Internet of Things education: labor market training needs and national policies

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***Abstract* — Small and medium sized enterprises (SMEs) are a pillar of European economy. Nowadays the acquisition of new e-competences is essential to follow the digital transformation for the society and the market, and to keep an adequate level of competitiveness. Internet of Things (IoT) are producing a relevant impact in several economic sectors (industry, transportations, energy, agriculture, home automation, etc.). This technology has a high potential in terms of new business opportunities and new job positions. Several national and European policies have been set-up to train the EU companies to the adoption and diffusion of the IoT technologies. This is also the main aim of the European project IoT4SMEs. In this paper, we describe the early activity of the project, focused on an assessment of the labour market training needs related to the IoT technologies.**

Keywords — Internet of Things, IoT Education, VET, SMEs

I. INTRODUCTION (*HEADING 1*)

Internet of Things (IoT) is widely considered as the next step towards of the digital society, where objects and people are interconnected and interact through communication networks. IoT not only has a huge social impact, but can support the employability and boost the competitiveness of European companies. It is widely considered as one of the most important key drivers for the implementation of the so-called Industry 4.0 and for the digital transformation of the companies. Relevant impact of this technology is expected in a wide range of sectors, from manufacturing to transportation, from energy to agriculture, from health to security [1-3].

The economic importance of IoT is underlined in several studies: to give an order of magnitude, a recent study of the European Committee estimates that the market value of the IoT in the EU will exceed one trillion euros in 2020.

Apart from private investments, several public initiatives have been set-up in the last years at national and European level to support the IoT diffusion. Among them, it is worth to mention the creation of Alliance for Internet of Things Innovation (AIOTI), set-up in 2015 by European Commission to closely work with all the stakeholders and actors of the IoT sector at European level [4]. Then, always in 2015 has adopted the Digital Single Market strategy, that aims to contribute € 415 billion per year to Europe's economy [5].

The huge expected growth of IoT in the next years and the planned investments in the sector foresee a high demand of professionals in the sectors. According to actual forecasts, 4.5 million developers contributing to IoT and billions of connected devices are expected by 2020.

European Universities and VET providers are not ready to face this educational challenge. Few European Universities and VET providers offer courses on IoT nowadays. On the contrary, U.S. Universities and private companies regularly offer courses on IoT to face the demand of professionals.

In this context, the European project IoT4SMEs has been funded in the framework of the Erasmus+ Strategic Partnership programme [6]. The main aim of the project is to qualify new professionals able to support the digital transformation of the European companies, exploiting to the advantages offered by the IoT technology.

Among the first activities of the project, an assessment of the labour market training needs has been performed, by means of a survey distributed in different European countries to IoT experts, managers and professionals working in SMEs. In this paper, we discuss the main findings of the survey.

II. AN INTRODUCTION TO IOT TECHNOLOGIES

Current predictions about the number of devices that will be connected within the Internet of Things (IoT), according to Gartner, indicate that there will be 20,400 million smart devices in 2020. By the same date, Cisco Systems speaks of 50,000 million and IDC of 212,000 million. All of them are fabulous numbers that clearly indicate the need to have the required skills needed to be part of this revolution.

IoT is the interconnected network of "smart" objects embedded with sensors, software, network connectivity and the necessary to collect and exchange data. In 2013, the Global Initiative on the Internet of Things (IoT-GSI) defined the IoT as “the infrastructure of the information society”. It is an architecture that allows the integration and exchange of data between the physical world and computers over the existing network infrastructure. IoT in reality does not focus on production but on the use of connected devices and products, which allows customers to communicate with their products as long as you need them.

The main components of IoT are:

- Hardware, which has the receptive physical objects and the capacities to obtain data and responds to the instructions
- Software, which enables the collection of data, as well as its storage, processing, manipulation and management
- Communications infrastructure, which consists of protocols, services and platforms that allow the exchange of data between physical objects.

The objects are characterized by identification, sensors, actuators, communication protocols, location and memory.

Thanks to the different existing technologies, the most common IoT sensors are able to measure the following parameters:

- Temperature
- Light variables
- Pressure
- Vibrations
- Deformations
- Acceleration
- Geophysical location
- Humidity
- Acoustic events, voice
- Visual events, video
- Behavioral processes
- Voltage
- Chemical molecules, used for example pollution detection

On the other side, the actuator is the technological complement of a sensor, it is a device that converts an electrical signal into an action, it is often converted into electrical energy, as movement. An actuator for example an electric motor that converts electrical energy into mechanical energy. The actuators can be simple or combined with an input IoT sensor.

Although there are different ways to classify IoT application areas, if we identify them for use in different markets, in addition to those cited for the industry, the latter are related to the following:

- Automation of buildings and home automation: for example, security, reduction of energy expenditure and maintenance, monitoring and control of buildings and “Smart homes”
- Smart cities: reduction of the expenditure of external lighting resources, traffic management, water distribution, waste management, environmental monitoring, surveillance, wireless connectivity, smart grid, etc.
- Automotive: connection of cars with infotainment services or emergency services, remote diagnosis of vehicles, layout and recovery of vehicles, safe driving, etc.
- “Wearables”: solutions in several areas based on very low power sensors, for example in sports, Smart watches, Google glasses, etc.
- Health: capture of health data, traceability of medical devices, personnel, patients, remote monitoring.

All these potential applications will have a huge impact on the marker. Between 2015 to 2020, BCG predicts that by 2020, 250 B€ will be spent on IoT technologies, products, and services. Predictive maintenance, self-optimizing production, and automated inventory management are expected to be the three top uses cases driving IoT market growth through 2020. Also BCG predicts that, by 2020, 50% of IoT spending will be driven by discrete manufacturing, transport and logistics.

III. LABOUR MARKET ASSESSMENT

Several studies suggest a high interest of companies towards IoT technologies, in particular regarding new applications, new services and new business opportunities. On the other hand, as all the new technologies, it also brings new real risks and new fake concerns. A quality training is the best way to facilitate the adoption of the technology, increasing the awareness about the potential solutions. It is also the correct way to reduce risks and remove fake worries [7].

Evaluating skills required by the labour market is essential in the build-up of the training process, defined by experts in the academic and corporate sector. The analysis plays an important role to promote the effective employability of the trainees. What is more, a proper needs and skills evaluation overlapping with the state of the art assessment can support a tailor-made learning process mirroring the chosen researchers' own competences. At a more general level, the evaluation aims to assess the overall initiative efficiency, while translating progress in terms of users' acquired competences and skills. The analysis has been performed by means of online surveys, designed to gather the point of view of experts, managers and professionals working into SMEs. This information, combined with other studies and policies about IoT, has allowed later to design training courses fitting the real needs of the labour market.

A. Methodological approach

Different players act in the labour market and are connected at different levels with IoT technologies. The survey had to be able to catch these different points of view.

The survey has been divided into three parts. The first one is for any kind of target and aims to get a general impression about IoT technologies. Including 12 questions, the section investigates about the level of awareness and familiarity with IoT technologies, the preferred sectors of applications of IoT and the kind of adopted IoT solutions.

Then, the survey has a branch according to the job position. A section is designed for directors, managers and designers. The main questions are related to the skills they consider relevant to manage IoT related projects and the ones the miss. Also, their point of view about the future of IoT technologies.

The last section of the survey is for IT and ICT staff. The main investigated aspects are the sector where they see the biggest sectors of IoT and the competences related to IoT that they would like to acquire in different domains (Hardware, OS and embedded systems, Communication and protocols, Mobile computing, Distributed systems).

B. The labour market point of view on IoT

The online survey has been launched on the 4th of February 2017 and closed on the 17th March 2017. In the whole, 800 companies from different countries participated to this survey, most of them (94%) coming from the countries of the IoT4SMEs partnership, that is to say France, Italy, Germany, Lithuania Portugal and Spain. Of the total 800 replies, 41% come from people working in SMEs, that is the target group of the assessment and will be analysed in depth. Other replies come from mini/micro-enterprises (25%) or large enterprises (34%).

In terms of business sectors, as shown in Fig. 1, the main answers are "Other" and "ICT", followed by "Services".

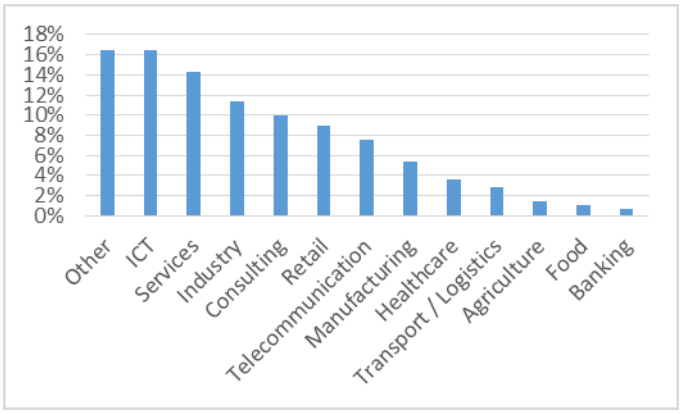

Fig. 1. Business sector of the companies answering to the survey

As shown in Fig. 2, IT/ICT staff and project managers is the most represented job role among the respondents (43%). Considering also an additional 9% of Designers, among the contacted companies the respondents are more technique-oriented. Up to 90% of the respondents has declared to be interested to IoT, and 63% is familiar with it. Additionally, 32 % declares to develop IoT projects/products, 32% will use them in the next future and the remaining 36% doesn't still plan to adopt IoT technologies. Further investigating why IoT technologies are still not adopted or its adoption is not planned, for 59% of the respondents the reason is lack of skills/competences, followed by a 15% related to financial issues and a 10% related to the lack of awareness about IoT. These answers show a great interest among IoT technologies, a great margin in its diffusion and a high need of qualified training.

More differences appear asking the domains where additional skills on IoT should be developed. As shown in Fig. 3, more than one third of the respondents require additional management skills are required, followed by IT and data analysis.

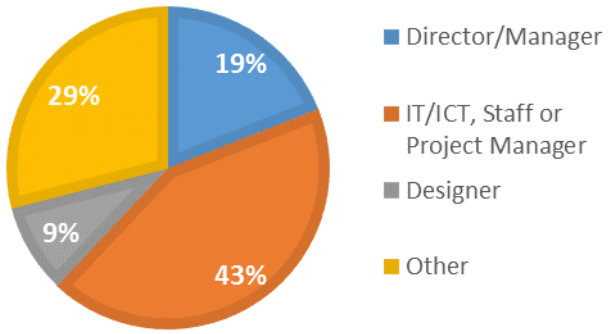

Fig. 2. Distribution of respondents to the survey by job profile.

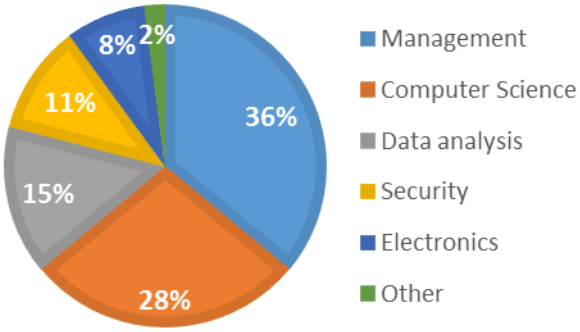

Fig. 3. IoT domains where additional skills are required.

The IoT technologies adopted by the respondents' companies has been investigated, divided by application. As shown in Fig. 4, the answers are quite heterogeneous. The main applications are oriented to services (20%) and data acquisition from sensors (20%), followed by smart objects (13%) and embedded systems (11%).

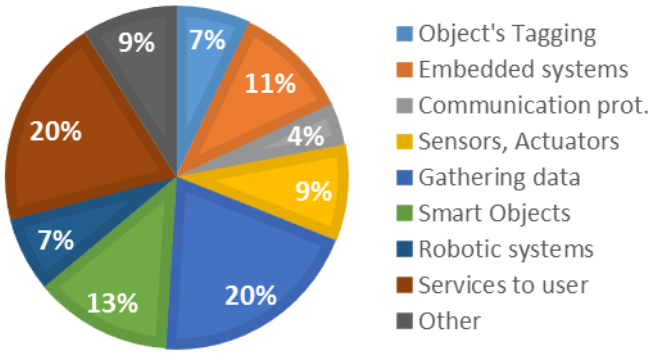

Fig. 4. IoT technologies by application.

C. *The managers' point of view*

After the generic questions, a specific set has been proposed just to managers and directors, in order to gather their specific point of view.

The first question is a ranking about the competences required to design and implement IoT project, with the possibility to assign a score between 1 (no needs) and 4 (highly needed). As shown in Fig. 5, it emerges that the most important competences are considered Creativity (average score 3.32) and Innovation management (3.31). The same competences/skills have been proposed again to the managers, asking in this case to evaluate their personal needs to be trained. The main training need is related to IT competences (3.02), while Creativity in this case takes the last place with 2.65, as shown in Fig. 6.

Then, the managers point of view has been asked about the achievement of future business outcomes that IoT will be able to bring. The 37% of the respondents believe that companies leveraging IoT will have a significant advantage in the next years and 25% believe that IoT business sector will have a relevant growth in the next future. The remaining 27% would like to learn more about IoT before expressing a judgement and only 11% sees too much confusion about IoT technologies. Finally, 80% of them would be highly interested to be trained on the IoT management.

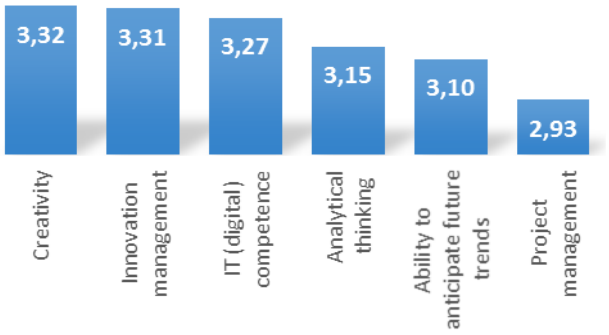

Fig. 5. Average ranking of the skills necessary to implement IoT projects (1 = no needs, 4 = highly needed).

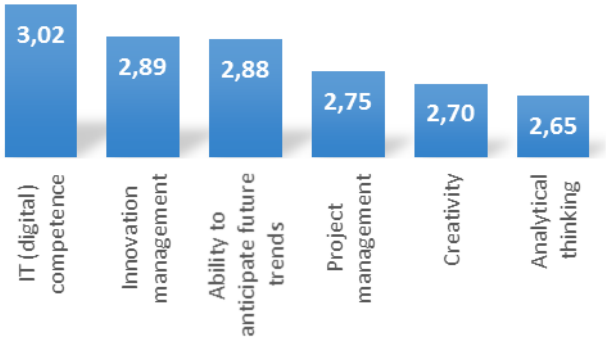

Fig. 6. Average ranking of the training needs required by managers to implement IoT projects (1 = no needs, 4 = highly needed).

D. *The ICT staff point of view*

At first, the interest of ICT staff declares to be trained in order to develop IoT projects, has been investigated, finding that more than 85% have replied positively. The skills that the ICT staff would personally improve to develop IoT projects has been investigated. In a range between 1 and 4, the average of the answers is quite similar. As shown in Fig. 7, the most requested skills are Machine learning (2.95) and Robotics (2.88), while the last one is Mobile computing (2.56).

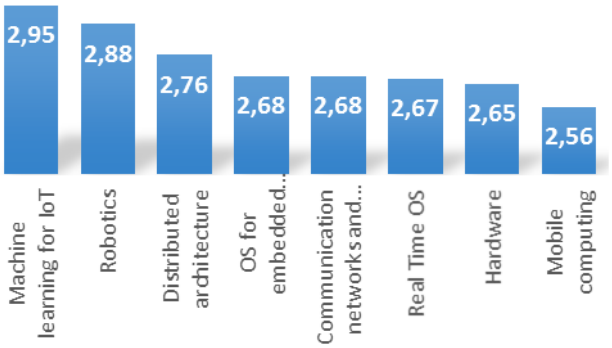

Fig. 7. Average ranking of the training needs required by ICT staff to implement IoT projects (1 = no needs, 4 = highly needed).

Then, the training needs have been investigated more in deep in different domains. In the "Hardware" domain, as shows in Fig. 8, the most relevant training areas are Sensors (29%) and Microcontrollers (23%). It's worth noting that the interest in microprocessors half the one for microcontrollers.

In the "Operating Systems and Embedded Systems" domain, as shows in Fig. 9, the more than a half of the answers are related to Embedded development and OS (31%) and Application development for embedded systems (29%).

In the "Communications, Networks and Protocols" domain, as shows in Fig. 10, there is almost an equal interest among Low power long and short-range wireless protocols, Networking and Web protocols. Instead, time constraints protocols have very few interest.

In the "Mobile computing" domain, as shows in Fig. 11, the most requested skill is Android development (35%), that is about the double of IoS development (19%) and four times the Universal Windows Platform development (8%). Mobile application design has a relevant interest too (27%).

Finally, in the "Distributed Architecture" domain, as shows in Fig. 12, the most requested skill definitely the Middleware for IoT (40%), with a percentage more than double of all the others.

Then, we have asked to the ICT staff what would be the advantages in their companies to leveraging the IoT. Results are show in Fig. 13. In general services (Data Analytics and services 28%, Customer services 26%) are considered much more important than processes.

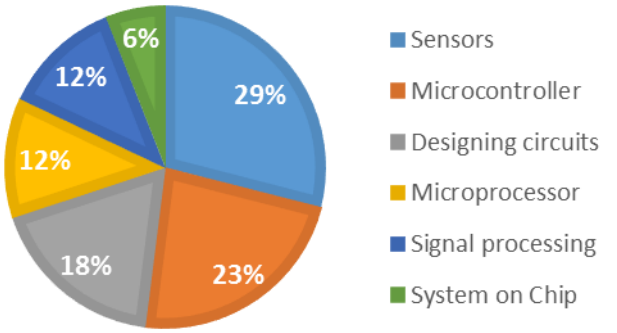

Fig. 8. Main training needs in the "Hardware" domain.

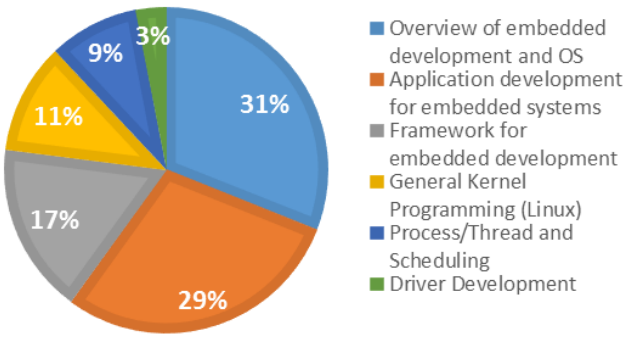

Fig. 9. Main training needs in the "OS and Embedded systems" domain.

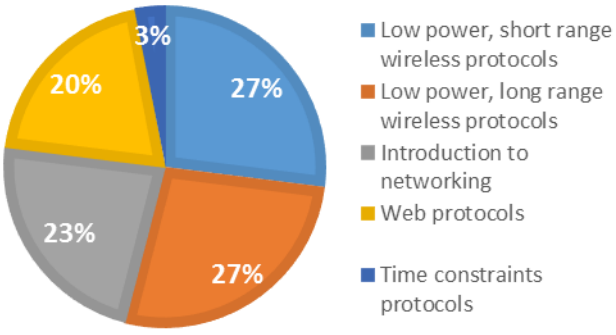

Fig. 10. Main training needs in the "Communications, Networs and Protocols" domain.

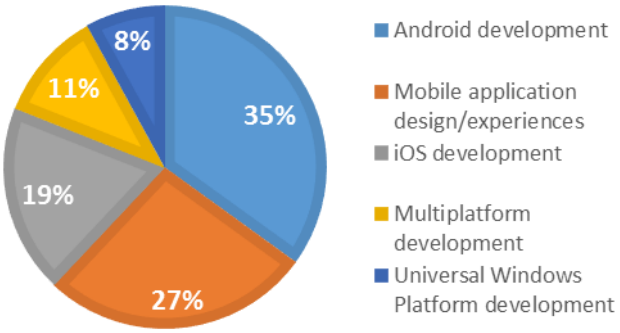

Fig. 11. Main training needs in the "Mobile Computing" domain.

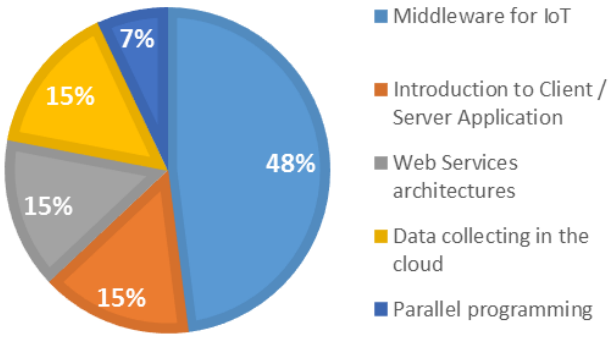

Fig. 12. Main training needs in the "Distributed Architecture" domain.

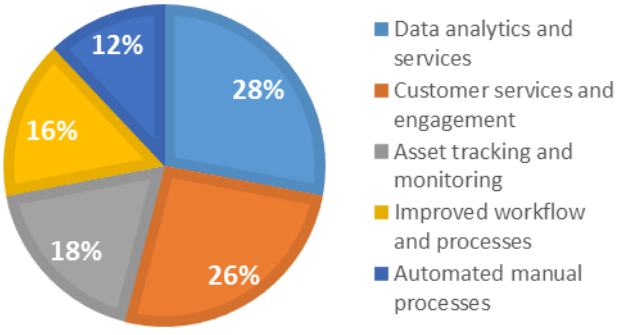

Fig. 13. Expected advantages to leveraging the IoT according to ICT staff.

IV. National Policies and the State of the Art of IoT in Different European Countries

The data for this summary were collected by parnters from different European countries of the the European project IoT4SMEs which has been funded by the framework of the Erasmus+ Strategic Partnership programme [6].

Various European counties and companies support the conduction of IoT-related programs with several projects. Table 1 below provides an overview concerning recent or currently running IoT- research projects.

In addition we found different development levels concerning the employment of IoT in selected European countries.

Concerning labour market trends and business opportunities, for Germany we found that IoT-SME-Mangers believe that the IoT will be a big deal, but most consumers in this country still don't know what it is, according to our research. They are interested in potential applications of the technology, though, suggesting some education is in order. In June 2015, the awareness of the IoT was at just 12% of consumers ages 16 and older [8]. That is striking for a country where 41% of marketers believe the IoT will have a massive impact on them by 2020 [9]. When Deutsche Telekom asked respondents whether they were interested in a variety of technologies that would ultimately be delivered by an IoT framework, the answer was frequently yes. A majority of respondents under age 60 wanted to be able to track shipments online, and nearly as many were interested in various smart-home capabilities like being able to turn the lights on and off remotely. Other popular technologies would allow cars to talk to each other about traffic and inform drivers about parts that need replacement, and adjust home heating automatically depending on whether anyone was there. Smart appliances including refrigerators and washing machines also garnered significant interest. These results leave little doubt that consumers in Germany are interested in the IoT after all — but education is clearly required about what it entails [10].

In France, it was the Nabaztag in 2005 that was surely the first connected object for the general public entertainment. 150,000 copies of the connected rabbit were sold, according to the company that repurchased the product. This first French connected object paved the way for the creation of many start-ups in the field of connected objects. Out of the 10 iPhone connectable devices the most sold on AppStore, four of them are French.

It is, however, important to note the supply segmentation of the connected objects between two global markets: the market for connected objects aimed at enterprises, and the market for connected objects aimed at consumers, which does not have the same degree of maturity. The prospects of demand for connected objects from consumers are now rather feverish. Indeed, if 53% of the French people who use the Internet do it via their smartphone, which represents a rise of 10 points in 18 months, only 17% of them are equipped with connected objects. The offer for individuals is currently very diversified and many French startups plan to sale or develop the connected objects of tomorrow.

TABLE I. Selection of current European IoT-projects

Acronym	Name	Coordinator
SOCIOTAL	Socially aware citizen-centric IoT	Univ.Surrey, UK
VITAL	Virtualized Interfaces for IoT deployments in smart cities	DERI, Ireland
ALMANAC	Reliable smart secure IoT for smart cities	SMB, Italy
CASAGRAS2	Coordination a for Global RFID-related Standardisation	AIM, UK
TWISNet	Trustworthy Wireless Industrial Sensor NETworks	Commissariat à l'Energie Atomique, FR
IoT-A	IoT Architecture	VDI/VDE-IT
ebbits	Enabling the Business-Based IoT and Services	Fraunhofer FIT, DE
IoT@Work	IoT at Work	Siemens, DE
AMI-4-SME	Ambient Intell.Technol. for Systemic Innovation in Manufacturing SMEs	ATB, DE
CE-RFID	Coord. Europ. Efforts for Promoting European RFID Value Chain	METRO, DE
CuteLoop	Customer in the Loop	ATB, DE
EUWB	Short Range Radio by Ultra-Wideband Radio Technology	GWT-TUD GmbH, DE
HYDRA	Heterogeneous physical devices in a distributed architecture	Fraunhofer FIT, DE
PRIME	Privacy and Identity Management for Europe	ULD,DE
IoT6	Integration of IoT by IPv6-based Service Oriented Architecture	Mandat International, Switzerland
SMARTIE	Secure and smarter cities data management	IHP, DE
SPRINT	Platform For Integration Of IoT	EADS, DE
GAMBAS	Adaptive Middleware for Behavior-driven Autonomous Services	Univ.Duisburg -Essen, DE
TagItSmart!	Smart Tags driven service platform for enabling ecosystems of connected objects	Donte Lotiro, SP
SWARMs	Smart and Networking Underwater Robots in Cooperation Meshes	HI Iberia, SP
C2NET	Cloud Collaborative Manufacturing Networks	Universitat Politècnica de València, SP

Interestingly, 37.5% of French industrialists believe that IoT will play an important or major role in improving the internal processes. On the other hand, they represent 64% for the two external processes studied: development of new services and improvement of existing services. This awareness leads to actions for the most advanced companies in their reflections and that already have an overview of the benefits that may go with the „digitization“ of factories, for example. French studies are showing that whether for internal processes or services, the main objectives of the French industrialists for the implementation of the IoT are rather internal-focused with an overall objective of improving competitiveness: to improve productivity, to lower costs and to stay competitive.

The IoT in Italy is a growing market that whole now the two billion euro (with a growth of 25% respect to the 2014), giving good signals, driven both by consolidated applications that harness the connectivity of smartphones that use other technologies such as wireless. Currently the development of IoT applications in Italy can be summed up in three levels: an early development, experimental phase, and solid results, ready for the market. The sector and its potential appears unlimited. Interesting on the market are in particular gas meters with 25% and the connected car with a control unit with 24%, two segments that alone touch one billion euro of value and are just a few of just numbers released by the observatory dedicated the

In Lithuania we discovered a different level: The general awareness of IoT in Lithuanian business is low and generated solutions or its applications remain outside of main stream business practices. The commitment is expected to grow with the benefits of IoT becoming more apparent as technology matures and develops outside of Lithuania. Nevertheless, on HEI level there are already significant research activities visible.

The development of IoT in Portugal is already following the international trend. Cities, houses, cars, refrigerators, television sets, belts and watches, all connected, collecting data, to transmit information. This may seem like a futuristic scenario, but the experts confirm: the IoT is really happening and Portugal is not lagging behind. “The IoT is already embodied in our society, in the urban environment in which we live and that is getting hyperconnected”, says Nuno Pereira Leite, director of Esri Portugal's business. „The growth of the IoT in Portugal is not inseparable from the international panorama, because one of the main effects of the growing ability of intercommunication which characterizes it is, without a doubt, the reduction of distances and the ability to develop solutions that can either be local and global, which can contribute to the internationalization of projects developed here,“ argues Frederick Muñoz, Smart Cities Solution Architect at IBM Portugal.

European funding has given an important boost in the realization of projects, which puts the country in a good position. “Portugal is well placed. However, you have to be able to orchestrate the integration of technology in order to have applicability, sense and added value in the lives of citizens and organizations, and apply intelligence to be able to process the information to extract and make decisions in real-time”, stressed the director of enterprise technology solutions in Portugal, Vasco Mendes de Almeida. Realizing the potential, the expert believes that sectors such as health, transport, utilities, safety and security, etc., may indeed enter into new paradigms as “result of the ease of integration of information”. The smart cities are an example of this integration and that is now on the agenda of decision makers.

Similar developments have been detected for Spain. There are already numbers of high level technical IoT-solutions. In many cases these solutions are already transferred into successful businesses , like a Smart Agriculture project in Galicia to monitor vineyards, the e-Physio project which is designed to analyse muscular effort to provide training improvements or a wireless system to improve hydric flow calculation in open foil. With their state-of-art business IoT-solutions companies like Libelium, Telefonica or IOTIFY are demonstrating the awareness of the Spanish IoT-Market. In addition, there are already very interesting public and private funded IoT-research projects (see Tab 1.), partly led by Spanish universities or companies, which are demonstrating a very high scientific level in the respective areas.

V. CONCLUSIONS

SMEs are essential components of the European economy. Therefore, it’s essential to ensure their survival and sustain their growth. Innovation and digital competences are key driver to raise their competitiveness. Internet of Things is a technology with high level of innovation, high impact in several sector and high business potential. The survey carried out in the framework of the IoT4SMEs project has proven once more the high interest of European SMEs towards this technology, but also several concerns.

The proper answer to these requests of the labour market is a qualified training, able to allow professionals to acquire relevant strategic skills and be ready to catch the new business opportunities offered by the IoT technology.

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REFERENCES

[1] L. Atzori, A. Iera, G. Morabito, “The internet of things: A survey. Computer networks”, 54(15), pp.2787-2805, 2010.

[2] D. Miorandi, S. Sicari, F. De Pellegrini, I. Chlamtac, “Internet of things: Vision, applications and research challenges”, Ad Hoc Networks, 10(7), pp.1497-1516, 2012.

[3] S.C. Mukhopadhyay, N.K. Suryadevara, “Internet of things: Challenges and opportunities”, In Internet of Things (pp. 1-17). Springer International Publishing, 2014.

[4] https://aioti.eu

[5] https://ec.europa.eu/digital-single-market

[6] https://www.iot4smes.eu

[7] S. Martin, D. Assante, I. Hamburg, A. Owens, R. Tavio Gallo, K. Konstantinou, A. Pascoal, M. Spatafora, M. Castro, “The role of VET certifications in MOOCs”, EDULEARN Conference, Barcelona, 2017.

[8] https://de.statista.com/statistik/daten/studie/448676/umfrage/bekanntheit-des-begriffs-internet-der-dinge-in-deutschland/(accessed 2018-01-19).

[9] eMarketer. Europe's Marketers See Challenges Shift as Technology Advances Digital platforms are transforming the marketer's role - See more at: https://www.emarketer.com/Article/Europes-Marketers-See-Challenges-Shift-Technology Advances/1012672?ecid=MX1086#sthash.rCPymazV.dpuf. 01 07 2015. (accessed 01/19/2018).

[10] eMarketer. Internet of Things Has Big Awareness Gap in Germany. 28.082015. https://www.emarketer.com/Article/Internet-of-Things-Has-Big-Awareness-Gap-Germany/1012919 (accessed 01/13/2018).

[11] L'IOT dans l'Industrie en France 2016: https://www.pac-online.com/liot-dans-lindustrie-en-france (accessed 06/07/17).