an option but we also had to engineer alternative solutions using GSM connection, SMS or USSD.

"In some cases, pushing data back to the cloud is not an option at all: use of SMS or USSD can quickly become expensive. In some cases, there was no reliable cellular connectivity at all. To extend the reach of LoRa (originally designed for star topologies) we also developed some LoRa relay points and added local processing and edge computing capability."

Many of the IoT applications in rural areas, such as irrigation, fish farming, and cattle monitoring, do not need to push data in real time back to the cloud. If well engineered, sensing and actuation can be implemented in a loop that does not require Internet connectivity.

Hence, the only way to create reliable solutions is to bring the edge computing concept to the gateway level, breaking long established models, widely adopted in developed countries simply because Internet connectivity is a given. The contextual background of developing countries imposes different design choices, requiring alternative thinking and much higher adaptation degrees than what one would consider otherwise.

"Another peculiar feature of WAZIUP solutions was to use single channel LoRa communication," recalls Abdur Rahim. *"There are few reasons for considering the single channel compared to more robust and secure multi-channel LoRaWAN."*

LoRa is a simple point-to-point link layer protocol, whereas LoRaWAN adds the network layer to the former, and includes added features like security (end-device data are encrypted and tunneled to a network server), multi-channel (handling up to eight simultaneous messages), disambiguation of packets (when same packet is "heard by" multiple gateways), and other features giving designers more flexibility in design, planning, and deployment.

"First of all single channel gateways are 50 times cheaper than a LoRaWAN gateway. In addition, most of the applications do not need high duty cycle (one measurement every 20 mins is sufficient). Hence, with single channel we can connect 256 devices which is much more than those applications require. In addition, LoRa is much simpler to deploy than LoRaWAN as it doesn't need backend connectivity to the Network Server, though is less secure. For the LoRa relays, we had to get around this problem by adding encryption in our LoRa communication protocol.

"Such approaches enabled us to successfully deploy application use-cases in many different countries and in different domains. Precision irrigation systems are piloted in 9 fields in four African countries (Senegal, Ghana, Togo and Burkina-Faso). Fish farming applications, which measure pond water quality real-time (i.e. oxygen level, PH and water temperature) are also piloted in 9 fish ponds in four different countries. Livestock management solutions are used for monitoring real-time position and health of the cattle as well as to prevent cattle rustling. These solutions are deployed by three firms in two countries whereas the deployment of cost-effective mini-weather stations has been adopted in four countries.

"One would think Africa is not yet ready for IoT. However, with technologies moving very fast, especially in the low-cost and wide-coverage part of the spectrum, things have changed rapidly in the last 4 years. Initially, one could see the activities were limited to gathering awareness, attending workshops and events. Today, many African industries and entrepreneurs are now concretely working with IoT solutions, as the pilot experience in these projects shows."

But to ensure success, one has to be aware of the perks and hurdles of the African environment. So far, we have illustrated with a few examples how the peculiar background typical of rural areas in developing countries can influence the design of IoT solutions, requiring a different mindset and an altogether different approach to problem solving. Technology, however, is only part of the solution.

In order to ensure that solutions can sustain a growing economy, one has to take advantage of so-called "home-grown alternatives." In fact, there is a trend aiming to redesign the existing expensive solutions available in developed countries and remake them in a highly cost-effective manner for the African market, using local resources, low-cost hardware derived from electronics waste, and so on.

Leveraging on WAZIUP technology inheritance, WAZIHUB took on this challenge. This project in fact is meant to foster the creation of startups, to develop IoT regional ecosystems, and to target capacity building for IoT-based solutions in local communities involving local actors.

WAZIHUB plans to empower African IoT innovation "Made in Africa" and "by Africa," engaging the local innovation hubs, makers' hubs, and accelerators across 20 countries in Africa. The hubs will operate in local settings but at the same time will be connected with the WAZIHUB Africa-wide ecosystem. These innovation hubs will create new business with the local communities for local needs, sharing best practices and inspiring entrepreneurs with appealing and locally validated business models.

Abdur Rahim reports that "*to foster IoT adoption in Africa we need to engage more and more young people as well as policy makers. It is also for these reasons that within the WAZIHUB project we plan to engage much more with so called "techhubs" which drive the innovation movement in Africa. There are different types of techhubs in Africa with mixed business models as well as activities. These innovation spaces gather most of the innovation and technology tools for local young people to tinker with. The main vision of the program is to offer innovation opportunities to potential entrepreneurs and create an IoT ecosystem sustained by one platform. For this model to work, we plan to offer both easy access to cutting-edge IoT technology, and supporting tools to create businesses and innovative solutions.*

FIGURE 2. WAZIUP pilot deployments in different application domains.

"In particular we plan to partner with the techhubs and offer them WAZIUP IoT technology catalysts and capacity building training. Once the hub participants become knowledgeable on the technology, they can themselves organize bootcamps and start-up events for local developers and entrepreneurs, giving them the opportunity to do hands-on training and rapid prototyping of IoT applications using WAZIUP technology components. It is planned that the best ideas will be selected and incubated for a minimum of 6 months. It is expected that this model will also foster collaboration amongst different hubs with the aim of sharing the IoT best practices. We strongly believe that following this innovation path will help techhubs create successful spin-offs and contribute to the sustainability of the whole initiative also from a business point of view."

More information and details on the described projects can be found through the websites of the mentioned projects, via social media channels, as well as getting in touch with the authors of this column.

Raffaele Giaffreda (rgiaffreda@fbk.eu) is a chief IoT scientist at FBK CREATE-NET, Italy. He has worked in the telecom R&D environment since the beginning of his career, focusing in the last decade on IoT and related technology transfer activities. In his role, he is now responsible for setting research and innovation directions, acquisition of funding, and the execution of a number of collaborative projects in the IoT domain. He has worked in Italy and the United Kingdom (10 years), acquiring experience in both corporate telco environments (R&D of BT and Telecom Italia) as well as in a small research organization (CREATE-NET before its merger with FBK), where the ability to acquire funding was key to ensuring continuity of operations. He is a recognized expert with a substantial record of IEEE publications and conference presentations, a patent, and various book chapters and tutorials on IoT. He is an experienced speaker and chair of IoT related events, serves as an EU reviewer, has served on the TPCs of a number of international conferences, and he is the Editor-in-Chief of the *IEEE IoT Newsletter*.

Abdur Rahim (arahim@fbk.eu) is a senior research staff member in the Open IoT group at FBK CREATE-NET, Italy. He is project co-ordinator of the WAZIHUB and WAZIUP projects, EU H2020 projects creating an open source IoT and big data platform for Africa. He was also the technical manager of iKaaS (create-net.fbk.eu), an IoT, big data, and cloud project funded by EU and Japan. He was also the project manager of EU project iCore (www.iot-icore.eu) empowering the Internet of Things with cognitive technologies. He serves as Technical Working Group leader of several EU projects and European cluster activities. He is very active in IoT since 2006 starting with sensor networks. He delivers talks at many conference, events, meetings, and so on. He has organized many technical/panel sessions and workshops at different international events like ICC, CROWNCOM, ICT Mobile Summit, and EU RAS. He has been involved in many activities related to cognitive technologies, Steering Committee Co-Chair (CROWNCOM), Management Board member of COST-TERRA, and Co-Chair of SIB European Alliance for Innovation.