Open Standards for the Internet of Things

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ABSTRACT

The Internet of Things, commonly abbreviated as IoT is a novel paradigm that describes the idea of everyday physical objects being connected to the internet. This includes everything from mobiles, vehicles, air conditioners, headphones, wearable devices and almost anything. Unquestionably, the IoT idea has a high impact on several aspects of everyday life and behavior of potential users. Consequently, companies have started to introduce numerous IoT based products and services and several consortiums have been formed to define protocols and standards for the IoT. This article aims to provide a brief revision of the state of the arte in the IoT field. On the other hand, the Audio and Communications Signal Processing Group and the Multimedia Communications Group of the ITEAM are currently involved in different research projects related to the IoT concept. These projects are also briefly summarized in this article.

Keywords: Internet of Things, NB-IoT, LTE-M, FIWARE, MAtchUP project, SSEnCe project.

1.- INTRODUCTION

The Internet of Things (IoT) paradigm refers to a global network of interconnected things, that is, devices such as sensors equipped with a telecommunication interface, processing and storage units [1]. This communication paradigm also called the Internet of Everything is a new technology paradigm that should enable integration of potentially any object with the Internet, thus allowing new forms of interactions with each other. The interconnected objects are able to communicate, exchange information, take decision, invoke actions and provide amazing services.

The IoT is an extremely challenging topic, it is one of the most important areas of future technology and the debate on how to put it into practice is still open. The IoT provides connectivity for anyone at any time and place to anything, moving towards a society where everything and everyone will be connected [2]. In fact, 50 to 100 billion things expected to be connected to the Internet by 2020 [3]. IoT is building a worldwide infrastructure that will influence a lot of aspects of our daily life, a few examples of applications scenarios are for example domotics, assisted living, e-health and enhanced learning.

With the advancement of the IoT technology, smart devices are nowadays equipped with different types of sensors and are able to connect and communicate over the Internet. For instance, cellular networks standards need to add new techniques to improve the network performance to address traffic patterns generated by an increasing number of IoT devices [4]. No single technology or solution is ideally suited to all the different potential massive IoT applications. As a result, the mobile industry is standardizing several technologies, including Long Term Evolution for Machine (LTE-M) and Narrow Band IoT (NB-IoT) [5].

The wide heterogeneity of devices, operating systems, platforms and services available make it necessary to solve some of the essential problems of applications developers. Several industrial, standardization and researches are currently involved in the activity of development of solutions to fulfill the technological requirements. The usual battle is between proprietary platforms, which allow the interoperability only of devices that have been certified by the manufacturer of the IoT system, and open source platforms that offers open standards that everyone can share and adopt. Open source platforms are considered more promising when compared with proprietary alternatives mainly due to their faster integration. The open standard may include open specifications and assures the interconnectivity and interoperability across IoT. Some examples are the oneM2M2 [6] which is a global partnership developing standards for machine to machine communications and the IoT; Wi-SUN alliance[7] is a global association to promote certified standards that coordinate various wireless system and standardize power levels, data rates, modulations among others and Open Connectivity Foundation (OCF) [8] is dedicated to ensuring secure interoperability for consumers, businesses and industries.

Thereby, the IoT consists of smart devices equipped with different type of sensors and actuators. These devices can sense, perform computation, take intelligent decision and transmit useful information over the Internet. The information is the sensed data about, temperature, orientation, humidity, noise, etc.. depending on the type of sensors. In the context of audio related task, Acoustic Sensor Networks (ASNs) are especially important for communication. Each node in the network makes its own noisy measurement of the sound field and communicates with other nodes by sending and receiving information. Regarding to IoT acoustic based application we can mention for example the detection of traffic, crowd areas or emergency situations between others, some of these applications can be viewed in Figure 1.

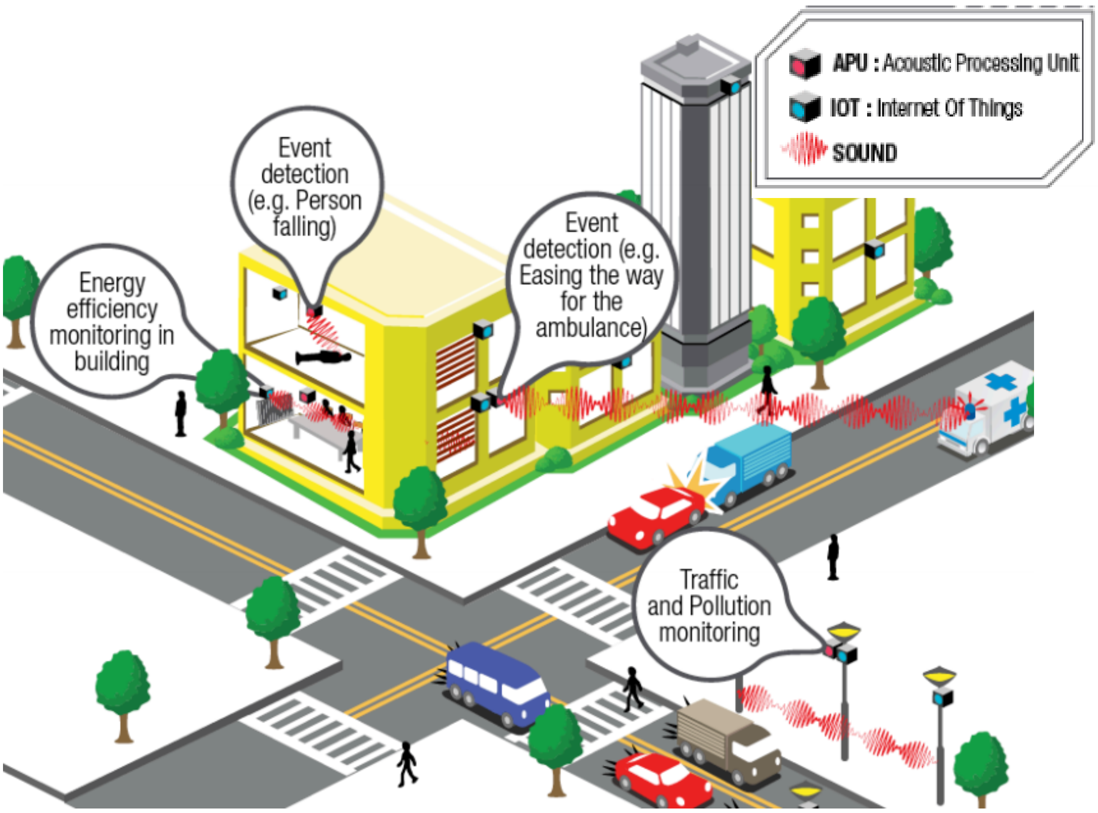

Figure 1. IoT acoustic based applications in smart environments. (IoT Accoustic Sensing Ressacs 2013, UBO).

In this way, research activities and projects already exist on acoustic monitoring of an environment. For example, in [10] the water quality and fish behavior in aquaculture tanks during the feeding process is monitored, [11] describes how to monitor and geo-reference noise in urban environments and [12] proposes how to infer hazardous situations via environmental sound identification. Thus, sound is an important source of information about urban and environmental life. This implies a great potential on intelligent audio based solutions to support a myriad set of applications.

2.- 5G IOT STANDARDS

Recent cellular standards like Long-Term Evolution (LTE) have been introduced for mobile devices but are not well suited for the requirements of the IoT devices. Basic requirements such as high throughput, low latency, high scalability to enable massive number of devices and efficient consumption are required. Thereby, next-generation networks and standards will need to solve complex challenge of combining communications and computing together. To address this, there is a number of emerging IoT standards.

Fifth generation (5G) is expected to play a vital role in the development of smart city applications addressing the limitations of previous cellular standards and be a potential key for future IoT [13]. One of the major advantages of 5G with respect to 4G are the increased data rate, reduced latency and the improved coverage supporting a large amount of devices. In this way, 5G allows the vision of a truly global IoT. To address the challenges, the standardization group 3rd Generation Partnership Project (3GPP), which is responsible for cellular telecommunications network standards, has been working to make sure that the communications are efficiently evolved in future and promising 5G New Radio systems be a reality for IoT application. The 5G air interface is planned to be standardized by 2020. The standardization is divided by 3GPP in phases: early commercial deployments and a subset of the 5G requirements is set up by 2018, first commercial launch is to be by 2020 and full 5G will be available once the standardization process is completed by 2022 and onwards [14].

No single technology or solution is ideally suited to all the different potential massive IoT applications, market situations and spectrum availability. As a result, the mobile industry is standardizing several technologies, including Long Term Evolution for Machines (LTE-M) and Narrow Band IoT (NB-IoT) which appears as promising solutions that will be included as 5G mobile standards [14]. Both are protocols with a low bandwidth that connect devices to the internet which need to transmit small amounts of data, at low cost and with high battery life.

LTE-M, also known as CAT-M1, is the industry term for the Long-Term Evolution (LTE) machine-type communications that was introduced by 3GPP in Release 13. Core specifications were completed in June 2016. Further work to enhance the technology has been ongoing in 3GPP. Release 14 enhancements were completed in June 2017, while Release 15 enhancements has been completed by June 2018 [15]. LTE-M supports IoT through lower device complexity and provides extended coverage, while allowing the reuse of the LTE

The other 3GPP technology is NB-IoT, also called Cat-M2, which has a similar goal as LTE-M. It was also standardized in Release 13 and is set to be completed in Release 15 [16]. NB-IoT uses Direct-Sequence Spread Spectrum (DSS) technology, which is a different technology to the LTE radios. Therefore, NB-IoT does not operate in the LTE band, meaning that providers have a higher upfront cost to deploy. However, NB-IoT would even support lower data rates and lower power consumption with a reduced bandwidth allocation than LTE-M.

The number of LTE-M and NB-IoT use cases are increasing and at the end of April 2018 there were a total of 48 commercial networks launched [17]. In [18], a list of all Mobile IoT commercial Network can be bound, where the country in which it is developed and the used technology are specified.

3.- FIWARE STANDARD

Implementing IoT enabled smart applications requires gathering context information coming from "Things" (sensor networks, systems, end users, etc.). This current and historic context information, needs to be processed, visualized, and analyzed at large scale, in order to produce the expected smart behavior. FIWARE is an initiative to provide a platform and a set of standardized APIs to support the creation of Smart Applications in various fields. It initially started in 2011 as an EU's Seventh Framework Programme (FP7) project with the goal of "introducing an innovative infrastructure for cost-effective creation and delivery of services, providing high QoS and security guarantees" [19]. Since then it has got significant attention resulting in various follow-up projects [20][21][22]. Besides this, the so called FIWARE Foundation [23], was recently founded with the goal of building a sustainable community around the project. FIWARE mission, is: "to build an open sustainable ecosystem around public, royalty-free and implementation-driven software platform standards that will ease the development of new smart applications in multiple sectors" [24].

FIWARE architecture is very extensive and is divided into seven technical chapters [25], based on components known as Generic Enablers (GEs) [26], which are general-purpose functions, offered through well-defined, standard and open APIs, easing development of smart applications in multiple sectors. FIWARE also provides GE Open Specifications (that are public and royalty-free) and their implementations (GEi). There might be multiple compliant GEis of each GE Open Specification and at least one open source reference implementation of each FIWARE GE (FIWARE GEri). Available FIWARE GEis, GEris and incubated enablers are published on the FIWARE Catalogue [27]. The advantage of using FIWARE is that software architects can rely on a consolidated set of open source general-purpose platform functions that are supported by a worldwide community.

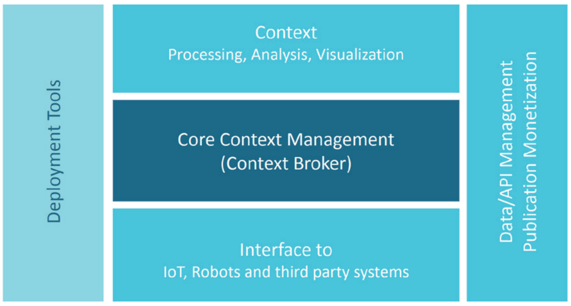

Figure 2. FIWARE architecture. (www.fiware.org)

Figure 2 shows the FIWARE Context Broker component that is the core component of any platform based on FIWARE. Around the FIWARE Context Broker, a rich suite of complementary FIWARE components are available for facilitating tasks such as the integration of the Internet of Things devices (Internet of Things, IoT), to analyze and process data at medium and large scale (Big Data), or to incorporate advanced interfaces to interact with users. Nevertheless, FIWARE is not about take it all or nothing. Developers are not forced to use all the complementary components (GEs), but they can use other components to design hybrid platforms. As long as it uses the FIWARE Context Broker technology to manage context information, our own platform can be labeled as "Powered by FIWARE" and solutions can be built on top as well.

Current deployment status

FIWARE provides an enhanced OpenStack-based cloud environment plus a rich set of open standard APIs that make it easy to connect to the Internet of Things, process and analyze Big data and real-time media or incorporate advanced features for user interaction. If the application has to be "smart", first of all we have to make it "aware". FIWARE provides us with means to produce, gather, publish and consume context information at large scale and exploit it to turn our application into a truly smart application.

Context information is represented through values assigned to attributes that characterize those entities relevant to the application. The Context Broker GE (open source reference implementation: Orion [28]) is the core and mandatory component of any platform or solution based on FIWARE. It enables to manage context information in a highly decentralized and large-scale manner. It provides the FIWARE NGSIv2 API which is a simple but powerful restful API enabling to perform updates, queries or subscribe to changes on context information. The Orion Context Broker holds information about the current context, and considering that the context information evolves over time, it creates a context history. the STH Comet Generic Enabler [29] is part of the Core Context Management Chapter and complements the Orion Context Broker component. The STH Comet Generic Enabler provides the means to store a short-term history of context data (typically months) on MongoDB whereas the Cygnus Generic Enabler [30] provides the means to manage the history of context. This last one is created as a stream of data which can be injected into multiple data sinks, including some popular databases like PostgreSQL, MySQL, MongoDB or AWS DynamoDB, as well as BigData platforms like Hadoop, Storm, Spark or Flink.

Likewise, a number of Generic Enablers are available making it easier to interface with the IoT, Robots and Third-party systems for the purpose of gathering valuable context information or trigger actuations in response to context updates. The IDAS Generic Enabler [31] is an implementation of the Backend Device Management GE, according to the FIWARE reference architecture. IDAS offers you a wide range of IoT Agents, making easier to interface with devices using the most widely used IoT protocols (LWM2M over CoaP, JSON or UltraLight over HTTP/MQTT or OPC-UA) as well as develop your own IoT Agent.

In order to implement the expected "smart behavior", the context information must be processed, analyzed or virtualized. To facilitate these tasks, a number of Generic Enablers are available: Wirecloud [32] that provides a powerful web mashup platform to develop operational dashboards highly customizable by end users, Knowage [33] that is a powerful Business Intelligence platform to perform business analytics over traditional sources and big data systems, and Kurento [34] and Cosmos [35], which enables real-time processing of media streams and tools for easyly performing Bigdata analysis respectively.

As mentioned above, to implement secured access to components in the architecture of any "Powered by FIWARE" solution, and the publication and monetization of context data resources, available through the core Orion Context Broker component, another set of Generic Enablers are available in the FIWARE platform. The Keyrock Identity Management Generic Enabler [36], which brings support to secure and private OAuth2-based authentication of users and devices, user profile management, privacy-preserving disposition of personal data, Single Sign-On (SSO) and Identity Federation across multiple administration domains. The Wilma proxy Generic Enabler [37] which brings support of proxy functions within OAuth2-based authentication schemas. It also implements PEP functions within an XACML-based access control schema and the AuthZForce PDP/PAP Generic Enabler [38], which brings support to PDP/PAP functions within an access control schema based on the XACML standard.

On the other hand, this chapter also brings Generic Enablers for the publication and monetization of context data resources, available through the core Orion Context Broker component of the developed platform. We highlight in first place the CKAN extensions Generic Enabler [39], which provides a number of add-ons able to extend current capabilities of the world-leading CKAN Open Data publication platform. It allows the publication of datasets matching right-time context data, the assignment of access terms and policies to those datasets and the assignment of pricing and pay-per-use schemas to datasets. In second place, we consider the Biz Framework Generic Enabler that brings backend support to Context API/ Data monetization based on open TM Forum Business APIs.

Current cases of use

FIWARE is an Open Platform for a better Internet, an Open Environment, available for everyone willing to build smart solutions. FIWARE has given rise an Open Community around Open Standards for a data-driven world, making open data and applications available for everyone. FIWARE has accomplished to be empowered by lead Industry big players, but being guide by the needs, challenges and ideas of the users in each application sector. Being this joint work what has turned innovation and research into real products.

FIWARE cases of use cover several sectors like Smart Health, Smart Logistics, Smart Energy, Smart Cities, Smart Industry and Smart Agrifood among others. Within the sectors of greatest impact, we can find the Smart Industry, where FIWARE is creating a smart manufacturing platform based on industry standards and open source components that helps developing smart applications for all production processes. Smart Agrifood or Smart Farming whose aims are to optimize the production in farms by using the most modern means in a sustainable way, thereby increasing the production and delivering the best products in terms of quality while maximizing the return. It makes use of a wide range of technologies including IoT sensors, wearables, GPS services, UAVs, robots and drones operating in the field, which provide real-time data to systems helping to monitor the production line and support decisions. This enables less waste and maximum efficiency in operations.

Taking as a reference the number of applications developed, we can see that although FIWARE is a generic platform, it is especially useful to enable the concept of Smart Cities, and more than 100 cities have already published open data and developed prototypes using FIWARE, while several Spanish cities have adopted it in their systems. In accordance with this global trend, the Universitat Politècnica de València is currently participating in different European projects related to the field of IoT applications.

4.- PROJECTS RELATED TO IOT IN ITEAM

MAtchUP Project on Smart Cities

MAtchUP [40] is an EU-funded Smart City project involving three lighthouse cities (Valencia-Spain, Dresden-Germany and Antalya-Turkey) and four follower cities (Ostend-Belgium, Herzliya-Israel, Skopje-FYROM and Kerava-Finland). It started on September 2018 and will finish on September 2023. During this period, MAtchUP partners will create and adopt solutions that can turn urban problems into smart opportunities to improve the citizens' quality of life and boost the local economies, mainly in the areas of energy, mobility and ICT (information and Communications Technologies). The final aim is to create a prosperous and more liveable urban environment for communities.

MAtchUP cities will join forces to reshape their social, economic and environmental models and to promote social inclusion, liveability and prosperity for their citizens.

MAtchUP will design and implement a palette of innovative solutions in the energy, mobility and ICT sectors that will serve as a model of urban transformation for other cities in Europe and beyond.

In the context of this project, the existing VLCi smart city platform in Valencia (Figure 3) already offers a set of IoT adaptors also known as IoT agents. These agents allow the platform to directly connect devices supporting certain IoT device semantic languages (UL 2.0, Sensor ML), making use of different transport protocols (OMA LWM2M, COAP, MQTT, HTTP). The IoT agents are also in charge of adapting the IoT device semantics to the open APIs exposed by the VLCi platform (based on FIWARE NGSI).

The city interventions planned by MAtchUP in Valencia will require the integration of additional IoT devices and data acquisition systems, and iTEAM is the partner in charge of providing the IoT devices integration in the platform, directly or through development of special IoT Agents. This will be done with the help of the VLCi platform SDK and APIs, and the main tasks will consist in adapting them to the specific city devices used as part of the interventions, beyond the standard protocols supported by the VLCi platform off-the-shelf.

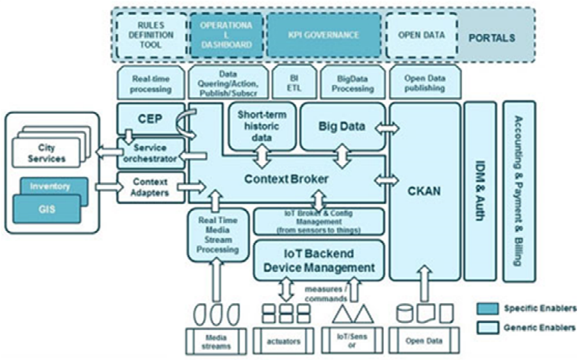

Figure 3. FIWARE architecture for Smart Cities. (www.fiware.org)

The action will include the development of a set of common basic data analysis blocks (both for batch historic files and real time data analysis) to be used for the design of the required complex analysis processes for the city of Valencia. It will be possible to reuse the common basic data analysis blocks in other cities, in order to build their specific complex analysis processes on top of them, therefore ensuring the replicability of the solution also in other cities. The implemented IoT & Big Data analysis processes will help the integration of new services into the VLCi platform, creating an innovative ecosystem. Additionally, they will help to evaluate and validate the effect of the applied city policies and the executed interventions, and will be a key input for the City Management Dashboard, where the output of these processes will be visualized and monitored.

Within the VLCi existing platform, new data resources will be integrated coming from the different data collection systems. Therefore, it will be necessary to publish non-sensible and anonymized data (privacy and security aspects) to be accessed and explored by citizens and developers willing to use them to create innovative services for the city. By collecting the data generated and exposed by the IoT devices used in the city interventions from the VLCi platform, new data insights will be generated and visualized in the City Dashboard. This action will cover the data analysis activities for the calculation of the new required KPIs (based on ISO 37120) associated to the planned interventions in the city of Valencia and also the generation of valuable data insights based on the combination of real time and historic context information gathered from the executed interventions in the areas of energy optimization, sustainable mobility, high performance buildings and environment.

SSEnCe Project on Acoustic-aided IoT

In general, the scope of the IoT technology is diverse, although the most important effort is being carried out in the field of health (e-health), transport and Smart Cities. The "Sound-Aided Smart Environments for the City, Home and Nature" (SSEnCe) project aims to encourage the dissemination and develop of real and practical prototypes focused on the Global concept of Intelligence in the IoT, particularly the applications are based mainly on the acoustic information of the environment. The main objectives of this project are the creation of an Observatory and the development of three technological demonstrators of immediate practical application.

The IoT observatory can be found at http://sound-aided-IOT.upv.es . The observatory will address issues related with the IoT projects carried out at iTEAM by publishing the most relevant information on the progress of the projects. Furthermore, the observatory will collect relevant information on the IoT field as news, new applications and products, prototypes, etc...

On the other hand, the demonstrators have the following specific objectives:

- In the home environment, it is intended to detect the acoustic events that indicate danger or emergency situation, especially for people with reduced mobility (sick people, elderly people, etc..). This application is related to IoT application in e-health.
- In the Smart Cities field, the project aims to develop applications which detect violence situations and disturbance of social coexistence (concerts, unauthorized manifestation, etc.) and to monitor the noise pollution.
- In natural parks is intended to detect any alteration of the natural environment produced by people.

In this sense, for the development of the three demonstrators the project presents three main axes of action, as shown Figure 4:

- Acoustic Sensor Networks (ASN) technology capable of "listening" the environment, processing the sound information and make decisions, that is, with computing capacity in the data source or near to it (edge computing).
- The IoT technology that allows to process additional information of the environment and to perform a much more complex processing (cloud computing).
- The applications, which are focused on the welfare of the citizen and the care of the environment.

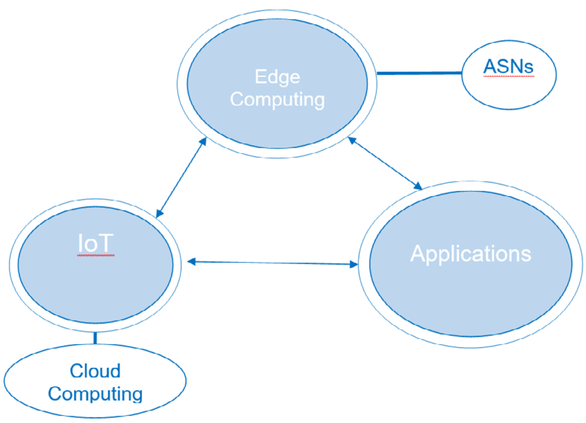

Figure 4. Basic elements for intelligence in the IoT.

The new paradigm called edge computing aims to move the border of the computing applications, data and services from the central nodes to the ends of the network. Thereby edge computing allows the analysis and generation of knowledge at the source of the data or near to it [41] [42]. The term edge computing covers a wide range of technologies, including: wireless sensor networks, networks and hoc cooperatives, node processing, storage and recovery of distributed data, self-configuring networks, etc.

On the other hand, acoustic sensors networks allow us to address new scenarios that traditional systems of digital sound processing have not been raised, many of them related to the mobility and versatility associated with these networks [43]. The use of several acoustic nodes instead of a single central system is justified when it is impossible to assume the computational cost of a centralized system; when the nodes have no physical possibility to access all the control information of the system and when a scalable system is needed.

For these reasons, in the SSEnCe project the proposal of the different applications implies a decision making from the acoustic information extracted from the ASN, both for the detection and for the classification of acoustic events. On the other hand, the needs of the end users are considered in the applications, as well as their integration. Likewise, notifications alarms and results reach to the end users in an easily way through various interfaces and devices (mobile devices, augmented reality, etc.).

Acknowledgment

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