Deploying Smart City Services in Messina with #SmartME

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***Abstract*—Some words mark an era, and "Smart City" is definitely one of these. A Smart City is an urban area where the Information and Communication Technologies (ICT) are employed to improve citizens' Quality of Life (QoL) in areas such as: mobility, urban surveillance, and energy management. Throughout this paper, we present the #SmartME project, which aims to create an infrastructure and an ecosystem of "smart" services by exploiting existing devices, sensors, and actuators distributed in the city of Messina. We also present the Stack4Things framework, which is the management core of the #SmartME project.**

I. Introduction

A Smart City is something more than just a bunch of Internet-connected objects, as it "brings together technology, government and society to enable the following characteristics: a smart economy, smart mobility, a smart environment, smart people, smart living, smart governance."[1] Projecting this definition in the technological context, a Smart City can be thus considered as an ecosystem of infrastructure and services aiming at implementing the aforementioned characteristics. This holistic view calls for an all-encompassing approach able to embrace heterogeneous technologies and services, thus providing a wider (or even a global) solution to (Smart) city problems. In this light, there is the need for a scalable architecture aiming at reusing, multiplexing, and sharing technologies and services on the urban scale. The goal is therefore to establish an homogeneous ecosystem where multiple applications can scale out to a metropolitan scope, thus underpinning an open shared ICT infrastructure made of sensing, actuation, network, processing, and storage resources.

Following a learning-by-example approach, in this paper we report on a case study that we are implementing in Messina through the #SmartME project[2]. This was born from a joint idea between a team of researchers in the University of Messina and the municipality of Messina in order to spur the creation of a novel, virtual ecosystem in its urban area, also involving several companies in the nearby area. The main goal of the #SmartME project is to establish an infrastructure and an ecosystem of services based on the already-in-place devices, sensors, and actuators. This way, we shifted the burden to the software side, adopting a specific framework able to solve interoperability, networking, security, and other issues. One of the main benefits of the proposed framework is *programmability*: anyone, if authorized, can inject and run own applications and services, exploiting the same Smart City infrastructure, which is therefore shared by several applications and services, even at the same time.

II. Overview

The #SmartME project [1] is a crowd-funded initiative aiming at morphing Messina into a Smart City [2]. The main goal is to disseminate IoT resources throughout the territory of the Messina municipality, thus creating an ubiquitous sensing and actuation infrastructure and a virtual laboratory to which multiple stakeholders can contribute with their own resources and on top of which they can develop applications and services for research, business, and administrative activities. As a result, one of the main contribution and novelty of the #SmartME project is to establish a new, crowd-sourced and shared/contributed form of Smart City where anybody, from citizens to public administrations, from shops and businesses to private buildings, can share their hardware facilities to build up the contributed infrastructure. This should be properly managed by a specific framework which allows contributors to share their resources, and application developers and users to use them. This is possible by the Stack4Things management framework[3] that allows to enrol and manage these resources altogether, as a whole, also providing customization facilities and fruition modalities for their actual exploitation, on a Cloud provisioning model. This way, several services have been developed exploiting this crowd-sourced Smart City involving several stakeholders into the #SmartME project as better described in the following sections.

The #SmartME infrastructure is composed of a set of devices that provide sensor and/or actuator facilities. Figure 1 reports the composition of a typical #SmartME node. The Arduino YUN is a Single-Board Computer powered by an Atmel ATmega32u4 micro-controller and the Atheros AR9331 System-on-a-Chip. The #SmartME YUN board has

[1] http://smartcities.ieee.org/about.html
[2] http://smartme.unime.it/
[3] http://stack4things.unime.it

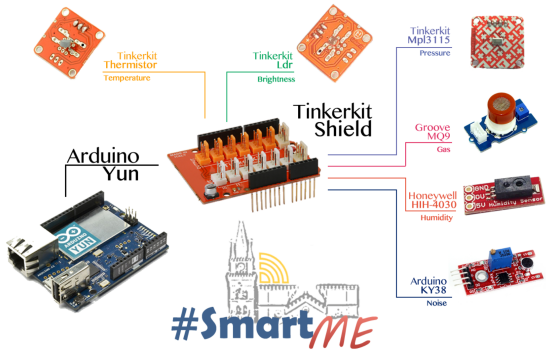

Figure 1. A typical #SmartME node.

been equipped with a Tinkerkit Shield hosting a set of low-cost sensors. Specifically, a Tinkerkit thermistore, Ldr, and Mpl3115 have been installed as temperature, brightness, and pressure sensor, respectively. A Groove MQ9 is used as gas sensor to obtain information about air quality. In particular, CO levels are captured as an indication of air pollution. A Honeywell HIH-4030 has been chosen as humidity sensor, while an Arduino KY38 captures the environmental noise level.

#SmartME nodes are programmed to periodically send samples to a set of *CKAN datastores*. The Comprehensive Knowledge Archive Network (CKAN)[4] is a Web-based open source data management system for the storage and distribution of datasets. Data delivery is performed through the CKAN REST API interface. Data is consumed by the *Public portal*, which provides a user-friendly showcase through which citizens can browse the #SmartME nodes and have a sneak peek at collected data. Moreover, the CKAN datastores offer the possibility for both citizens and third party services to perform complex queries and retrieve historical series.

The hearth of the #SmartME project is powered by the Stack4Things framework [3]. It allows to manage IoT nodes following an on-demand, service-oriented provisioning model, moving the IoT paradigm towards the Cloud for, on the one hand, providing control and management capabilities to IoT nodes, and, on the other, extending the Cloud paradigm with pervasiveness capabilities to interact with the physical world.

In a crowdsourcing-based system, one of the most important facilities to provide is the incentive mechanism for motivating contributors. To this purpose, we designed and implemented a virtual complementary currency called UniMeCoin. This currency is implemented through an Android-based mobile application that leverages the Ethereum blockchain technology[5]. Currently, we have implemented a proof-of-concept version of UniMeCoin based on a private chain. However, we plan to migrate to a version of UniMeCoin in which the complementary currency is implemented as token on top of the blockchain currency by means of a specific smart contract.

UniMeCoin is planned to be the official currency for access and payment of services belonging to the #SmartME ecosystem.

III. Applications and Services

Several applications and services have been developed on top of the #SmartME infrastructure. Some of them are briefly described in the following.

#SmartME Parking: #SmartME Parking is a service implemented in collaboration with ParkSmart Srl[6], a startup that aims to solve parking problems with an innovative solution based on computer vision algorithms executed close to the cameras on the AISee box, an IoT device capable to run complex AI algorithms. This way, Park Smart proposes a solution that exploits the Edge Computing paradigm, with sensors distributed on the city and computational units that process the data and send only the parking occupancy information to the Cloud.

#SmartME Lighting: The #SmartME platform integrates a low-cost solution for data collection and remote control of public, private, and industrial areas lighting systems developed by Meridionale Impianti Spa[7]. The #SmartME Lighting system uses conveyed waves (PLM) as the main mean of communication. Each lamp is equipped with an electronic device (called End Device in the following) that activates/deactivates the lamp (lamps can be either SAP or LED) and monitors the main consumption parameters such as voltage, current, and absorbed power. Every single End Device is periodically queried by a Gateway located in the plant electrical panel. In the context of the #SmartME project, the Gateway has been equipped with an Arduino YUN board, connected through the serial interface, that acts as a bridge with the external world allowing all the information to be sent to the #SmartME portal and actuation commands to be received and forwarded to the Gateway for remote control of the whole lighting network.

#SmartME TrashCan: #SmartME Trashcan is the waste management solution conceived by the University of Messina within the #SmartME project. It exploits the Internet of Things and Cloud computing and provides three main contributions. Firstly, it optimizes the waste collection process by adjusting the type, number, and route of the collection vehicles according to the information obtained from the smart dumpsters distributed throughout the city. This leads to an overall reduction in traffic, pollution, and collection costs and increases citizens' satisfaction. Secondly, smart dumpsters are also employed to sense

[4]http://ckan.org
[5]https://www.ethereum.org
[6]http://parksmart.it/
[7]http://www.merimp.com/

environmental parameters (e.g., temperature, humidity, light, noise, air quality) for the enablement of several Smart City services. Last but not least, the proposed solution monitors the type of produced waste in order to identify possible critical conditions from the epidemiological point of view.

#SmartME Pothole: #SmartME Pothole is an example of mobile application, coupled with a Web service as backend for, e.g., mapping and other visualization tasks, following the mobile crowdsourcing (*crowdsensing*) paradigm. The purpose of the system lies in detecting potholes and other distress elements on the surface of public roads. The detection system is based on two components: i) a Cordova-based multi-platform mobile app running on volunteer-owned mobiles, ii) a Back-End system to collect, filter, analyze, and mine data. The app computes changes in the sampled values for the norm of the acceleration vector: intuitively, when bumping into a pothole on the way, or more generally going down a distressed road surface, these changes may turn out to be significant. The presence of a potentially critical condition is then marked together with the corresponding geospatial coordinates.

#SmartME Airport: #SmartME Airport is a collection of services in the making aimed at increasing the safety and comfort for travelers at the Fontanarossa Airport in Catania. In particular, at the moment the first deployed service of this kind is based on the presence of thermal cameras, connected to #SmartME boards installed at check-in rows. Its aim is to detect the presence of long queues at the check-in desk or even other kinds of gatherings (flash crowds, etc.), which may both annoy the travelers due to unpredictable waiting times and pose a threat in terms of security (e.g., potential targets for terrorism). The underlying mechanism consists in coupling computer vision and machine learning techniques to isolate human presence (detected by emitted heat) and count heads. The pipeline (image capture, preprocessing, segmentation, object detection, enumeration, processed frames plus count upload) has been implemented by wiring up the corresponding phases as processing blocks in the Node-RED flow-based visual programming tool.

Carpooling@UniMe: Within the #SmartME project, the Centro Informatico di Ateneo (CIAM) and SmartMe.io startup[8] designed and developed Carpooling@UniMe, a software platform that implements a carpooling social network. The platform involves the use of an Android-based mobile application that allows to combine supply and demand in terms of mobility between students, technicians, and faculty members of the University of Messina. Carpooling systems usually need incentives mechanisms. The sharing of means of transportation implemented through Carpooling@UniMe can be for free or can require small refunds (mostly, fuel refunds). This is performed under the complementary currency UniMeCoin that guarantees a form of economic sustainability in the ecosystem.

#SmartME Art: #SmartME Art is an Android-based mobile application that has been developed with the aim to support tourism in a smart city. The service provides tourists with a tool that allows them to better explore artistic heritage within a urban environment by using just their smartphones camera. The software solution is based on Google TensorFlow, an innovative deep learning framework mainly designed for pattern recognition tasks. Such a technology is exploited to recognize art objects (i.e., historical buildings, statues, monuments, paintings) belonging to a pre-built database that tourists frame with their camera. After the recognition phase, the application serves its user with videos and other engaging content in a mobile optimized format.

#SmartME Taxi: #SmartME Taxi represents the integration of a fleet management application developed by Arkimede Srl[9] into the #SmartME portal. It is an Android-based mobile application running on a tablet and periodically sending position and speed of the taxi to the CKAN datastore. The #SmartME portal visualizes the data on a map in real-time and allows users to get information about the status of the taxi (available or engaged).

IV. Conclusions

In this paper, we presented the #SmartME project together with all its main smart services: Parking, Lighting, Trash management, Pothole detection, Airport, Carpooling, and Art. A description of the adopted technologies and the core framework to orchestrate and manage the aforementioned smart services was provided as well. The Cloud capabilities make the #SmartME system flexible and scalable, allowing the on-the-fly definition of new smart services in the next future.

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[8] http://smartme.io

[9] http://www.arkimedenet.it/