IoT4SMEs
INTERNET OF THINGS FOR EUROPEAN SMALL AND MEDIUM ENTERPRISES

Erasmus+

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State of art of IoT technologies at European level

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Introduction

Today the Internet is used in any situation to send, receive or communicate a variety of information, wherever the most people cannot do without their smartphone. The concept of the **'Internet of Things' (IoT)** means that in addition to having very powerful computers, small devices – thin clients – will be employed in order to connect the virtual world with the real world. The term 'UbiComp', or 'ubiquitous computing', is very much related to IoT.

The 'thing' is physically presented by identifiable real world objects. These objects can receive input from the environment and turn signals into data to be sent on the Internet so that they are stored and processed by other devices. Intelligent objects are also capable of receiving data from other network instances and act in various ways after processing.

The equation that defines the Internet of Things is:

PHYSICAL OBJECT
+
CONTROLLER, SENSOR, ACTUATOR
+
INTERNET
=
INTERNET OF THINGS.

In 1977 *Bill Gates* said in an interview „A computer on every desk and in every home" (Bill Gates 2017), and no one would have ever thought possible one day such a situation. The same thing will happen for the IoT. A study of Morgan Stanley pointed out that IoT experienced a good growth in the last 12 months, as the public began to approve the idea of smart everyday objects (Morgan Stanley 2017). Still, for the next five years, it is believed that the main target of the IoT will be the corporate market, which could use the technology to cut costs and increase productivity. Moreover, it states that 2017 will be the year of IoT for the uses of everyday life. Taking into account the time of study and production of 12 to 18 months, a wave of IoT products should reach the market between the second half of the first months of 2017 and 2018.

The large companies have already positioned themselves in terms of staffing and finance to take advantage of the potential of smart engineering and digital transformation. Now small and medium-sized enterprises (SMEs) are following their example. However, up to now only around 20 per cent of European SMEs have digitized their processes, though in five years this figure is expected to be 80 per cent. For a long time now, the IoT has no longer been the music of the future, and digitization of all production and business processes is an existential must for every company.

Experts consider that SMEs in particular will have good opportunities through digital transformation to increase their competitiveness and defend their position against their competitors. There is therefore no alternative to the digital transformation of the production processes. This is the only way that enables a look at the complete process and supply chain in real time and makes the customer structure more transparent. Thus, digital transformation becomes a win-win situation.

Customers enjoy a distinctly optimized service and companies gain attractive business models (see: Telekom 2017).

This report analyses the state of the art of the IoT at European level. It was produced within the ERASMUS+ project *Internet of Things for European Small and Medium Enterprises* funded by the European Union. The report is based on contributions of the project partners from Germany, France, Italy, Lithuania, Portugal, and Spain and was assembled by University of applied science (FHM), Bielefeld, Germany.

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1. Internet of things: global state of the art

1.1. Smart Engineering, digital transformation and SME 4.0

Internet of Things is considered to be a relevant assumption for the promotion of the so-called **'Industry 4.0.'**, or 'Production 4.0' is the current trend of automation and data exchange in manufacturing technologies. Industry 4.0 is an industrial evolution concept with four stages (see fig. 1). The term is mainly used in Europe, having its roots in Germany.

The term 'Industrie 4.0' is a German word creation, so there is, for example, the word 'industry 4.0' as an English equivalent. There are, however, similar initiatives in many countries such as France 'Industrie du *future'*. In the US, it is called 'Industrial Internet Consortium (IIC)'. The Industrial Internet Consortium was founded in March 2014 by the companies *AT&T, Cisco, General Electric, IBM* and *Intel*. New Internet technologies are to be jointly promoted, although the approach is not limited to the industrial sector. Further initiatives are in Japan under the name 'Industrial Value-Chain Initiative (IVI)'. Initiators are major Japanese companies. China also took similar initiatives in the five-year plan of 2015. They are intended to play a decisive role in the shift from low-wage countries to global industrial power. South Korea also invests in so-called smart factories.

Industry 4.0 has its basic focus on the production process within a „smart factory" (Wikipedia, Industry 4.0 2017), while the Internet of Things focuses on the utilization phase of digitalized and connected devices and products. In order to describe general digital transformation processes, resulting value chain changes and effects related to non-industrial small and medium enterprises (SME) we consider the term 'industry 4.0' as too constricted (see fig. 1).

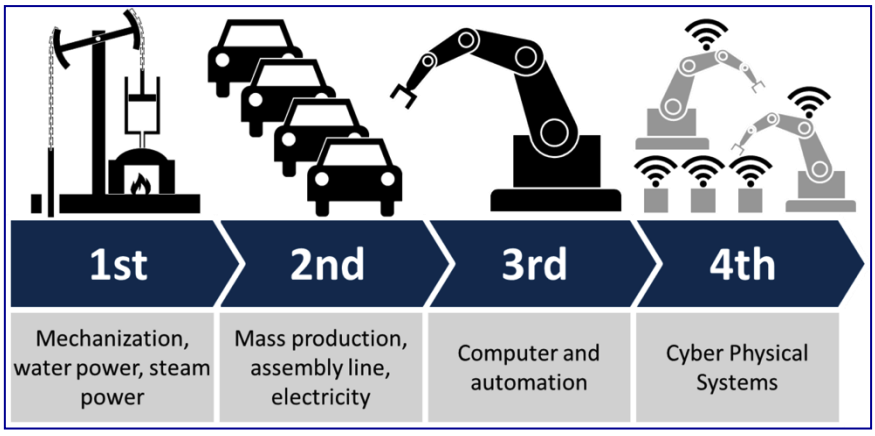

Figure 1: Industrial revolution and future view (Wikipedia, Industry 4.0 2017).

The Industry 4.0 passes through the concept of smart or intelligent factory, which consists of 3 parts:

- Smart Production: new production technologies that create collaboration between all elements in the production or collaboration between operator, machine and tools;

- Smart Services: all the information and technical facilities which allow you to integrate systems; but also all the structures that allow, in a collaborative way, to integrate the companies as a supplier - customer each other with external structures such as roads, hub, waste management, and so on;

•Smart Energy: all this always with an eye to energy consumption, creating higher performance systems and reducing energy waste.

Enabling technologies are:

•Advanced production systems: interconnected and modular systems that allow flexibility and performance. These technologies are covered by the automatic material handling systems and advanced robotics.
•Additive Production: additive manufacturing systems that increase the efficiency of materials.
•Augmented Reality: vision systems with augmented reality to better judge the operators in carrying out daily activities.
•Simulation: Simulation of interconnected machines to optimize processes.
•Horizontal and vertical integration: integration and exchange of information both horizontally and vertically, between all actors of the production process.
•Industrial Internet: communication between the elements of production, not only within the company but also externally through the use of Internet.
•Cloud: implementation of all cloud technologies such as online storage of information, the use of cloud computing and external services for data analysis, in which the Cloud are also covered management techniques of large amounts of data through open systems.
•Cyber security: the increase in internal and external interconnections open the door to the whole issue of information security and systems that must not be altered from the outside.
•Analysis of Big Data: management techniques of large amounts of data through open systems that allow forecasts or predictions.

Industry 4.0 creates or resembles what has been called a 'smart factory' (Wikipedia, Industry 4.0 2017). A smart factory is a smart system that is based on smart engineering. Smart systems incorporate functions of sensing, actuation, and control in order to describe and analyse a situation, and make decisions based on the available data in a predictive or adaptive manner, thereby performing smart actions. In most cases the *smartness* of the system can be attributed to autonomous operation based on closed loop control, energy efficiency, and networking capabilities. Smart systems typically consist of diverse components (Wikipedia, Smart Systems, 2015):

•Sensors for signal and data acquisition;
•Elements transmitting the information to processing unit;
•Processing unit that take decisions and give instructions based on the available information;
•Components transmitting decisions and instructions;
•Actuators that perform or trigger the required action.

Smart systems are linked to the development of the IoT, in that they provide smart functionality to objects, e.g., to industrial goods in the supply chain, or to food products in the food supply chain. With the help of active or passive object identification technology, wireless sensors, real-time sense and response capability, energy efficiency, as well as networking functionality, objects will become smart objects. These smart objects are often seen as special IoT-applications, e.g., they could support the elderly and the disabled, or the close tracking and monitoring of food products could improve food supply and quality. Smart industrial goods could store information about their origin,

destination, components, and use. And waste disposal could become a truly efficient individual recycling process (see: Wikipedia, Smart Systems, 2015).

What is **smart engineering**? This term covers the methods, processes and IT tools for the cross-disciplinary, system-oriented development of innovative, intelligent and connected products, manufacturing facilities and infrastructures. These areas are currently also grouped together under the term Industry 4.0. This refers to the networking of, and comprehensive exchange of information between, all the components involved in the manufacturing process, and between all the individual part-processes of product development and manufacture, with the aim of achieving significant improvements in performance, cost, quality and customer acceptance of products.

An important part of smart engineering is securing and testing an interdisciplinary lifecycle management process, as the various knowledge domains and interrelationships are currently not sufficiently connected, with the result that information can be lost and networked relationships have to be recaptured and re-implemented.

For product development purposes, smart engineering applications come into play as early as the planning stage, because it is here that, within a diverse range of defining criteria, the developer first starts to create the product's structure and associated information models. This digital development process ultimately benefits the qualifying and networking of production and the modelling of processes and automation technology. This must involve secure and reliable communication between not just the individual sub-processes but also the various components of the manufacturing facilities. A particular challenge here is communication with mobile elements. Ultimately, smart engineering is about the integration of product development, production planning and production management to ensure the rapid market-ready implementation of innovative product ideas and the creation of value via a digital development process (see: University of Duisburg 2017).

For this report, smart systems that focus on typical SME value chains will be considered as **SME 4.0**. According to Herrmann, Pentek und Otto (see: 2016: 11) **smart engineering** constitutes of:

- cyber-physical systems,
- Internet of things,
- cloud computing.

In cyber-physical systems (CPS), physical and software components are deeply intertwined, each operating on different spatial and temporal scales, exhibiting multiple and distinct behavioural modalities, and interacting with each other in a myriad of ways that change with context (see: US National Science Foundation 2010). Examples of CPS include Industry 4.0 or SME 4.0 in general or smart grid, autonomous automobile systems, medical monitoring, process control systems, robotics systems, and automatic pilot avionics in particular. Often, CPS are seen as a pre-stage to IoT. They are sharing the same basic architecture, nevertheless, CPS present a higher combination and coordination between physical and computational elements (Rad, et al. 2015: 73-79).

Common applications of CPS typically fall under sensor-based communication-enabled autonomous systems. For example, many wireless sensor networks monitor some aspect of the environment and relay the processed information to a central node (see: Karnouskos 2011: 2). A challenge in the development of cyber-physical systems is the large differences in the design practice between the

various engineering disciplines involved, such as software and mechanical engineering (see: J. Fitzgerald 2014: 1).

1.2. Internet of Things: definitions, components, technologies

IoT is the network of interconnected **smart objects**, which are embedded with sensors, software, network connectivity and necessary electronics that enables them to collect and exchange data making them responsive. In 2013, the Global Standards Initiative on Internet of Things (IoT-GSI) defined the IoT as „the infrastructure of the information society" (ITU 2017). It is an architectural framework which allows integration and data exchange between the physical world and computer systems over existing network infrastructure. IoT does not have a focus on production, but on the utilization phase of digitalized and connected devices and products, which allows the vendors to communicate with their own products while they are used by the customers and to provide new 'digital' customer services such as predictive maintenance (see: Vogt 2016).

The technology ecosystem of the Internet of Things is diverse and includes complex solutions including hardware and software features heterogeneous in terms of performance and costs. RFID tags (Radio Frequency Identification) and readers, sensor nodes, gateways and control centres are just some of functional elements that make up the current Internet of things. The mode with which the individual devices are organized in networks and interact with each other depends strongly by the specific application.

In order to provide an architectural classification, it can be said that the devices which constitute the Internet of Things are generally structured in an architecture of three-level network:

- Interface with the physical world: a large number of nodes at this first level (tags or sensory units) interacts with the environment by providing an identification code, acquiring information or commanding an actuator. These nodes are devoid of power (passive tags) or powered by battery (sensor units and actuators) and generally characterized by a reduced processing capacity and memory; They are also equipped with mechanisms for communication (wired or wireless) to communicate with the units of the second level. The cost depends on the features offered and can vary from a few euro cents per passive RFID tags up to 30-150 Euros for nodes with sensory capabilities and / or implementation; the operational life ranges from a few years to the battery-powered devices (strongly dependent on the type of application), until to exceed ten years for passive RFID tags.

- Mediation: the second-level units, which includes the RFID tag readers and gateways, have the task of collecting the information from the first-level nodes to convey them to the control centres. They are characterized by a greater capacity processing and memory, are generally powered from the grid fixed and have a cost which can vary greatly, from 50 EUR a gateway node to 2,000 euro of a RFID reader.

- Processing and control center: the third level units, which includes the acquisition systems, central and operating rooms, have the task of receiving the information from the units of the second level for the subsequent stages of storing, processing and commissioning usability of the data.

The lack of standardization in the first two levels of units has led to the consolidation an ad-hoc approach, aimed at optimizing the individual application (for example on the energy side) rather than to the abstraction from the specific problem application in favour of a development useful to a wider class of applications. This heterogeneity of technological solutions is even more evident when looking at the mechanisms for communication between devices, with solutions for specific application field.

For example, in the field of *Smart Home & Building*, technology used for the interconnection between the level 1 and level 2 devices depends on the specific application scenario; then we find both radio technologies (such as IEEE 802.15.4, ZWave, Bluetooth, UWB) and wired technologies (such as Power Line Communication). Similarly, in the field of Smart City and Smart Environment there is a clear distinction between the last mile of communication technologies and technologies for the creation of the backend infrastructure. Also in this case, depending on the application scenario, the last mile technologies vary by ZigBee, Wireless M-BUS, WiFi and Bluetooth, while the backend infrastructure generally supports the 2G mobile technology, 2G +, 3G, Wireless Mesh or Power Line Communication.

Main IoT components are:
•Hardware: making physical objects responsive and giving them capability to retrieve data and respond to instructions;
•Software: enabling the data collection, storage, processing, manipulating and instructing;
•Communication Infrastructure: consists of protocols and technologies which enable physical objects to exchange data.

Smart objects are determined by:
•Object identification,
•Sensors,
•Actuators,
•Communication protocol,
•Identification of location,
•Memory.

Object **identification** is usually based on auto-id technologies such as:
•RFID, Bluetooth beacons etc.,
•Bar-, QR-Code,
•Image recognition,
•Biometrical identification:
-Fingerprint,
-Iris-recognition,
-Face recognition,
•Analysis of surface structures,
•GPS in combination.

Based on various technologies common IoT **sensors** are able to measure the following parameters:

•Temperature,
•Various light parameters,

- Pressure,
- Vibration,
- Deformations,
- Acceleration,
- Cardinal direction,
- Moisture,
- Acoustical events, speech,
- Visual events, video,
- Personal profiles, e.g. behavioural profiles.

The technological complement to a sensor is an **actuator**, a device that converts an electrical signal into action, often by converting the signal to nonelectrical energy, such as motion. A simple example of an actuator is an electric motor that converts electrical energy into mechanical energy. Actuators may be stand-alone (i.e. just an output device), or may be combined with an IoT input sensor. An example might be an intelligent light bulb designed for night lighting outdoors – where the sensor detects that the ambient light has fallen to a predetermined level (that may be externally programmable), and in addition to reporting this data upstream also directly triggers the actuator (the light bulb itself) to turn on.

In many cases an actuator, in addition to acting on data sent to it over an IoT network, will report back with additional data as well, so in some sense may contain both a sensor as well as an actuator. An example, again using a light bulb: the light bulb turns on only when specifically instructed by external data, but if the light element fails, the bulb will inform the network that this device is no longer capable of producing light – even though it's receiving data. A robustly designed network would also require the use of light bulb actuators that issue an occasional 'heartbeat' so if the bulb unit fails completely, the network will know this and report the failure (see: Parasam 2016).

With regard to the OSI seven-layer reference model there are different communication protocols available. Some protocols work jointly on different OSI-layers.

<u>There are two major technical problems that are currently on the agenda:</u>

- Protocols for meshes, communication between objects without access point
- Requirement of low energy consumption.

This selection of available protocols is not complete:

- Bluetooth low energy (BLE): Specification providing a low power variant to classic Bluetooth with a comparable communication range.
- Near-field communication (NFC): Communication protocols enabling two electronic devices to communicate within a short range.
- Radio-frequency identification (RFID): Technology using electromagnetic fields to read data stored in tags embedded in other items, also for identification.
- WiFi (802.11b, g, n),
- Z-Wave: Communication protocol providing short-range, low-latency data transfer at rates and power consumption lower than Wi-Fi. Used primarily for home automation.
- ZigBee: Communication protocols for personal area networking based on the IEEE 802.15.4 standard, providing low power consumption, low data rate, low cost, and high throughput.
- GSM, 3G, LTE, 4G.

Current technologies for identification of location are GPS, triangulation or ultrasound for room inside of buildings. Memory technologies depend on actual hardware implementation.

IoT refers to networking objects with the Internet so that these can communicate independently over the Internet and carry out various tasks for the owner. The most important evolutionary step in implementing the vision of the Internet of Things took place in 2012 when the leading Internet groups switched to the Internet Protocol Version 6. This hugely increased the number of available IP addresses: whereas before 4.3 billion addresses had almost entirely been used up, there are now 340 sextillion free addresses available. Furthermore, web addresses could previously only be issued to computers, smartphones, and other devices - now every container, every pallet and, even every individual garment can get its own IP.

The IoT-map (see fig. 2) below provides an interesting view on different application areas for IoT-system with and without allocated IP-addresses. The map makes a difference between IP-based -system und such systems based on non-IP-protocols. Systems based on non-IP-protocols are for instance RFID or Meshes. Actually, from the computer science point of view there is no Internet. But for this report, such system shall belong to the class of IoT applications. On the other hand, we have IP-based systems – part of the Internet. This particular figure focuses on systems of smart objects and systems of machines attached to people – the Internet of people.

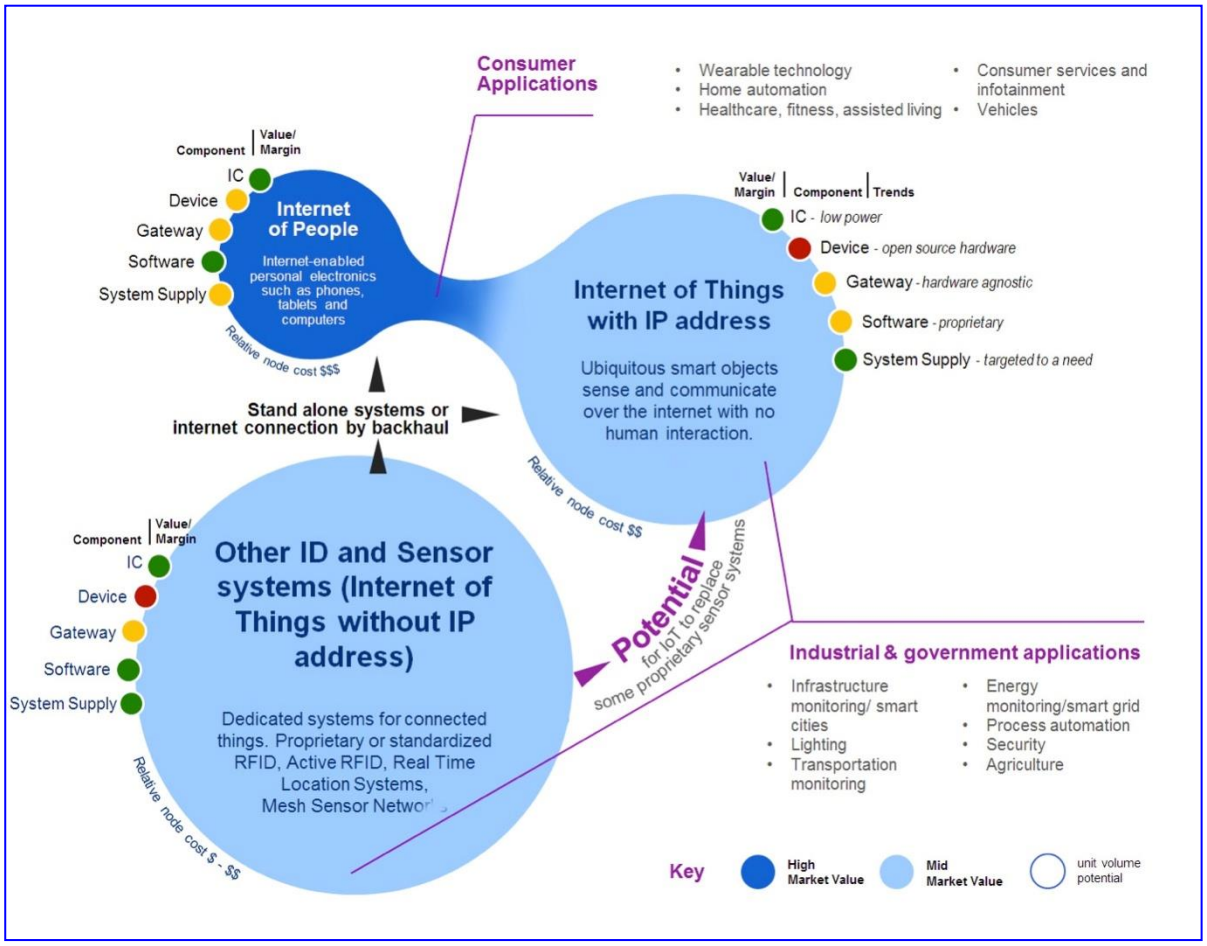

Figure 2: Different application areas for system with and without allocated own IP addresses (IDTechEX 2017).

The non-scientific term 'Internet of people' (IoPTS) describes the vision where people, things (physical objects) and services are seamlessly integrated into the networks of networks as active participants that exchange data about themselves and their perceived surrounding environments over a web-based infrastructure. The IoPTS, amongst many other aspects, is characterized by: its massivity in terms of people, services, and things, that will generate information populating massive databases; its advanced capability for tracking people, objects and things; its focus is on multiple frontiers, a person can assume multiple identities where each identity is associated with multiple things (devices) connected to multiple services; its vertical mobility with a phenomenal increase in the level of complexity from a governance point of view (see: Eloff, et al. 2009).

1.3. Internet of Things: application areas

There are several options to classify IoT application areas, e.g., a technical classification or a function-based classification would be possible. In order to address specific SMEs' requirements, we have chosen a market-oriented classification. We have identified a number of key markets for the IoT with potential for exponential growth (see: fig. 3).

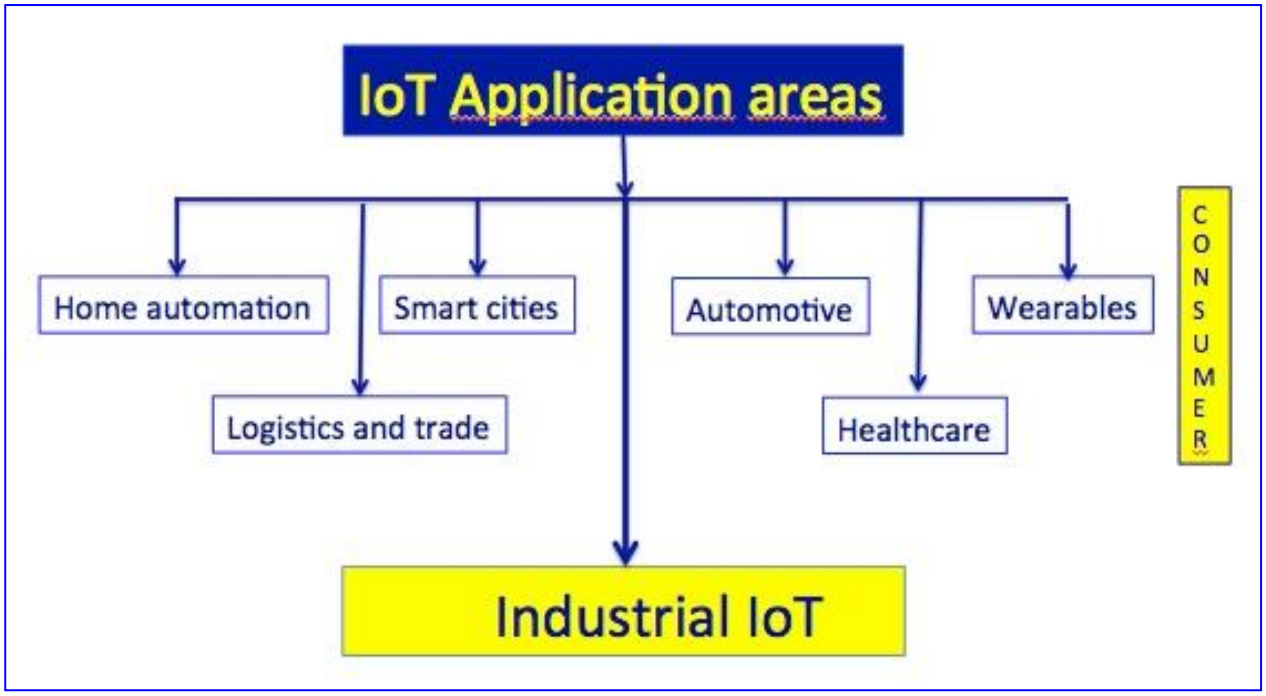

Figure 3: IoT application areas (own illustration).

Below we have listed characteristic applications and products that belong to the above IoT key markets (Texas Instruments 2017):

1.Building and home automation:

Typical functions: enhancing security, reduction of energy and maintenance costs, monitoring and control of intelligent buildings and smart homes.

Product examples:

•Light control;

•Smart Lock: can be activated using keys, buttons, RFID, biometrics or other types of door keypads and readers;
•Nest: Learning Thermostat that can automatically adjust temperature based on location with far-field sensor to determine the time and temperature from a distance.

2.Smart cities:

Typical functions: Reduction of cost & resource consumption for outdoor lighting, traffic management, water distribution, waste management, environmental monitoring, surveillance, long range wireless connectivity, centralized & integrated system control.
Product examples:
•Smart grid for energy distribution,
•Smart meters,
•Smart sensor bank: array of standard sensors mounted on light poles that detect location (GPS), air quality, proximity to detect traffic/pedestrian movement, light level monitoring, moisture, temperature and more.

3.Industrial IoT (as the main IoT application field):

Typical functions: This term is linked to *Industry 4.0* and *Digital Transformation*,
see special chapter below.

Product examples:
•Communication Modules,
•Various Sensors,
•Process & data analytics.

4.Automotive:

Typical functions: connected car with a variety of infotainment services and connected car applications for drivers such as emergency services, remote vehicle diagnostics, vehicle tracking and recovery, safe driver and no-texting services.

Product examples:
•Engine management,
•Infotainment,
•Electronic toll collection system.

5.Wearables:

Typical functions: sensor based ultra-low power solutions in various areas, e.g. sports.

Product examples:
•Fitbit allows people to track their health and exercise progress,
•Smart watches,
•Glasses, like Google glass.

6.Healthcare:

Typical functions: capture health data, hospitals keep tabs on the location of medical devices, personnel and patients.

Product examples:
•Remote health monitoring,
•Tracking Healthcare Devices,
•Smart disease surveillance,
•Ultrasounds, thermometers, glucose monitors, electrocardiograms become connected and letting patients track their health.

7.Logistics and trade:

Typical functions: asset tracking, mobile payment.

Product examples:
•Inventory & Warehouse Management,
•RFID tags, active & passive, near-field communication (NFC),
•Bluetooth beacons,
•Connected fleet management.

Figure 4 below provides an impressive image of the traffic increase of M2M connections resulting from the IoT utilization, here in an international provider network.

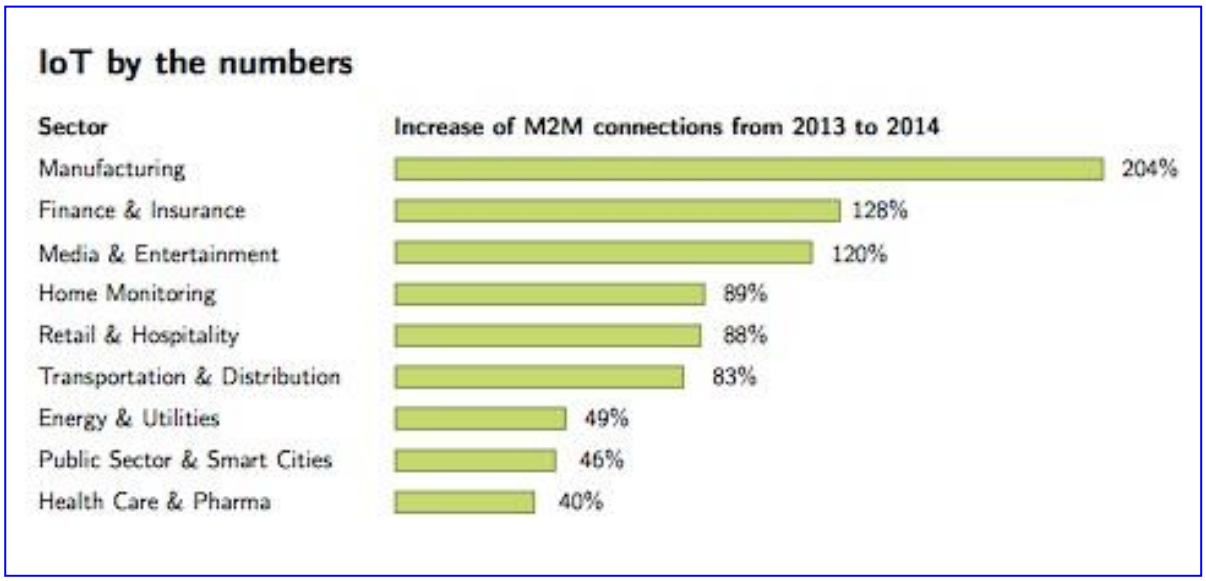

Figure 4: Increase of Machine-to-machine connections in the Verizon network (Verizon 2015).

Industrial Internet of Things

The Industrial Internet of Things (IIoT), which is considered as the main future IoT-application area, is defined by the Industrial Internet Consortium as „machines, computers and people enabling intelligent industrial operations using advanced data analytics for transformational business outcomes" (Industrial Internet consorium 2017).

Generally, it is one basis of Industry 4.0 and the digital transformation. The IIoT is the connection between IT (information technology) and OT (operational technology). IIoT is the most important segment in IoT, much more than consumer applications (see fig. 3). The Industrial Internet of Things is related to the Industry 4.0: all IoT applications in Industry 4.0 are forms of IIoT but not all IIoT use cases are about the industries which are categorized as Industry 4.0 (see: i-SCOOP 2016). Typical use

cases of the Industrial Internet of Things include intelligent machine applications, industrial control applications, factory floor use cases, condition monitoring, use cases in agriculture or smart grid applications. Figure 5 below tries to address the different technological areas involved with the IIOT. It is important to know that the IIoT is not just about saving costs and optimizing efficiency though. Companies also have the possibility to realize important transformations and can find new opportunities, e.g., entirely new business models in Industry 4.0 (see: i-SCOOP 2016).

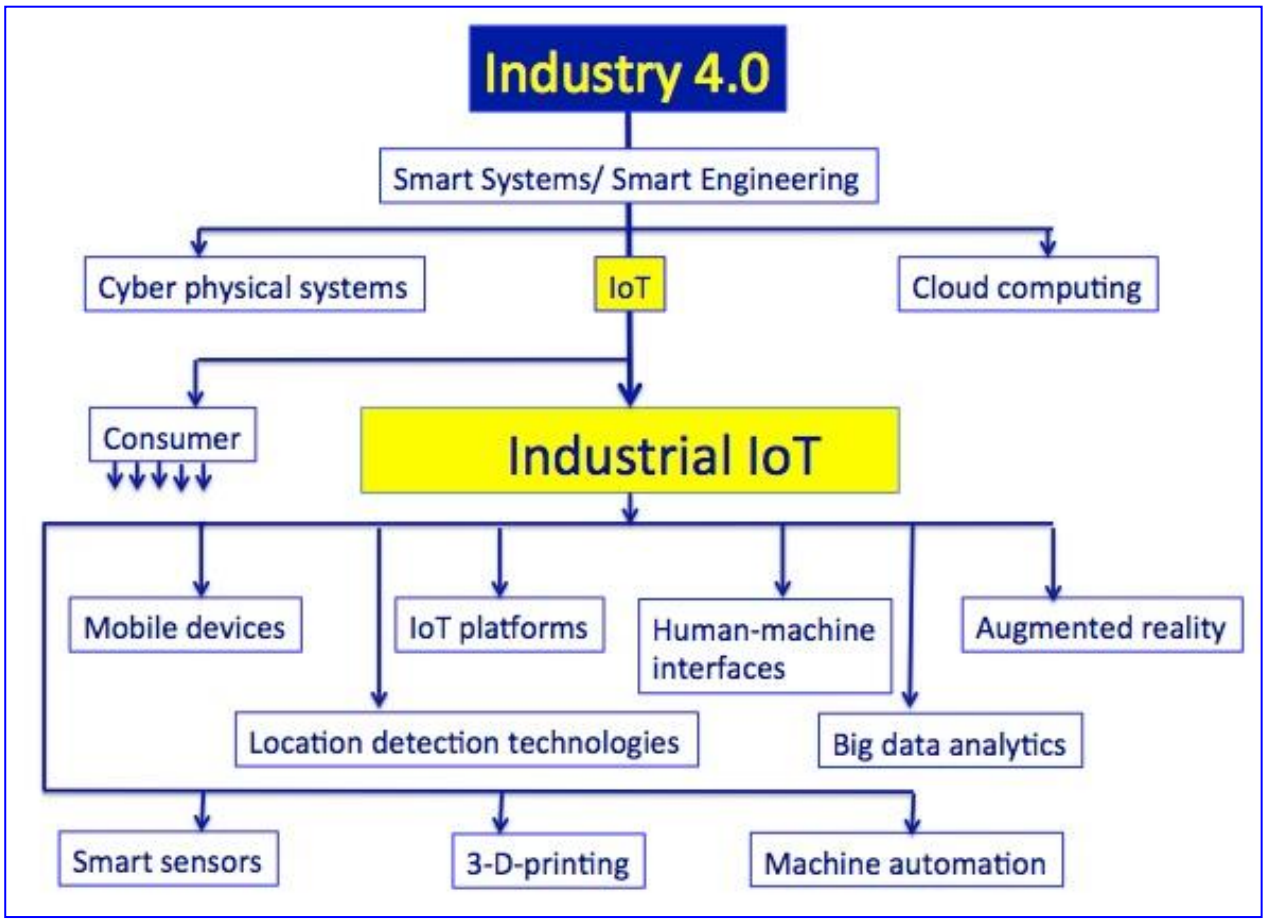

Figure 5: The IIOT environment (own illustration).

Vogt (see: 2016) proposes a slightly different value-chain focused view: Both, Industry 4.0 and IoT, examine the possibilities arising through increasing connectedness on various levels – from the device and machine level, to the machine park level (in production) or device groups (customers' use) to connected machines and products on a business process level (see fig. 6).

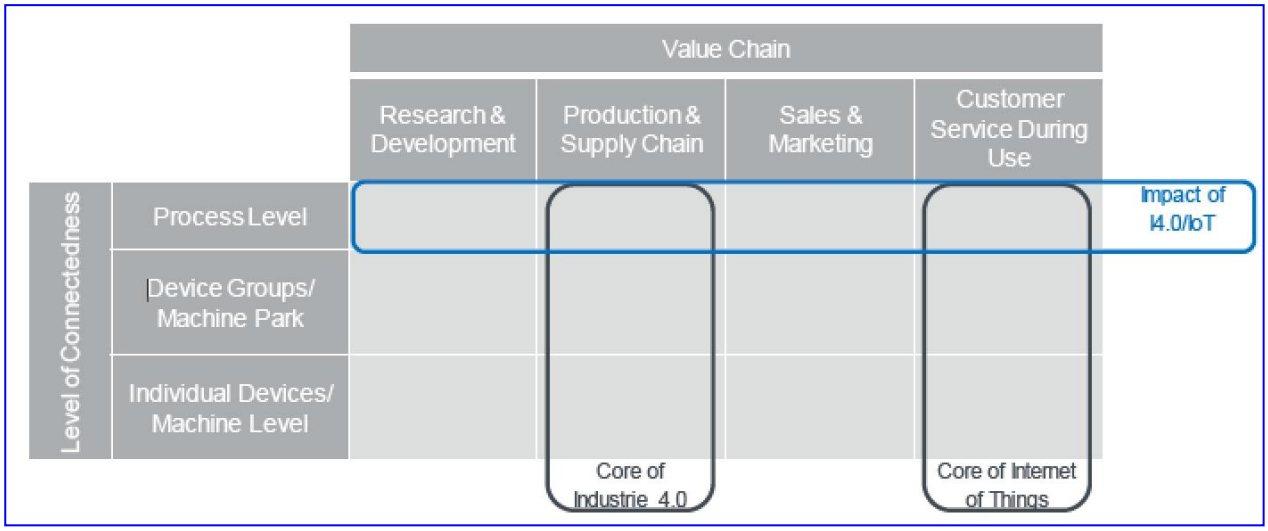

Figure 6: Cores of IoT and Industry 4.0 in the value chain (Vogt 2016).

The IIOT enables industries to rethink business models. These industries might also belong to the SME sector. In case of SME's we are proposing the expression SME 4.0. It is capable of generating actionable information and knowledge from IIoT devices, for instance, enables the creation of a data sharing ecosystem with new revenue streams and partnerships.

The term IIOT is often used in the context of Industry 4.0/SME 4.0, which is the term that describes a new industrial revolution with a focus on automation, innovation and data (see fig. 5). On top of IIoT, Industry 4.0 also is about other technologies, which are related with it. Examples include robotics, cloud computing but also the evolutions in operational technology (OT). It involves specialised technologies for data analyses (see also next chapter).

<u>According to i-SCOOP (2016) below are a few typical IIoT use cases and business contexts:</u>

- Smart factory applications and smart warehousing,
- Smart metering and monitoring,
- Smart environment solutions,
- Smart city applications (parking, traffic, waste management etc.),
- Smart farming and livestock monitoring,
- Security systems,
- Energy consumption optimization,
- Industrial heating, ventilation, and air conditioning,
- Asset tracking and smart logistics,
- Ozone, gas and temperature monitoring in industrial environments,
- Safety and health (conditions) monitoring of workers,
- Smart maintenance and equipment management.

<u>Above use cases can be illustrated by a collection of technical IIOT examples (s. fig. 7):</u>

<u>Example 1: Optimizing Maintenance in Wind Energy:</u>

Using sensors in vital components enables users to retrieve information on the condition of wind turbines during operation and process it in real time in a solution of *Schaeffler*. It is planned to use wind turbines to explore how machine learning can reveal additional insights about the performance of equipment in different operating conditions. Sensors in the equipment and in the bearings themselves will report on the condition of components in real-time. Using wind forecasts algorithms, turbine operators will be able to plan ahead and replace parts during less windy periods.

Example 2: Digitized Monitoring and Optimization of Trains:

Using cognitive insights from the cloud, this particular solution (see: Batty 2016) is aiming to enhance its predictive maintenance systems for railways, helping to improve efficiency and safety. Smart bearings will be able to measure their own vibration, temperature, torque and speed triggering alerts and informing railway operators about possible safety issues.

Example 3: Connected Equipment Operations Centres:

The connected Industry 4.0 will allow for the monitoring of thousands of machines and pieces of equipment on and off site. Data can be transmitted to an operation centre and processed in the cloud. Algorithms and cognitive approaches can analyse that data to make predictions about machine performance and create opportunities for optimization. Irregularities and potential faults can be automatically identified and corresponding actions rapidly initiated.

„This is an era of unprecedented industrial transformation defined by factories, machines and parts capable of self-assessing, triggering actions and exchanging information with each other, and with the people who manufacture and maintain them“ (Batty 2016) said Harriet Green of IBM Watson IoT.

Figure 7: Vision of a connected operations centre (Schaeffler Germany 2017).

1.4. Data analysis for the Internet of Things

It is important to not only collect data from machines, sensors, ERP systems, manufacturing execution systems (MES) and other sources, but to also ensure a detailed analysis of these data. Data collection is done via adapters (also called connectors, agents etc.). Typically, these adapters transmit machine-readable data into traditional systems such as databases or databases that are integrated with an ERP system or MES to conduct various analysis of these data, which today often must be prepared manually by specialists. Very advanced solutions are able to process certain data without intermediate processing steps.

An important issue is the big amount of data. Based on the assumption that critical information might be hidden in a single value for a certain signal source that may vary from the mass of other values, raw data must not be filtered, compressed or changed otherwise. Mathematical procedures and

algorithms such as compressed sensing (see: Indyk 2017) could be implemented within the machine to reduce the amount of generated signals without losses. Although improved predictive maintenance is of quite some relevance today, industrial analytics goes far beyond such predictive analytics. In future, we will see the convergence of CAD, CAM, PLM and ERP topics, for instance, to allow for mass-customized, batch size 1 production, which is an aspect that hardly plays a role for the benchmarked vendors. Still, vendors' offerings are limited to forecasts, which are sold under new names such as „predictive“ and „prescriptive“ (Vogt 2016). Common differentiation of analyses methods:

- Descriptive: retrospective to find out what has happened and why;
- Predictive: looking ahead to find out why something will happen;
- Prescriptive: looking ahead to find out how an undesirable situation can be prevented, if necessary.

1.5. International research activities on the Internet of Things

Internet of Things activities are gathering momentum around the world, with numerous initiatives underway across industry, academia and various levels of government, as key stakeholders seek to map a way forward for the coordinated realization of this technological evolution. In Europe, substantial effort is underway to consolidate the cross-domain activities of research groups and organizations, spanning M2M, WSN and RFID into a unified IoT framework. Supported by the European Commission, the 7th Framework program (EU-FP7) includes the *European Research Cluster on the Internet of Things* (see: IERC). Encompassing a number of EU FP7 projects, its objectives are: to establish a cooperation platform and research vision for IoT activities in Europe and become a contact point for IoT research around the world.

It includes projects such as *CASAGRAS2* (see: Casagras2 2017), a consortium of international partners from Europe, the USA, China, Japan and Korea exploring issues surrounding RFID and its role in realizing the IoT. Also, *IERC* includes the *Internet of Things Architecture (IoT-A) project* (see: Internet of Things Architecture (IoT-A) project 2017) established to determine an architectural reference model for the interoperability of IoT systems and key building blocks to achieve this. At the same time, the *IoT Initiative* (IoT-i) is a coordinated action established to support the development of the *European IoT community* (see: European IoT community 2017*)*. The IoT-i project brings together a consortium of partners to create a joint strategic and technical vision for the IoT in Europe that encompasses the currently fragmented sectors of the IoT domain holistically. Simultaneously, the *Smart Santander project* (see: Smart Santander project 2017*)* is developing a city-scale IoT test bed for research and service provision deployed across the city of Santander, Spain, as well as sites located in the UK, Germany, Serbia and Australia.

At the same time, large-scale initiatives are underway in Japan, Korea, the USA and Australia, where industry, associated organizations and government departments are collaborating on various programs, advancing related capabilities towards IoT. This includes smart city initiatives, smart grid programs incorporating smart metering technologies and roll-out of high speed broadband infrastructure. A continuing development of RFID-related technologies by industry and consortiums such as the Auto-ID lab (founded at MIT and now with satellite labs at leading universities in South Korea, China, Japan, United Kingdom, Australia and Switzerland) dedicated to creating the IoT using RFID and Wireless Sensor Networks are being pursued.

Significantly, the need for consensus around IoT technical issues has seen the establishment of the *Internet Protocol for Smart Objects* (IPSO) Alliance, now with more than 60 member companies from leading technology, communications and energy companies, working with standards bodies, such as IETF, IEEE and ITU to specify new IP-based technologies and promote industry consensus for assembling the parts for the IoT. Substantial IoT development activity has been also underway in China, with its 12th Five Year Plan (2011–2015), specifying IoT investment and development to be focused on: smart grid, intelligent transportation, smart logistics, smart home, environment and safety testing, industrial control and automation, health care, fine agriculture, finance and service, military defense. This is being aided by the establishment of the *IoT center in Shanghai* (see: IoT center in Shanghai *2017)* with a total investment over US $100 million to study technologies and industrial standards. The *IoT UnionSensing China* (see: IoT Union Sensing China 2017) has been founded in Wuxi, initiated by more than 60 telecom operators, institutes and companies who are the primary drivers of the industry.

1.6. Aspects of the technical future of the Internet of Things

One of the key aspects of the future of Internet of Things, especially in the consumer area, will still be the standardization of the communication protocols between devices and applications. Obvious examples of this evolution, which will be discussed by the analysed applications, concern the work of the 'ZigBee' Alliance, for the definition and promotion ZigBee standard, and IPSO Alliance, for the definition of the standard '6LoWPAN'. Although there are fundamentally different approaches, two working philosophies share the same goal: the need to ensure the interoperability between individual devices of the Internet of Things.

- **ZigBee** approach: the ZigBee Alliance brings together major vendors of embedded systems, radio modules, microprocessors / microcontrollers, appliances and systems home automation. The ZigBee solution defines several shared application profiles by all devices that cooperate to the realization of a given service, ensuring interoperability between devices of different vendors.
- **6LoWPAN** approach: the goal is to use physical devices on the same standards a classic of the Internet IPv6 + TCP communication, thus making the devices themselves accessible with the same procedures (protocols) with which one accesses such a web server. At the moment, the ZigBee approach has the necessary maturity and a greater critical mass, also due to the fact that the work of the IPSO Alliance began recently. However, there are already hybrid solutions in which the ZigBee approach exploits communication primitives 6LoWPAN.

Another aspect of the future development of the IoT is the enhancement of the data collected, on which there are still no data strategies established. This fact can be exploited in internal company processes such as reducing costs and improving efficiency to customers, or they can create value outside with the sale to third parties, opening up new business opportunities. The availability of precise data on the use of products with IoT makes new pricing strategies 'pay-per-use', that begin to affect not only the services, such as car insurance, which varies according to the annual mileage, but also products, such as tires paid on the basis of the kilometres driven. In some cases the sale is even encouraged in order to have access to new data, which constitute a source of value for companies, as in the case of wearable devices, or according to personal needs, promoted by insurance. The

consumer devices connected to the house, the city, the car and the industry continue to grow and the movements of large retailers, remained on the edge so far, represent a new point of contact with customers, along with the Internet, the insurance and the traditional home automation industry.

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2. EUROPEAN STATE OF THE ART OF THE INTERNET OF THINGS

This part of the report covers France, Italy, Germany, Lithuania, Spain and Portugal and aims to investigate the IoT state of the art and its adoption at national and European level. The research results provide a view on the actual IoT use and its potential for SME businesses. Research methods have been online-surveys and scientific desk research. The results of the scientific desk research for each of the above countries include the following topics:

1.Overview of the existing IoT technologies in each of the above countries. It focuses on the technologies already employed in the respective country and provides brief but technically sufficient descriptions.

2.The IoT adoption in each of the above countries including IoT developers/providers as well as IoT adaptors. Market overviews will be provided. Products and solutions, market shares etc. will be covered.

3.Collection of already existing studies and analyses on IoT in each of the above countries.

4.Already performed research projects in each of the above countries.

5.IoT awareness in selected businesses and branches of each of the above countries.

The structure of the national report parts might differ.

2.1: Germany

2.1.1. Overview of the existing IoT technologies

The market researchers at IDC estimate that in 2020 around 30 billion ‘things’ worldwide – such as machines, cars, washing machines and fridges – will be connected via the Internet. In Germany alone, there will allegedly be six connected devices per inhabitant in 2017. Parallel to this development, a genuine explosion in data volumes is taking place: the data volume on the Internet doubles every two years. By 2020, mobile data traffic will be 150 times the size it was in 2010 (Telekom 2017).

According to a study by German BITKOM and the Fraunhofer IAO, the key branches of German industry can expect an additional value creation potential of 78 billion euros through digital transformation by 2025. This corresponds to an average annual growth of 1.7 per cent.

Vogt (2016) confirmed Bosch Software Innovations’ role as an opinion leader and pacesetter in the Internet of Things. Vogt (2016) ranks key vendors and service providers in the realm of Industry 4.0 and the Internet of Things (IoT) with regard to the attractiveness of their portfolio and their competitive strength.

IoT business model example for a German toothbrush vendor

According to Vogt (see: 2016) a particular German company that considers optimizing the toothbrush production through IIoT will simply increase the efficiency of the existing production processes through connectivity and automation and also connect the toothbrushes in order to collect data on customers' usage behaviours to optimize related research & development efforts. As a result, efficiency gains might be achieved and a new toothbrush, based on the collected customer usage data, could be developed. But those who only pursue such approaches will not have done enough once the next toothbrush competitor leverages the technological IIoT opportunities to transform his business model, for instance, towards 'mass customization', which means that toothbrushes are manufactured, based on a customized, highly automated batch size 1 mass production (with individual colours, brushes, designs, name engravings etc.).

This business model requires a focus on Industry 4.0, since customers will certainly only accept slightly higher prices for such customized toothbrush. Connecting the toothbrushes (IIoT), on the other hand, is not absolutely necessary to implement the business model. Sales & marketing also will change completely through such business model. Products are not sold anymore through traditional retailers, but must be sold via the Internet. If a company is able to sell customized toothbrushes for slightly higher prices via the Internet, the 'mass customization business model' is certainly ahead of the 'traditional business model' – IIoT is only a means.

Additionally, the competition from the Silicon Valley is often thinking one more step ahead. For instance, 'customer data-based business models' can be used to eliminate whole markets. This effect could occur if toothbrushes are not sold to end customers or consumers anymore, but to health insurances. Health insurances would supply connected toothbrushes to their members for free and would measure their teeth brushing behaviours. Control will certainly have an effect on the cleaning behaviour, and health insurances could adjust contributions to dental insurances to the cleaning behaviour of their members accordingly. While the health insurance would spend some more money on preventive dentistry (for toothbrushes), related savings would be much higher, and these financial resources could be spent on conservative dentistry. As a result, the toothbrush market would practically be merged with a larger conservative and preventive dentistry market.

IoT vendor trends for Germany

In Germany, customers can choose between two basic IIoT approaches in order to address their requirements: a customized complete solution or a standardized platform. Customized complete solutions to connect machines, products and things have already been available for some time, and vendors can demonstrate respective competences and experiences gained for specific industries. Standardized platforms, on the other hand, are new and still in their infancy, and there is still a lack of clarity regarding their capabilities and functionality. Since the complexity of most IIoT solutions is very high, most German B2B-customers decide in favour of a customized complete solution, rather than a standardized platform (see: Vogt 2016).

It is expected, that more and more German IIOT-vendors will position themselves as full-service providers, acting as 'tailors' that develop and implement customized solutions, based on standard platforms (see fig. 8).

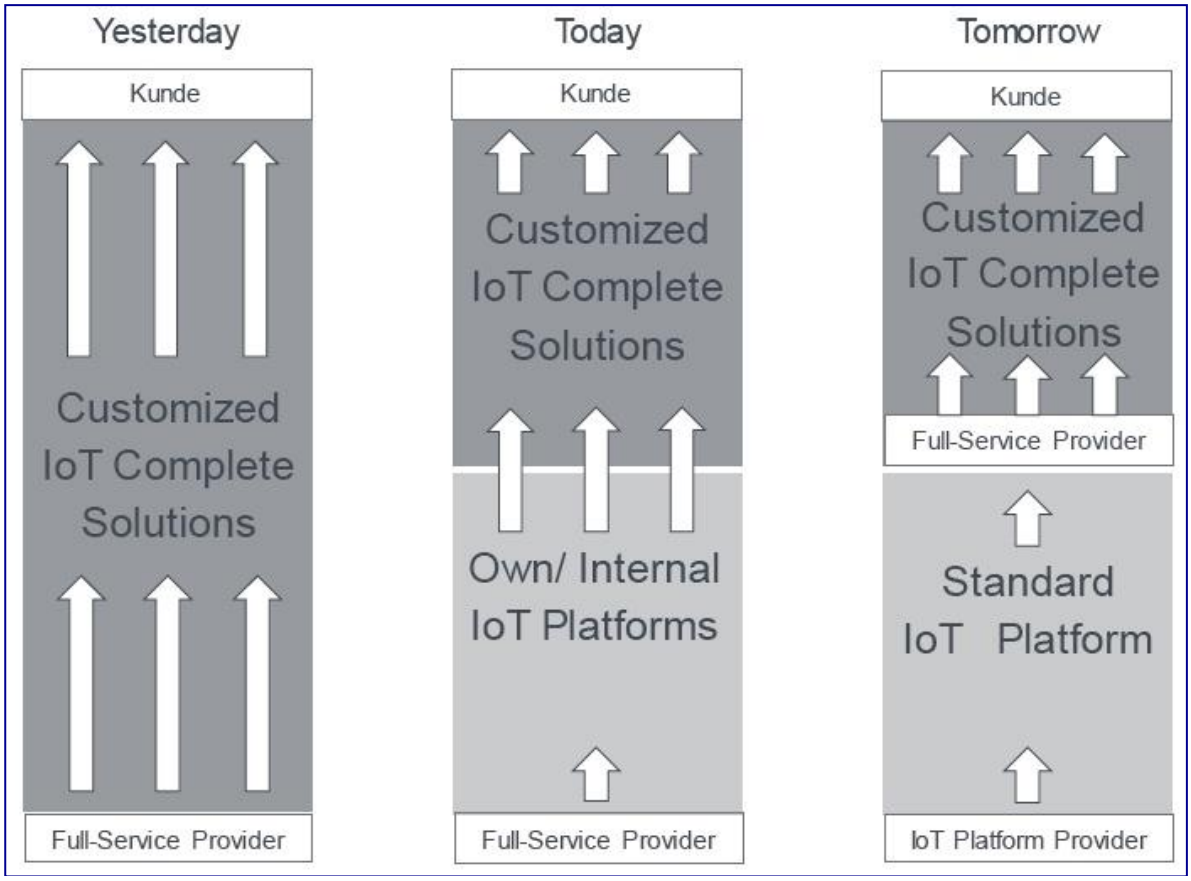

Figure 8: Expected evolution of German IoT solutions – yesterday, today and tomorrow (Vogt 2016).

Industrial (B2B) IoT solutions & technologies

New technologies such as IoT/IIOT are hotbeds of innovation in Europe. For Germany, there is the great opportunity to strengthen its industrial competence through consistent digitalization, which requires a broad, technology-driven innovation culture addressing this topic, and this is a challenge for large, renowned enterprises and small and medium-sized businesses alike. There are a number of studies that provide an overview in that regard. For this report we have utilised and cited a selection of these studies, such as Vogt (2016), Stolpe (2016), Columbus (2016), and Mc Kinsey (2015). For practical reasons these studies are not always marked when cited within the description below.

Employed technologies for connection

According to Stolpe (2016: 10) leading technologies vs. provided data rate for the necessary connectivity are (see fig. 9):

Technology	Rate		Type
EDGE	237.0	kB/s	Mobile Phone
UMTS 3G	48.0	kB/s	Mobile Phone
LTE	40.75	MB/s	Mobile Phone
802.15.4 (2.4 GHz)	31.25	kB/s	Wireless
Bluetooth 4.0	3.0	MB/s	Wireless
IEEE 802.11n	75.0	MB/s	Wireless
IEEE 802.11ad	900.0	MB/s	Wireless
Solid-state drive (SSD)	600.0	MB/s	Storage
eSATA	750.0	MB/s	Peripheral
USB 3.0	625.0	MB/s	Peripheral
VDSL2	12.5	MB/s	Broadband
Ethernet	1.25	MB/s	Local Area
Gigabit Ethernet	125.0	MB/s	Local Area
100 Gigabit Ethernet	12.5	GB/s	Local Area
Infiniband EDR 12x	37.5	GB/s	Local Area
PC4-25600 DDR4 SDRAM	25.6	GB/s	Memory

Fig. 9: Data rates for common IoT transmission protocols (Stolpe 2016: 10).

2.1.2. German IoT pioneering technological solutions

With this sub-chapter we present start-ups and other young IoT innovation leaders that recently appeared on the German market, although they do not fall under the commercial vendor market segment.

•Digital IoT-business platform for manufacturers (**AXOOM**):

Axoom with headquarters in Karlsruhe shall build up a platform for software that helps plan production processes in the machine hardware branch. Similar to an app store, IoT applications for industrial production shall be offered by various vendors. Cooperation partners for this solution include *Klöckner, Linde, Schmalz, Sick, Wicam,* and *Zeiss*. Industrial companies will be enabled to map whole production processes, from order entry to delivery, and to also connect to suppliers and customers. The open, vendor-independent platform ensures secure data transport and provides data storage and analysis capabilities. The cloud-based platform is available to all machine manufacturers.

•Smart Factory Starter Kit (**FORCAM**):

FORCAM is an IT/IoT technology and consulting provider headquartered in Ravensburg. FORCAM's Manufacturing Execution System (MES) is used by customers such as *Audi, BMW, Daimler, EADS, MTU Aero Engines, Hilti, Mann+Hummel, MAHLE, MSR Technologies* and *WEIR Minerals.* The company has launched its *MES 'FORCAM FORCE'* solution, based on in-memory technology, for real-time IoT big data analyses. *This Smart Factory Starter Kit* is based on a „smart factory out of the box" (Forcam UK 2014)concept, including cloud-based connectivity of up to three machines, including IoT big data analytics and graphical visualization in real

time. It includes the fast and easy implementation of pilot projects at an affordable fixed price.

•IoT Platform (**M2MGO**):

Berlin based M2MGO offers a IoT platform on top of Microsoft Azure. It has been designed for the fast and easy development of IoT apps and also provides data and device management capabilities. Web applications can be created fast and cost-efficiently with a simple browser and an Internet connection and based on a SaaS model. It targets product manufacturers that do not have the required IT competences in areas such as IoT software development, systems engineering, cloud computing and online security. M2MGO can also be used by system integrators within their customer projects as well as by other IoT platform providers who provide data & device management capabilities, but lack their own application layer. Problem is, that an easy-to-use approach is urgently needed to reduce the high complexity of IoT platforms.

•Smart Industry Apps and Manufacturing Execution System (MES)-as-a-Service (**nemetris**):

nemetrisis headquartered in Balingen (Swabian Alb) and with a focus on the automotive sector (mainly automotive suppliers) and discrete manufacturers. The company provides the nemetris JIS just-in-sequence solution and has also a focus on smart industry IoT apps, which can be deployed from the cloud, on mobile and on smart devices. Available smart industry apps include drag & drop web dashboards and traceability apps and also a complete, cloud-based IoT-MES-as-a-service solutions. Future manufacturing execution systems (MES) will not only map production processes, but have the potential to evolve into real industry 4.0/IIoT platforms that act as link between the production IT and the office IT. Things (machines, devices, components, etc.) within the production chain are not only connected to business applications (ERP, CRM), but also to user devices (for the operator) and even to other web services.

Commercial vendors with their technologies

For this part of the overview Vogt (2016) proposes three segments to be analysed:

•I4.0/IoT full-service providers (consulting houses & system integrators)
•Standardized platforms for Industry 4.0/IoT use cases
•Big data/analytics as the key technology enabler for Industry 4.0/IoT solutions.

Concerning IoT platforms Data & device management is the core functionality in order to allow the centralized management of connected things (devices, products, machines) and for processing (storing, integrating, analysing and visualizing) their data. Common additional functionality includes big data analytics, application development and connectivity management. IoT platforms are no vertical, i.e., industry-specific, but horizontal platforms to connect data and things across multiple industries.
IoT platforms connect four key elements: things, user devices, business applications and web services. Information is collected by things (machines, devices, products, components and materials) and prepared accordingly to visualize this information on various user devices. Remote access to 'things' via user devices is also possible, as is data integration with business applications (ERP, CRM or PLM) and external web services such as social media data or weather information.

Important vendors in the German market for IoT-Platforms are *Atos, BOSCH SI, Cognizant, Cumolocity* or *Deutsche Telekom*.

The German IoT market is still in its infancy. While these terms have been hype topics for quite some time, only few vendors have entered the German market with a concrete offering. Customers are primarily looking for full-service providers that are able to completely cover their individual solution requirements, rather than for providers of standardized platforms. To address these demands, solution vendors and system integrators act as full-service providers to provide a complete offering from a single source. Many small IoT platforms have evolved within short time; they are used by the vendors themselves in their role as full-service providers and/or are offered to other full-service providers that do not have their own IoT platform. According to (Vogt, et al. 2016) far more than 100 IoT platforms are already available worldwide, and consolidation is inevitable. Authors of the above study believe that it will not necessarily be the vendors with the technologically best platform that will succeed in the market, but those that are able to speedily set up a strong ecosystem around their own IoT platform.

Employed technologies with respective providers/supplies

Examples of vendors are:

- **'Connected Living Enabler'** of *ATOS* is a very advanced IoT-platform with enormous future potential. Atos is strongly involved into the *Gemini 4.0* initiative to gain important new insight for its own company as well as their customers. Atos has acquired important interface expertise between IT and industry. On the other hand, *Siemens* is a strong industrial partner with whom Atos has engaged in close cooperation to invest into innovations.

- The ***Bosch*** **IoT Suite** is based on a combination of acquisitions and in-house developments of *Bosch* Software Innovations. *Bosch* wants to position itself as 'lead provider' in the market. No other vendor pursues such strong marketing efforts, and Bosch SI is perceived as *the* IoT/I4.0 thought leader in the German market. Close cooperation with the *University of St. Gallen* in the 'Business Model Navigator' context.

- ***Deutsche Telekom*****'s 'Connected Industry/DT IoT Platform'** is a modular end-to-end solution. No other vendor has so many renowned references in the German market.

- *IBM* is another strong player in the German market segment and can add various strengths to its **'IoT Foundation IoT platform'**, such as its excellent analytics/big data expertise and application development in the *Blue Mix IoT Zone.* This 'Blue Mix IoT Zone' is an opportunity for *IBM* to build up a developer ecosystem around its IoT Foundation platform

Examples from the IoT Consulting & System Integration segment are:

Especially businesses with a weak digital background, such as a number of SMEs, will hardly be able to start Industry 4.0/ IoT initiatives, let alone implement them, without the help of partners, who must have respective horizontal and vertical competence, must have implemented concepts and must interact within a digital network to ensure the success of such initiatives. Consulting companies are able to support SMEs in this situation.

Specific topics/technologies for consulting and system integration services include the following areas:

•Smart Factory: consulting and system integration for the IT-based optimization (through automation and connectedness) of the internal production and logistics processes and related supply chain towards a 'smart factory';
•Smart Services: consulting and system integration for the IT-based optimization of value-added services, for instance through the 'connected car';
•Digital Transformation: consulting and system integration for the integrated IT-based transformation of the value chain towards new digital services and business models (Vogt 2016).

Accenture, one of the largest service providers worldwide with a focus on technology, management and outsourcing, is strongly involved in *Bitkom's* Industrie 4.0 workgroups. *Accenture's* mission and vision is the digital strategy; together with the involvement in and support of the German Innovation Award initiative, this helps the provider to achieve good market awareness and thought leadership ratings. One consulting focus is on the digital transformation. The IT-based optimization of smart industry services is one of Accenture's great strengths, while system integration for smart factory and smart industry services – for the machine & plant engineering sector – still bears development potential.

Beckhoff Automation, a local company from the Bielefeld area, has become a renowned automation technology market leader. Automation bundles all of *Beckhoff's* products and system solutions. A key characteristic of this technology is a PC-based control technology for SMEs that is developed, based on open IT and PC standards. *Beckhoff* has also set up a very good portfolio strategy, covering consulting and system integration services for specific automation and application programs, security solutions and specific high-performance control solutions, which have a very good reputation among German Industry 4.0 experts and customers (Beckhoff Automation 2017).

Bosch Rexroth is a manufacturer of drives and control technology in the automotive sector. It is a leading Industry 4.0/IIOT industrial supplier. Bosch Rexroth's consulting and system integration for smart factory/smart industry services for the machine & plant engineering sector are very advanced, and the company enjoys a very good position on the global machine & plant engineering market with its decentralized, integration-oriented Industry 4.0/IIOT product and service portfolio.

Bosch SI (Bosch Software Innovations) is the software and system house of the *Bosch group*. The focus is on the design, development and operations of innovative software and system solutions that address customers' specific requirements. The company provides its own *Bosch* IoT Suite (Bosch 2017) as well as an IoT platform. Features of the suit are (see fig. 10):

•Analytics: Analysing field data, anomaly detection service helps investigate problems that occur in connected devices, usage profiling service can determine typical usage patterns within a group of devices.
•Hub: Messaging backbone for device related communication as attach point for various protocol connectors.
•IoT Integrations: Integration with third-party services and systems.

•IoT Permissions: User management, role-based access control, and multi-tenancy for IoT applications.
•IoT Remote Manager: Administration of device functions like network connection, configuration, monitoring, etc.
•Rollouts: Manages large-scale rollouts of device software or firmware updates.
•IoT Things: Managing assets, reading data from assets, controlling assets, etc.

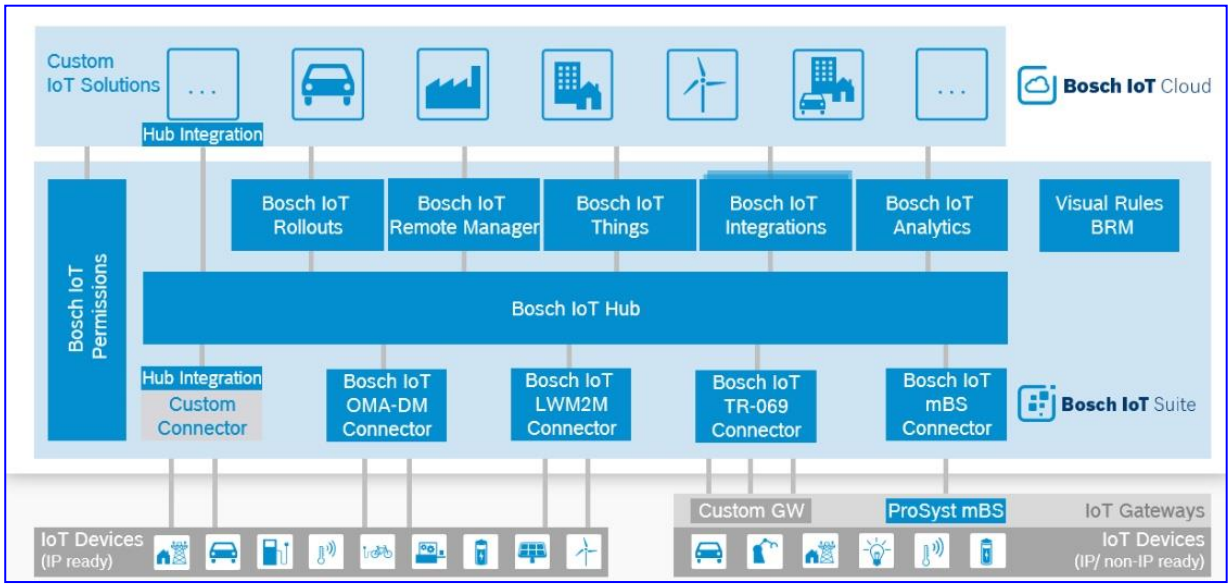

Figure 10: Scheme of the Bosch SI Platform (Bosch 2017).

As the global sensor technology market leader and based on its hardware and software know-how and derivation of networked products and new business models, Bosch SI is positioned as one of the lead users and leading vendors of smart industry consulting and system integration services.

Examples from the Automotive Sector segment are:
In Germany, the market for Smart Automotive and Transport is major reason for the emerging IoT and M2M communication market because Machine-to machine (M2M) connectivity enables navigation, Internet browsing, remote vehicle diagnostics and also provides information to the drivers for better and safe driving experience, thus leading to fewer accidents. Therefore, automotive is a key IoT target industry and manufacturing processes are largely automated. The potential of cyber-physical systems to even better coordinate production is obvious. The goal is to ensure the profitability of production batch 1 vehicles. IIoT consulting for production control purposes is therefore an important market within the automotive sector. At the moment, most projects are targeted at automation, analytics and predictive maintenance, and machine connectivity and production process digitalization are still limited to individual projects and infrastructure services.

The 'connected car' is another aspect, which also includes objects within the car, information systems and drivers' smartphones. The automotive manufacturers as the *masters* of all vehicle sensor data are expecting a huge business potential of this topic, which is gaining traction with real implementations that do not only deal with infotainment, but address the connectivity with external services for smart control, including use cases such as smart home control (prior to arrival), the localization of power supplies for electric vehicles and insurance policies that adapt to the driving behaviour. Cyber-physical systems, cloud services, big data and analytics, mobile devices and security

are contributing to help integrate additional services such as connected car and autonomous driving into this mobility service that has a strong IoT focus.

An impressive example is vehicle electronics, which signal to the driver that he has to stop if the engine is overheating. However, an automated, permanent exchange of this data between 'the things', such as vehicle and workshop, does not take place. The person has to become active and trigger the exchange of information. It is often too late for an adjustment to the system, maybe the engine has already been damaged by the excessive heat. The central issue is therefore the automated data exchange between devices without human involvement, but with the person's previous agreement. So-called machine-to-machine (M2M) communication helps real 'things' to access information on their current physical condition (for example, 'engine too hot') via sensors and pass this message on in the network for further processing. As this example shows, permanent control of technical systems is not possible without constant exchange of data. If the human being has agreed the procedure in advance, he no longer has to trigger communication between the devices. Then everything runs automatically: The respective device sends its current data independently, i.e., at regular intervals or whenever required (Telekom 2017).

Here a short selection of typical products in this area:
IBM uses the four-stack model to provide a comprehensive scope of smart factory, connected car and digital transformation services, based on *IBM*'s own and third-party software portfolios for cloud, analytics and mobile solutions. *IBM* provides a specific Internet of Things platform for the automotive industry.

Prosyst is a middleware vendor and active in the smart vehicle, e-health, smart home and Industry 4.0 segments. *Prosyst* addresses topics such as telematics and vehicle control systems and also conducts projects to implement connected car applications within the context of the European e-call system. The e-call regulation requires all new cars be equipped with e-call technology from April 2018. In the event of a serious accident, e-call automatically dials 112 - Europe's single emergency number (European Commission 2015).

Siemens drives factory digitalization in the automotive sector through industrial software that integrates automated production processes with manual processes and also monitors these processes. The company has implemented a digital smart factory based on its own MES system for Maserati in the manufacturer's plant in Grugliasco, Italy. The whole production process is monitored in real time; robot automation and diagnostics are integrated to detect problems immediately. *Siemens* demonstrates its thought leadership, also in the automotive segment, through research partnerships, as described above, with the Technical University of Munich (TUM), the *Ludwig Maximilian University of Munich* (LMU), the *DFKI (Deutsches Forschungszentrum für Künstliche Intelligenz,* or *German Research Center for Artificial Intelligence*), and the *Fraunhofer Institutefor Applied and Integrated Security*.

Baldwin (2014) concludes: Germany leads the internet of things with its automotive industry. Germany and Israel lead the world in implementing the IoT, according to *Cisco*. Baldwin (2014) also said Germany is leading the global trend, especially in its manufacturing and automotive industry: „Germany's automotive industry is totally embracing IoT with the impact of semi-autonomous driving and safety." Interestingly, Baldwin (2014) said different cities in the world are embracing IoT at

different speeds and in different ways. E.g. Barcelona has seen revenues and great citizen experience from automating parts of the city, as well as Japan.

Examples from the Logistics Sector segment are:
Logistics is an integral part of any production and value chain. Warehouse and delivery processes must be connected to the smart factory. The market for complete connectivity is still in its early phase. Innovations have a current focus on two core topics:

- Smart Logistics:
  Solutions to track and trace goods for optimized logistics management at sea, from the port to the route and the optimized goods delivery, based on big data analysis;

- Smart Traffic Management:
  Synchronization of a ship's arrival with the cargo transport to increase the efficiency of the goods discharging process; more efficient train management through better control of train movements, signal control and platform capacities; electronic control of street traffic systems (Vogt, et al. 2016: S?).

Providers come from the traditional IT service segment or are specialized ERP system integration partners and specialized solution vendors for the logistics industry such as:
***Fritz & Macziol*'s** offering for the logistics sector features its own Value-Added-Service- Platform for shipping automation, including the centralized control of global logistics processes, the web integration of carriers and customers and connectivity to all industrial sensors (to determine the status and also to identify and control the industrial facility) to allow for the automatic control of planning, production and logistics processes, based on this information. Customers that use this solution include *Heidelberger Zement*.

Sopra Steria is a provider of solutions to help optimize transportation, from the road to rails, sea and air routes. The portfolio includes travel management, geographical information systems for the improved tracking of freight and transportation system optimization solutions.

Inconsohas specialized in software for planning, controlling and monitoring logistics processes. The service offering includes warehouse management, transport management and yard management as well as logistics network planning and control.

Overview of the consumer (B2C) IoT solutions & technologies

In Germany, compared to the B2B sector the IoT end customer sector is a niche market. Nevertheless, selected products with respective technologies will be discussed here.

Generally, IoT products from the following commercial sectors are successful in Germany:

- Smart Home:
  -Home automation,
  -Smart metering,
  -Automation of home appliances, like washing machine, refrigerator etc.,
  -Network based entertainment systems,

-Security.
-Mobile Fitness/Health: Some popular applications in detail:

1.Home automation (s. fig. 11):
a.Control of complex processes on the basis of programmable scenarios, e.g. IFTTT,
b.Remote control over network connections and mobile devices.

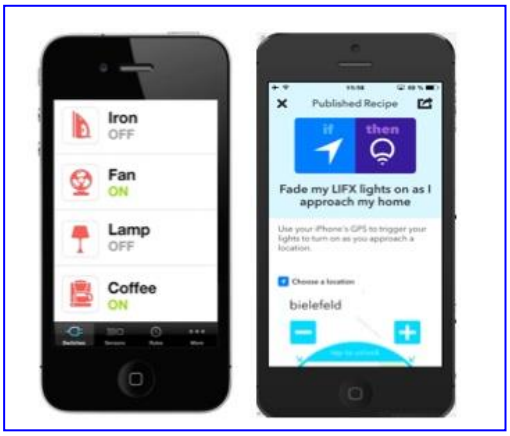

Fig. 11: Home Automation example (own illustration).

2.Smart metering for:
a.Electricity,
b.Gas,
c.Heating, water (s. fig. 12).

Fig. 12: Smart metering for electricity (own illustration).

3.Automation of home appliances:
a.Goal:
i.Processes more simple and optimal,
ii.Save energy and resources;
b.Intelligent home and kitchen appliances, like Miele from the Bielefeld area:
i.Including smart gridapplications: save energy cost when it is cheap (s. fig. 13);
c.Robots that support processes, e.g. cleaning.

Figure 13: Home automation with smart grid enabled washing machine and cleaning robot (own illustration).

4.Network based entertainment systems (s. fig. 14):

a.Central data memory (Server, Cloud) for media,
b.Reachable from all places in the house,
c.Universal Plug and Play (UPnP) / Digital Living Network Alliance (DLNA),
d.Wireless connection via WLAN, Bluetooth,
e.Wireless Speakers.

Figure 14: IoT entertainment system (own illustration).

5.Security:

a)Connected sensors, e.g. for smoke, motion, status of windows and doors, moisture (s. fig. 15).

Figure 15: Different IoT applications in the security sector (own illustration).

b)Automated control via IFTTT (IF This Then That, s. fig. 16).

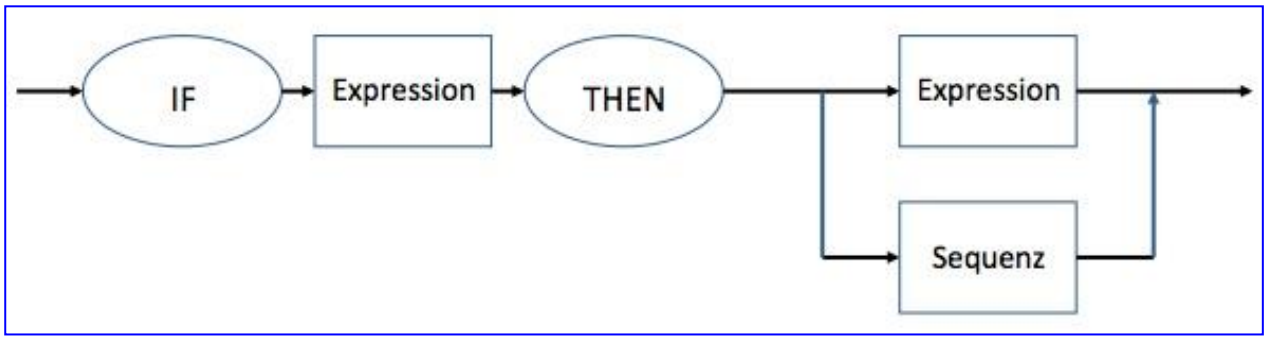

Figure 16: The IF-clause is the basis of the IFTTT service (own illustration).

In Germany, the adoption of the IFTTT service for IoT-based security applications is very popular (s. fig. 17):

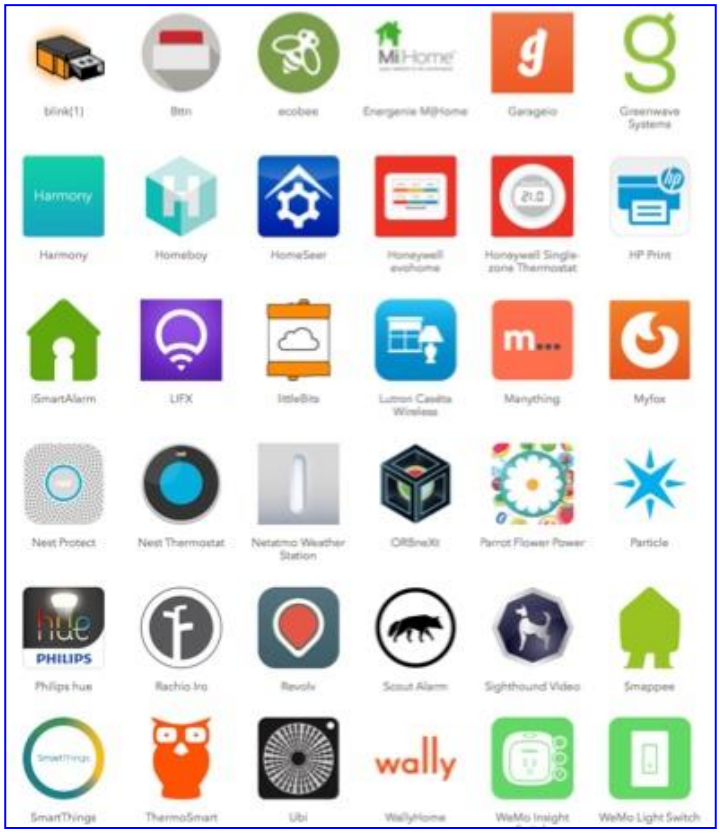

Figure 17: Selection of IFTT enabled IoT sensors and actors (own illustration).

But, fewer than 10% of adult Internet users in Germany said they owned wireless speakers in July 2016, according to a report from *Deloitte* (Genter 2016). Only 4% of those surveyed said they owned a fitness tracker, e.g. *FitBit* (see fig. 18). The same share said they owned a smart watch, like *Apple*'s. Smart watches are also among the most desired IoT devices, though, fewer than one in 10 respondents were interested.

Only 7% of respondents said they would consider purchasing a smart watch, the leading response along with wireless speakers. Other choices, like the speakers, pointed to domestic concerns: 6% said they would consider purchasing a surveillance security system, while another 4% would consider a home appliance, and 3% would consider a smart lighting system or a smart thermostat (s. fig. 19).

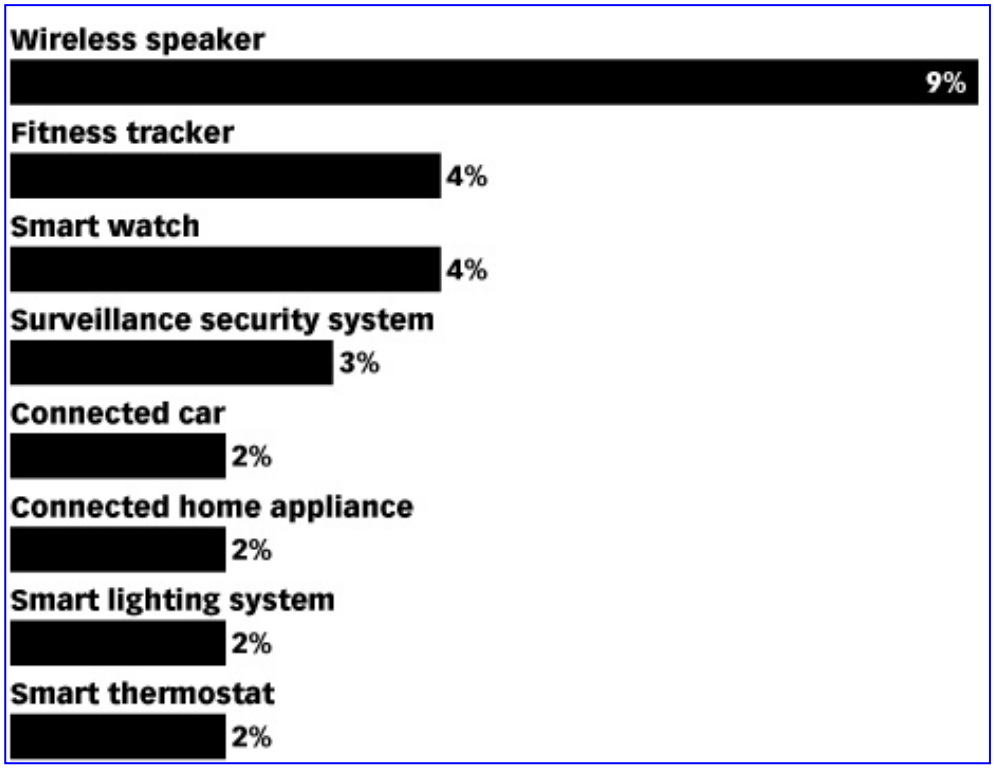

Figure 18: IoT B2C devices owned by Internet users in Germany, n=2000 (Genter 2016).

Purchase costs are the leading barrier to those who might otherwise adopt smart-home technologies, according to earlier research (s. fig. 19):

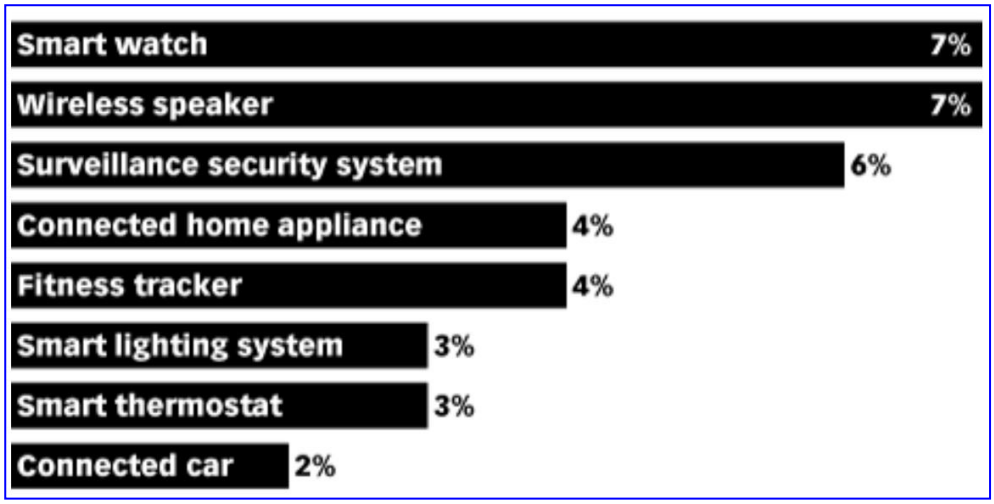

Figure 19: IoT B2C devices that Internet users in Germany would consider purchasing, n=2000 (Genter 2016).

Digital marketers in Germany might be too slow, too: According to the survey from August 2016 conducted by the company *eprofessional* (see: eprofessional 2016) fewer than 20% of digital marketers in the country named the IoT as a digital marketing trend. And with nearly 50% of consumers in Germany not knowing the term 'smart home', or nearly 70% not able to describe a 'connected car', there is a long way to go before mass adoption of these technologies.

The market researchers at IDC estimate that in 2020 around 30 billion 'things' worldwide – such as machines, cars, washing machines and fridges – will be connected via the Internet. In Germany alone, there will allegedly be six connected devices per inhabitant in 2017. Parallel to this development, a

genuine explosion in data volumes is taking place: the data volume on the Internet doubles every two years. By 2020, mobile data traffic will be 150 times the size it was in 2010 (see: Telekom 2017).

2.1.3. Existing studies and projects on the Internet of Things

Table 1 below provides recent studies on IoT, primarily from Germany.

Title	**Author/Company**	**Reference**
State of the Market: The Internet of Things 2015	Verizon	(Verizon 2015)
Internet of Things – IoT guide with definitions, examples, trends and use cases	i-Scoop	(i-SCOOP 2016)
The Internet of Things: Opportunities and Challenges for Distributed Data Analysis	Stolpe/ TU Dortmund	(Stolpe 2016)
Warten auf das „Next Big Thing"	Genter/ Deloitte	(Genter 2016)
Industrie 4.0 / Internet of Things Vendor Benchmark 2016	Experton	(Vogt, et al. 2016)
The Internet of things: Mapping the value behind the hype	Manyika, C, Mc Kinsey Company	(Mc Kinsey 2015)
2016 Internet Of Things (IOT), Big Data & Business Intelligence Update	Columbus,L. Forbes	(Columbus 2016)
Internet of Things in Deutschland 2015: Eine Anwenderbefragung	Schulte, A./ IDC	(Schulte 2015)
The Platform Architect's Guide to Designing IoT Solutions	Gartner	(Gartner 2015)
The Internet of Things: The next growth engine for the semiconductor industry	Raman Chitkara, Werner Ballhaus, Olaf Acker/ PWC	(Chitkara, Ballhaus und Acker 2015)

Table 2 below provides recent/running research projects with German participation:

Acronym	**Name**	**Coordinator**
SOCIOTAL	Creating a socially aware citizen-centric Internet of Things	Klaus Moessner, University of Surrey, UK
VITAL	Virtualized programmable Interfaces for smart, secure and cost-effective IoT deployments in smart cities	Manfred Hauswirth, DERI, Ireland

ALMANAC	Reliable smart secure IoT for smart cities	Maurizio Spirito, ISMB, Italy
CASAGRAS2	Coordination and Support Action for Global RFID-related Activities and Standardisation - 2	Ian Smith, AIM UK
IoT-I	Internet Of Things Initiative	Rahim Tafazolli and F. Carrez, University of Surrey, UK
IoT-A	Internet of Things Architecture	Sebastian LANGE, VDI/VDE-IT
ebbits	Enabling the Business-Based Internet of Things and Services	Markus Eisenhauer, Fraunhofer FIT, Germany
IoT@Work	Internet of Things at Work	Amine M. Houyou, Siemens AG, Germany
AMI-4-SME	Ambient Intelligence Technology for Systemic Innovation in Manufacturing SMEs	Harald Sundmaeker, ATB, Germany
CE-RFID	Coordinating European Efforts for Promoting the European RFID Value Chain	Gerd Wolfram, METRO Group, Germany
CuteLoop	Customer in the Loop	Harald Sundmaeker, ATB Bremen, Germany
EUWB	Coexisting Short Range Radio by Advanced Ultra-Wideband Radio Technology	Hrjehor Mark,GWT-TUD GmbH, Germany
HYDRA	Heterogeneous physical devices in a distributed architecture	Markus Eisenhauer, Fraunhofer FIT, Germany
PRIME	Privacy and Identity Management for Europe	Marit Hansen, ULD, Germany
IoT6	Universal Integration of the Internet of Things through an IPv6-based Service Oriented Architecture enabling heterogeneous components interoperability	Sébastien Ziegler, Mandat International, Switzerland

Below we have described an interesting subset of five IoT-projects from the table 2.

Project 1
Title: *Secure and smarter cities data management* (see: SMARTIE)
Acronym: SMARTIE
Co-ordinator: IHP GmbH, Germany
Programme: Framework Programme 7, ICT Objective 1.4 IoT (Smart Cities)
Term: 9/13- 8/16

SMARTIE created a distributed framework of shared large volumes of heterogeneous information for the use in smart-city applications, enabling end-to-end security and trust in information delivery for

decision-making purposes following data owner's privacy requirements. A secure, trusted, but easy to use IoT system for a Smart City will benefit the various stakeholders of a smart city: The City Administration will have it easier to get information from their citizens while protecting their privacy. Furthermore, the services offered will be more reliable if quality and trust of the underlying information is ensured.

Privacy and Trust are a key prerequisite for citizens to participate in Smart City activities. A Smart City can improve the Smart and Comfort Live of their citizens enormously. Enterprises benefit from the securely provided information. They can optimize their business processes and deal with peak demands introduced by the dynamics of the Smart City. Furthermore, they can offer more tailored solutions for their customers based on the status of the Smart City. Main Objectives of SMARTIE are to:

- Understand requirements for data and application security and creating a policy-enabled framework supporting data sharing across applications.
- Develop new technologies that establish trust and security in the perception layer and network layer.
- Develop new technologies for trusted information creation and secure storage for the information service layer.
- Develop new technologies for information retrieval and processing guided by access control policies in the application layer.
- Demonstrate the project results in real use cases.

Project 2
Title: Business-Based IoT & Servics (see: ebbits)
Acronym: ebbits
Co-ordinator: Fraunhofer FIT, Germany
Programme: Framework Programme 7, IoT
Term: 10- 2/15

ebbits developed a widely deployed platform and service concept for the Internet of Things and Services, with which:

- Producers can integrate physical devices, systems and components directly into their optimising systems, i.e. managing workflows, people, processes, assets, data, information and knowledge, and turn them into useful, value-added business services or service components.
- Producers can obtain interoperability between various subsystems in manufacturing environments across manufacturing cells, manufacturing lines end entire manufacturing plants, regardless of geographical location with the aim to support production and energy optimisation.
- Producers can meet increasing consumer demands and regulatory requirements for authentication and traceability of their products by providing support for authentication and traceability through ubiquitous services integrated in wireless communication networks and existing smart home infrastructures.
- Producers, in particular, SME's of components, devices and systems can easily and cost-effectively network their products with mainstream enterprise systems in order to support higher value-added, interoperable solutions in an open architecture.

Ebbits platform also will:

- Introduce a Service oriented Architecture (SoA) based on open protocols and middleware, that effectively transforms every device into a web service with semantic resolution.
- Support mainstream business applications with connectivity to and monitoring of products in their entire lifecycle, i.e. from early manufacturing stages to end-of-life.
- Allow for distribution of intelligence between the edge network and the centralised business/process information system and eliminate centralised gatekeeper lock-in of critical business functionalities.
- Enable the convergence of the *Internet of Things (IoT)* and the *Internet of Services (IoS)* into the *Internet of People, Things and Services (IoPTS)* for business purposes.

Project 3
Title: *Ambient Intelligence Technology for Systemic Innovation in Manufacturing SMEs* (see: AMI-4-SME)
Acronym: AMI-4-SME
Co-ordinator: ATB Institute for Applied Systems Technology Bremen, Germany
Term: 05- 08

The **AMI-4-SME** project is aiming at a „Revolution in Industrial Environments" (ami4sme.org 2017). - Finding new technological and organisational approaches to enable Manufacturing SMEs to use Ambient Intelligence Technology for Systemic Innovation.
The next revolutionary step in process innovation in industry is to radically innovate the whole industrial working environment, by focusing it upon the main actor in industry: the human actor, and by applying emerging systemic innovation approaches. The application of *Ambient Intelligence (AmI)* Technology can be considered as a key enabler to achieve such advances in the working environment. And especially SMEs need to be systematically enabled to actively take part in this revolution.

The project achieved the following results:

AMI-4-SME ICT vendor partners are keen on an answer to the question: „How to penetrate the SME marketplace with innovative AmI solutions?" (ami4sme.org 2017). Therefore, the project intensively analysed the SME innovation needs within the business cases. This clearly indicated the SMEs' need for highly tailored turn-key solutions, required to guarantee the realisation of business benefits and competitive advantage. To effectively serve those SME needs with turn-key solutions in a suitable price range, the AMI-4-SME project elaborated the following results:

- AMI-4-SME Software Platform: to easily set-up the required runtime environment as well as software infrastructure to provide a cost and time efficient realisation of a human centric turn-key solution.
- AMI-4-SME Methodology: providing clear instructions, guidelines and templates for realising the successful utilisation of new AmI technologies. It is based on a traceable improvement process, driven by the company staff, enabling informed decisions of the management.

•Building Blocks as enablers for realising innovative *AmI* (Ambient Intelligent) as well as human centred solutions:
- RFID based sensor system, mobile readers & middleware, highly compatible for integration with SME infrastructures.
- Speech recognition system, for implementing configurable natural human interaction on mobile devices; easy to generate & maintain; using standard inter-faces.
•AmI system adaptor for mobile device, service & system integration. Enabling a flexible, secure & efficient configuration, mapping & interfacing of legacy systems, AmI services as well as mobile devices.

Project 4
Title: *Software Platform For Integration Of Engineering And Things* (see: SPRINT)
Acronym: SPRINT
Co-ordinator: EADS, Germany
Programme: FP7 Project (ICT-2009.1.3: Internet of Things and Enterprise environments)
Term: 10/10- 10/13

SPRINT proposes to leverage the concept of Internet of Things, establishing the foundation for the Internet of System Engineering. Based on an Internet-like service infrastructure the SPRINT Networked Environment will provide the virtual blending via Internet of all 'things' pertaining to a complex system: sensors, actuators, processing elements, system design tools and models and design teams that are in general spread over different geographical locations. The platform will include novel early verification approaches that involve virtual integration of mathematical models of components to alleviate the problem of late error discovery while supporting the entire cycle of product development: design, integration, verification and deployment. This research will open a new vista on the use of Internet of Things that may change radically the way in which systems are designed and tested.

To assess the results of this innovative research in a tangible fashion, the SPRINT project will establish a measurement activity to show the achievement of the objectives. The measurement will be done against a set of verifiable set of indicators. A set of indicators is displayed in the following table.

Goals are to:
•integrate tools and models of the whole development cycle;
•integrate physical devices in the design process;
•base the integration on semantic contracts;
•demonstrate feasibility of the approach by applying it in industrial case studies;
•create an open specification for the Internet of Engineering.

Project 5
Title: *Generic Adaptive Middleware for Behaviour-driven Autonomous Services* (see: GAMBAS)
Acronym: GAMBAS
Co-ordinator: University of Duisburg-Essen, Germany
Programme: FP7 Project
Term: 2/12- 10/15

The main objective of **GAMBAS** was to develop an innovative and adaptive IoT-data acquisition and processing middleware to enable the privacy-preserving and automated use of behaviour-driven services that are able to adapt autonomously to the context of their users.

Compared to other platforms provided by some of the major players of the software industry, GAMBAS exhibits three main differentiating characteristics:

- The GAMBAS platform is open to third party developers. Thus, it allows small and medium enterprises to deliver advanced applications at low cost – thereby, improving competition and facilitating innovation.
- The GAMBAS platform is distributed and interoperable. Thus, it not only enables data providers to offer information but it also allows applications to integrate data from different providers in an easy and efficient manner.
- The GAMBAS platform is built on the principle that the data of the citizens should be stored and processed locally on the mobile device – unless they explicitly agree to share the data each other or a particular service provider.

The GAMBAS IoT-middleware specifically targets the acquisition of personal context information. To do this, while ensuring the user's privacy, the acquisition is performed primarily with personal Internet-connected objects. This empowers the user to limit the sharing of the acquired context. In order not to overwhelm the user, the GAMBAS middleware will contain a framework to automate the sharing in a privacy-preserving manner. Furthermore, in order to directly use the acquired context on the connected object, the middleware will provide concepts to implement intent-aware user interfaces. Finally, in order to use the shared context effectively in enterprise business processes, the middleware will make use of an interoperable data representation with the associated processing infrastructure that supports a large number of sensors. This will provide the basis for efficient object to object interactions and thus, it will enable the development of novel services.

2.1.4. Trends and awareness of Internet of Things

The German and European wide IoT markets are set in motion by above mentioned new technologies. Each new technology that establishes itself in the marketplace can set off disruptive market changes through the sheer speed of its adaptability. From the German point of view, (Voigt 2016) identifies various IoT trends for the next couple of years:

1. Trend: Industry 4.0 / IoT killer apps

What are the Industry 4.0/IoT killer applications? There are definitely many good use cases out there right now, yet there is still no „silver bullet" that offers a clear and obvious advantage recognizable to all. Industry 4.0/IoT is definitely an 'enablement technology' for many applications, including cloud computing. IoT will change our world permanently, regardless of whether or not it gives rise to any true killer applications.

2. Trend: Power to the Industry 4.0/IoT user

Experience shows that vendors and consultants often expend great effort seeking out new application scenarios, yet far more frequently these are discovered by the users themselves. For this reason, solutions will quickly become much easier to use. When every user is able to use the IoT for

their own purposes, this type of trial and error approach will allow new application areas to be identified far more rapidly.

3. Trend: Standardized Industry 4.0/IoT complete solutions

Identified use cases that are suitable for a broad customer base will be brought to market as standard solutions. Currently, IoT solutions still come into being largely within the context of individual customer products. This custom-tailored approach is the breeding ground for the following standardized solutions. In the future, IoT projects will rely on standardized IoT platforms, and they will also be packaged as integrated complete solutions. This provides enormous efficiency benefits for vendors due to economies of scale, and in turn provides lower prices for users.

4. Trend: Industry 4.0 manufacturing

The idea of an Industry 4.0 manufacturing environment that is fast, custom-tailored, and automated will become a reality sooner than expected. Of course, the wide-scale adoption of this concept is still something of a futuristic fantasy in several industrial sectors, but we will soon see practical implementations. The capability to rapidly produce and deliver custom-tailored products (e.g. high-value consumer items) is an important feature of the combination of IoT and smart processes.

5. Trend: IoT platforms

IoT platforms are already highly relevant as data hubs for the integration, storage, analysis, and visualization of data (see chapter *Commercial vendors with their technologies* of this report). Right now, they are popping up like mushrooms, but while this wild growth phase is certain to persist for some time yet, there is bound to be an initial wave of consolidation in the next two years. Aside from the integration of devices and pure data management, we will also see an increasing emphasis on other features such as device management (e.g. for software updates related to device security and device functionality) and business process management. Fast, easy-to-use connectors for IoT applications and IoT data are also becoming increasingly important.

6. Trend: Industry 4.0/IoT data integration and big data/analytics

Analytics, big data, and machine learning all play a critical role in every product portfolio. These are without a doubt extremely important items when looking at the long-term picture. At the current stage of IoT evolution, data integration calls for more immediate attention than big data/analytics. Integration will be a permanent key topic in the digital world. The integration of heterogeneous devices, data, and applications represents the ‘compulsories’ in the Industry 4.0/IoT world.

7. Trend: Users become Industry 4.0/IoT vendors

We will increasingly be seeing typical enterprise users with Industry 4.0/IoT experience gained through in-house projects attempting to market this expertise to external customers. In the process, these typical Industry 4.0/IoT enterprise users are becoming Industry 4.0/IoT vendors.

8. Trend: IoT Ecosystems

IoT ecosystems will continue to expand over the next two years, frequently be centred on IoT platforms, around which increasingly complementary micro services will be grouped. A true network effect can always be expected when a strong core solution and a strong business model attract an increasing number of partners. We will see intense competition between competing IoT ecosystems in the next two years.

Concerning the awareness of IoT in Germany, the below fig. 20 displays the share of consumers who have been aware of IoT in Germany in June 2015. Only 12 per cent of responding consumers were aware of IoT.

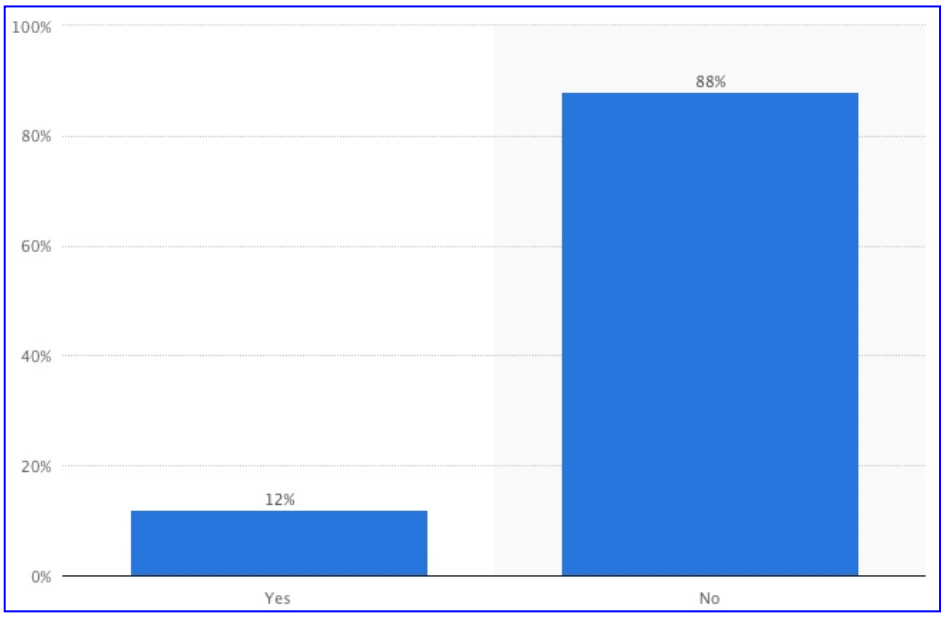

Figure 20: Share of consumers who are aware of the Internet of Things in Germany (Statista 2015).

The below statistic fig. 21 represents the predicted revenue generated by IoT in Germany until 2020. According to the source, the market volume in 2018 will have risen to 24.5 billion euros (Statista 2016).

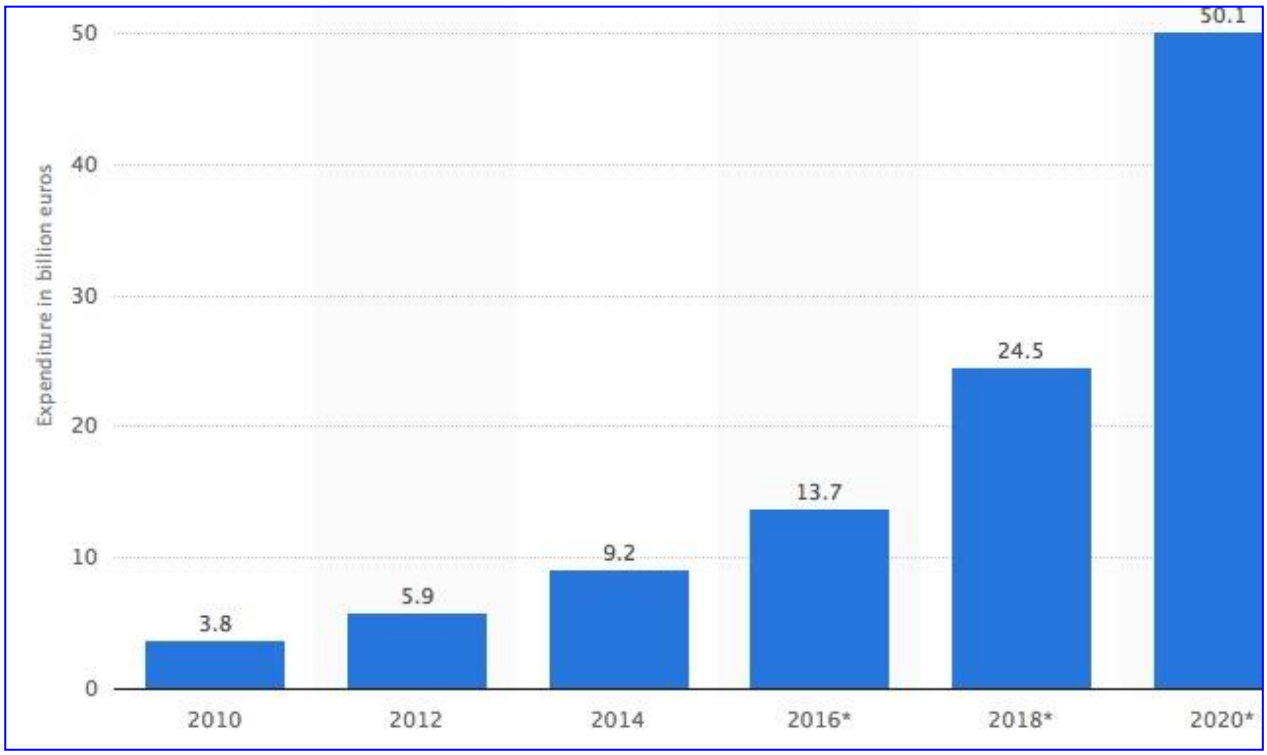

Figure 21: Prediction of revenue from the Internet of Things in Germany from 2010 to 2020 (in billion euros) (Statista 2016).

CONCLUSION

Managers of German IoT SMEs believe the IoT will be a big deal, but most consumers in the country still don't know what it is, according to 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 (see fig. 20). That is striking for a country where 41% of marketers believe the IoT will have a massive impact on them by 2020 (eMarketer 2015a). 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 (eMarketer 2015b).

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2.2. France

2.2.1. Overview of the existing IoT technologies

The *International Communication Union (ITU)* is the United Nations agency specialized in the development of Information and Communication Technologies, located in Geneva (Switzerland). According to the ITU, the Internet of Things is defined as „the global infrastructure for information society, that provides advanced services by interconnecting objects (physical or virtual) through existing or evolving interoperable information and communication technologies" (ITU 2017). In this recommendation, the ITU provides five fundamental characteristics of the Internet of Things:

1.Inter-connectivity: the objects can be connected to each other and to the entire internet infrastructure;
2.Specific services: the objects provide services intrinsically;

3.Heterogeneity: the devices used for the objects to operate are heterogeneous (software, networks, physical features);
4.Dynamic changes: the objects evolve in a changing environment (location, pace) and the number of devices evolves too, with the emergence of new technological waves;
5.The very large scale: the devices to be managed and that will communicate between each other will be significantly more numerous than those connected today to the internet.

The last three identified points are features of the IoT. But the first two points raise the main axes of the IoT: the objects themselves, interconnectivity, data and the services they produce. This thematic structure based on 3 axes will therefore be used to draw up this part of the report.

Inter-connectivity

• Wireless

To communicate over long distances, the connected objects do not use cellular GSM networks but low speed and energy sufficient infrastructures especially designed for them. These are the LPWAN networks (Low Power Wide Area Networks) or extended long-range networks since they have a range of frequencies (800-900 MHz) greater than those of 2G/3G/4G networks.

In this field, two technologies, both of French origin, prevail: **SigFox** and **Lora.**

Sigfox has already covered the national territory with some 1500 antennae and is currently deployed in nineteen other countries. The French start-up raised 127.5 million euros in four financing rounds and claimed 7 millions of connected objects. Sigfox is foremost positioned on industrial sensors knowingly limiting the size of messages to 12 bytes with a maximum of 140 messages per day. Starting first, Sigfox has already allowed deployments at a European scale. „At Sigfox, a client company has only one interlocutor, it does not have to negotiate country by country". Among its shareholders, Sigfox numbers *Bpifrance* but also industrialists like *Air Liquide* and *Engie*.

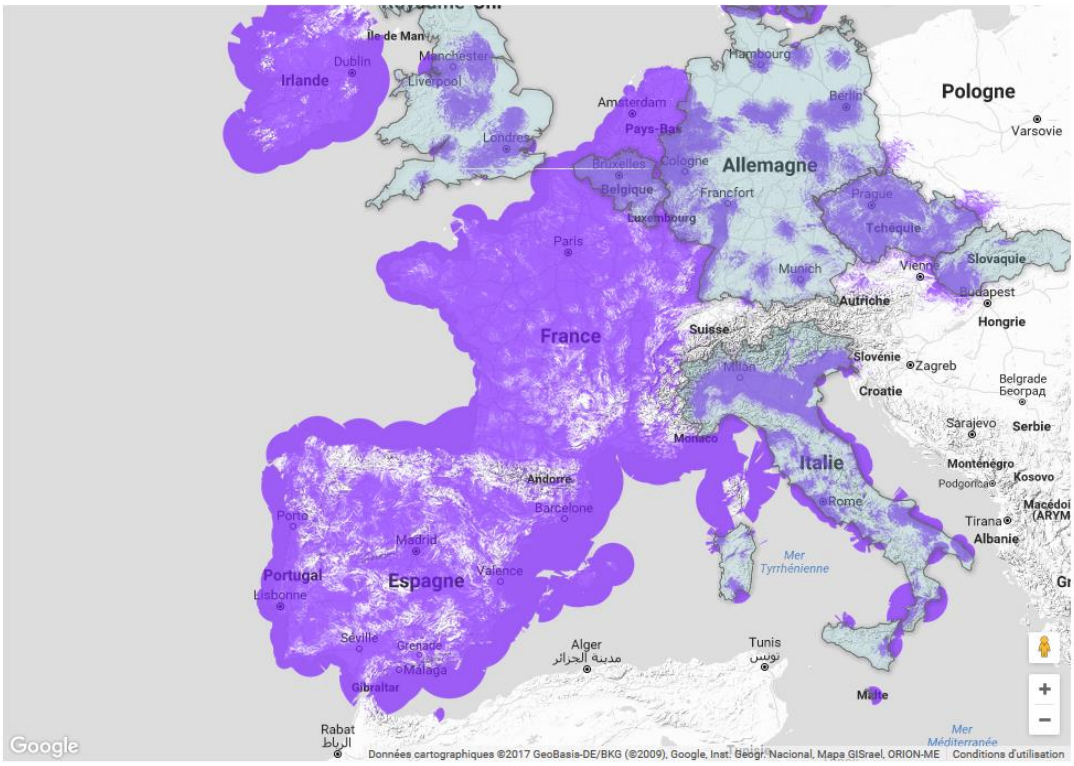

Figure 1: Coverage of the Sigfox network (Next Inpact, 2017).

Facing Sigfox, **LoRa** technology (for Long Range) is also of French origin. It was born out from the acquisition of 'Cycléo', a start-up from Grenoble, by *Semtech*, the American manufacturer of semiconductors. LoRa is currently supported by the LoRa Alliance. An organization that brings together 330 industrialists who work on all aspects of this technology: the network, the chip, the layer software, the terminals. This alliance includes Samsung, Tata Communications and China Telecom. In France, Orange, Bouygues *Telecom, La Poste, Qiwisio* and *Archos* deploy each a LoRa network. This technology is based on an open standard, allowing then a company to switch from one LoRa network to another. Compared to SigFox technology, LoRa technology allows for larger messages (50 kbytes) and is also more efficient in terms of 'indoor' penetration (i.e inside buildings) and even 'deep indoor'. For example, in Paris the antennas were densified to raise the data from meters buried at a depth of 3 meters below ground level.

- <u>Wired</u>

  New electric meters are currently deployed throughout France and in every household. The goal of these new 'intelligent' devices is to know the electricity consumption of users in real time, and to be able to better control it to save money. For now, *Linky*'s contribution lies mainly in the automation of consumption reports. These electricity meters collect consumption information once or twice a day, and send them to *ERDF* through the electrical network. Once the new *Linky* meter is installed in their homes, households have a personalized and secure access to a site set up by *ERDF* where they can consult their daily consumption, or even hourly for those who request it. This data is daily updated.

  Linky today finds all its purpose in the experiments of 'smart grid', these intelligent electrical networks developed at the neighborhood scale. With the 'IssyGrid' network, France leading

neighborhood network in Issy-les-Moulineaux, in homes equipped with a home automation system, and *Linky*, residents can monitor their real, overall consumption, by usage (lighting, heating, hot water and cold water). *Linky* is connected to the Internet, not via Wi-Fi or GSM, but by an online Power Line Communication (PLC) system, on the house's electrical wires. The eco2mix site provides access to electricity production and consumption data in France.

- Connected Objects

  In the field of creation and implementation of connected objects, France holds a leading position on a global level. As evidence, the French delegation was the second *Eureka Park* start-up delegation at the CES (Consumer Electronic Show) in January 2017 in Las Vegas and the second at the CES behind both the United States and China. There were 275 French exhibitors, including 233 start-ups.

  Several startups already have significant market shares in connected objects. Among the 100 French startups that moved the IoT market in 2016: *Netatmo, Ubiant, HDSN, Sen.se* (for housing), *Aroma thérapeutics* and *Leka* (for the medical and healthcare sector), *Actility* (for smart-cities).

- Data collection and storage platform

  France Stratégie made the following observation in 2015: if France is well positioned on the physical design of connected objects (design, connectivity, microelectronics), it cannot rely on a national or European platform large enough to conserve the economic value of the many services that will be associated with the objects.

France ranks ninth in the classification of the most advanced IoT nations. A list of rankings made by the US-based International Data Corporation (IDC) in its new report entitled *G20 Countries and IoT: Comparative Evaluation.* The United States, South Korea and the United Kingdom are in the top three on the podium, followed by Australia and Japan. This study was published on 2nd November 2015. It assesses the level of maturity of the 20 richest states or groups of states in the world compared to the upcoming boom in the Internet of Things sector. IDC ranks them according to different criteria, such as the percentage of GDP devoted to research related to the Internet of Things, the level of development of the cloud infrastructure, the quality of the IoT networks deployed across the territory or the effectiveness of the public support policies of the sector.

If as previously shown, the IoT networks are largely developed in France (French companies being at the origin of those technologies), and many startups contribute to the creation of the Internet of Things, France owes that average ranking in this classification to the data collection and storage platforms. Indeed, very few French cloud platforms allow to store specifically the data of the Internet of Things. The Hexagone thus loses points compared to countries like the United States, whose cloud infrastructure dedicated to the IoT carried by giants like *Amazon* is already solid. „France must boost its public and private spending in the sector of connected objects", in particular to advance research, IDC points out.

Key IoT sectors in France

New incomes but also productivity gains for companies, purchasing power and time-saving for citizens: more than a new industry estimated at € 15 billion in 2020 (and € 23 billion in 2025), the Internet of Things induce several 'leverage effects' whose impact on the French economy could reach 3.6% of GDP by 2020 (and about 7% by 2025).

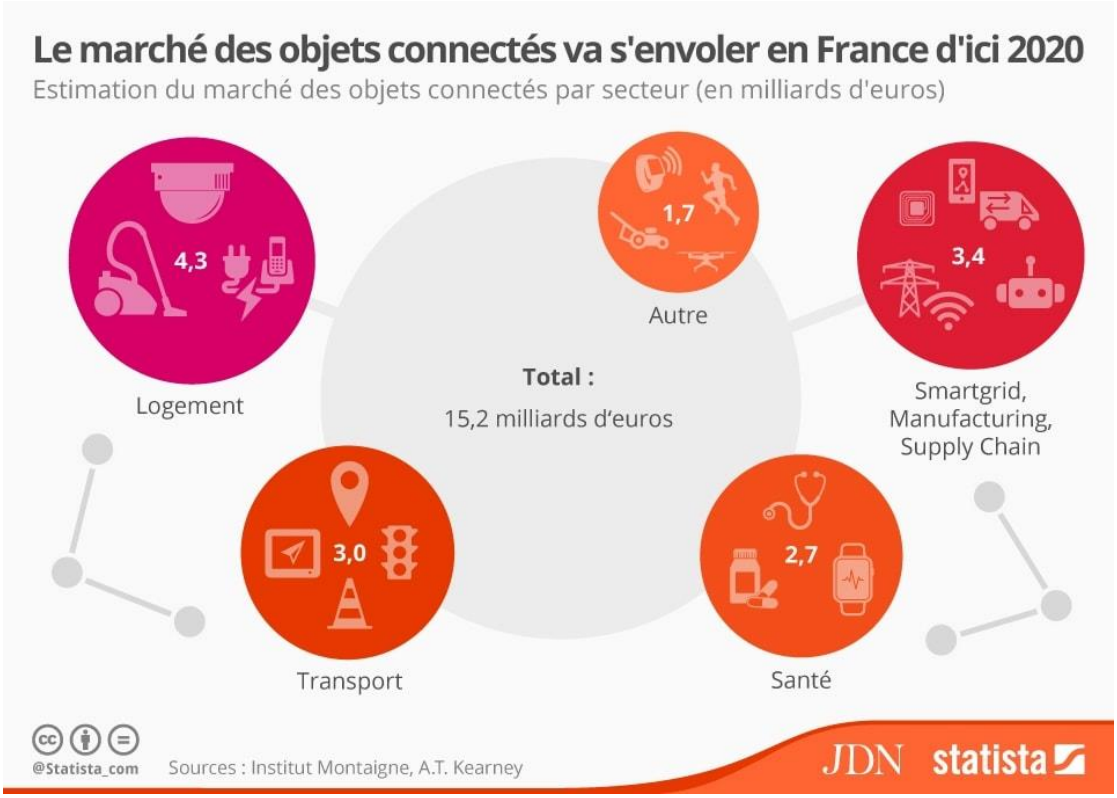

Figure 2: Estimation of the Internet of Things by sector in France (in billion euros). „The market of Internet of Things will take off in France by 2020" (A.T. Kearney 2017)

This is what reveals the *A.T. Kearney's study* (A.T. Kearney 2017), that analyses all the direct and indirect potential impacts of the connected objects on the French economy and society. 80% of this potential will concern:

- **transport (mobility)/logistics:** (€ 17-36 billion from 2020 to 2025): transport represents a significant inefficiency in terms of waste of time (€ 5.5 billion „wasted" in traffic jams), energy consumption (€ 83 billion in operating expenses) and accidents (€ 22 billion related costs, in addition to injuries and deaths). The multiplication of sensors and driving assistance systems, coordination between vehicles and roads, the development of multi-modality will allow a reduction of these inefficiencies.

- **health (€ 16-35 billion from 2020 to 2025):** the connected objects have a strong impact on the health sector, in particular, by allowing better follow-up of chronic diseases (diabetes, asthma, high blood pressure, etc.) and a better treatment compliance. Of the € 66 billion cost of long-term illness, up to 10% could be saved by a better monitoring of the constants and care pathways (€ 6.6 billion). Noncompliance, whose cost is estimated at up to € 9 billion per year, could be reduced by 80% in 2025 (€ 7 billion) through the use of monitoring systems such as connected pillboxes.

- **housing:** (19 to 28 billion euros from 2020 to 2025): this is the main household consumption item in the GDP with nearly 395 billion euros. The main lever for value creation will be energy savings of 10% of the € 56bn current spending, or € 5.6bn in 2025. Next come time savings through the development of a domestic appliances and automation market that are more autonomous and service-bearers. The *INSEE* (National Institute of Statistics and Economic

Studies) estimates that housework today requires about 20 hours per week per person, which could be reduced by 20% and generate an economic potential of up to 20 billion euros in 2025.

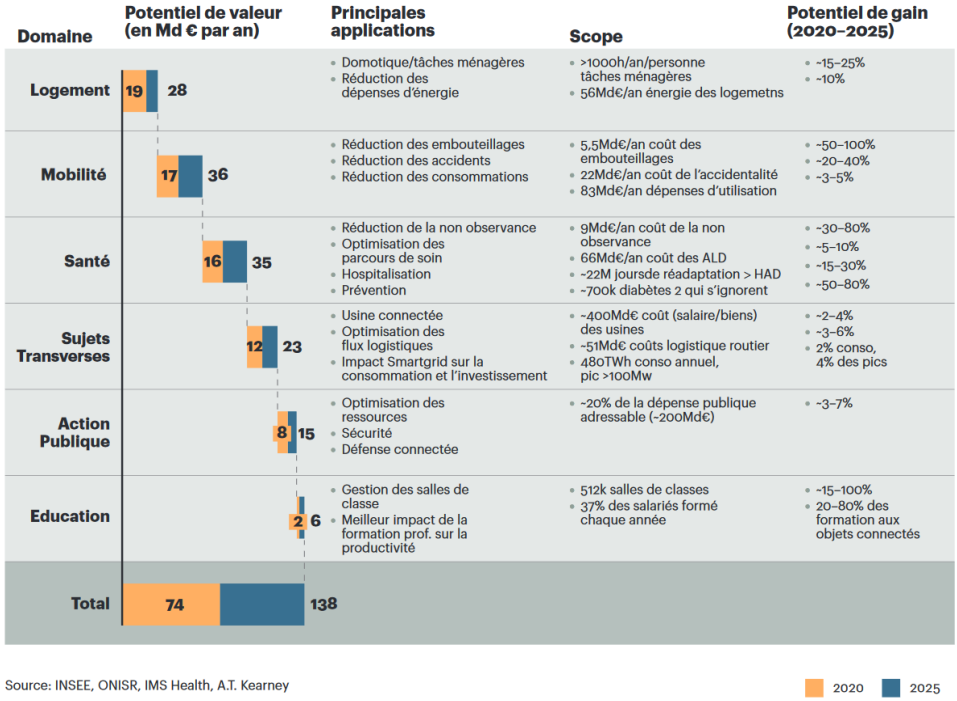

Figure 3: Potential of creation of added value of the Internet of Things in different activity sectors in France. (A.T. Kearney 2017)

2.2.2. The IoT state of the art and its adoption

The concept of IoT appeared in 1999 at the *MIT Auto-ID Center* (Massachusetts Institute of Technology in Boston) with the idea of associating a *RFID* (Radio Frequency IDentification) chip with each object in the real world to identify, record and capture its movements. But the first identified use was a Coca-Cola distributor installed at the Carnegie Mellon University (USA) in the early 1980s. Developers could then connect to the machine via the Internet, monitor its status and then determine if they could rely on a fresh cool drink in case they decided to go down the floors.

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 startups 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.

Connected objects for individuals

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 offer for sale or develop the connected objects of tomorrow. Among the 275 companies (including 233 startups) at the last CES in Las Vegas, the following startups by fields of application were present:

Housing:

- **Ubiant**: Control your energy consumption and your well-being: two objectives combined in one with the Hemis Luminion control panel. This connected object uses an Artificial Intelligence that learn your needs and adapts while improving the energy consumption of your home. The control panel can also connect to other objects to create a real intelligent network.
  http://www.ubiant.com/ (accessed 06/07/2017).
- **HDSN**: The start-up, located near Marseille, specializes in sensors for the supervision of housing (control of air quality, carbon footprint, energy saving etc.). The company aims to become a leader in this market
  (http://www.hdsn.fr/ (accessed 06/07/2017).
- **Sen.se**: Sen.se is the creator of the Mother station. With her set of sensors, it can take care of you and your family in various ways: send important reminders, locate someone, prevent intrusion, monitor physical activity, etc. A real virtual mom!
  https://sen.se/mother/ (accessed 06/07/2017).

Medical/health:

- **Aroma Thérapeutics**: Health with essential oils: this is what Aroma Therapeutics offers with its Aroma Care module. Insert an oil capsule, program a session on your smartphone and the device will broadcast the mixture best suited to your current situation.
  http://www.aromatherapeutics.fr/ (accessed 06/07/2017).
- **Leka**: Leka has an ambitious project: to improve interaction with children with autism or behavioral illnesses. For this, the start-up has invented a connected robot that aims to improve children's concentration while helping parents and specialists in their therapeutic tasks.
  http://leka.io/ (accessed 06/07/2017).

Smart City:

- **Actility**: Based in Paris, Actility is a start-up specialized in Machine-to-Machine that created the platform ThingPark. It offers services dedicated to long-range connected objects for municipalities, businesses and individuals, too. Actility also works in the energy optimization of industrial sites.
  http://www.actility.com/ (accessed 06/07/2017).

Several companies have gone beyond the startup stage and are now SMEs or companies with international visibility. Examples include:

•***Parrot*** is a French company based in Paris and created in 1994 by Jean-Pierre Talvard and Henri Seydoux. It designs, develops and markets consumer and high-tech products, mainly for smartphones and tablets, including connected objects. The company had 948 employees in 2015.
https://www.parrot.com/ (accessed 06/07/17).
•***Withings*** is a company of French origin founded in 2008, which designs, develops in France and sells connected objects (scales, tensiometers, baby phones, watches ...). It was taken over by Finnish Nokia in 2016. The company has about 150 people.
https://www.withings.com/ (accessed 06/07/17).
•***Netatmo*** markets a personal weather station that also measures air quality, allowing users to monitor their environment indoors and outdoors, and to view it in real time on the Netatmo application on their smartphones, tablets and computers. Their product has already been observing the environment of more than 105 countries, their product is in particular distributed in Apple Stores in the USA and Europe. With a fund raising of 4.5 million euros and rewarded at CES 2014 with its object, June, Netatmo is undoubtedly one of the best French startups of connected objects.
https://www.netatmo.com/ (accessed 06/07/17).

Connected objects for companies

For the general public, the IoT often amounts to an avalanche of connected products or gadgets. For the industry, the IoT announces its most important revolution, its fourth one. This 4.0 industrial revolution will have significant socio-economic consequences in France. The growth of communicating machines will first lead to better assets optimization and improved productivity. Then the machines will self-learn, until they end up being autonomous. This perspective pushes the frontiers of industry.

The promises of the Internet of industrial objects are then huge: the alliance of sensors, cloud, data analysis, intelligent algorithms or cryptographic systems combined with platforms and more open ecosystems will change our way to think of a production that will become closer to the customer.

Interestingly, 37.5% of French industrialists believe that IoT will play an important or major role in improving the four internal processes (production management, extended supply chain, shop floor and traceability).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.The study of *PAC*(L'IOT dans l'Industrie en France 2016) shows that whether for internal processes or services, the main objectives of the 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 more „offensive“ and customer-oriented goals come much further: to improve customer satisfaction or to increase the share of recurring revenues (for example, subscription or usage).

Some examples of IoT domains in France

Smart Grid: The rise of smart meters (Linky meters) and the connection of network infrastructures has made it possible to collect a lot of data on household lifestyles and on the consumption strategies

of companies. This innovation has an impact on all the activities of the electricity sector. Firstly, this new collected information allowed to improve and optimize the performance of the production and distribution chain of the electrical system, secondly, to develop offers, services or products more adapted to the needs of customers, which is made possible by processing the information left by the users on the network. For example, the Electricity Transmission System (RTE) deployed Eco2mix, which enables its users to track over the Internet and on mobile devices electricity production and consumption in France, free of charge and in real time.

Smart Agriculture: Farmers seem to have realized the potential of digitizing their sector. According to a 2016 study by Ipsos (23), the agricultural community surveyed is connected with an average of four „e-Farming" equipment, and only 12% of these farmers do not use any connected equipment. If one looks closer to the connection solutions available to farmers, 60% have already acquired a geolocation management and operation management system (GPS or via low-density network antennas); 40% of decision support tools and 20% of cloud-based management solutions. In addition, 65% of farmers surveyed say they intend to equip themselves in the coming years, with a preference for objects connected to farm machinery, farm animals or farm buildings. Nearly one out of three farmers wants to have his cattle connected with sensors, and one out of two wants to use a centralized management software. For example, *Arlinov* is a company that created sensors that can be installed on drones for mapping fields. The overflight of the drones provides many data to farmers: fertilizer requirements of each plot, damage caused by wild animals or bad weather; Indices of biomass and height of the plants, etc.

Smart Car: The two major French automobile groups (*PSA* and *Renault-Nissan*) are developing projects around connected cars. Against this lack of infrastructure for data collection in France (and in Europe), *Renault-Nissan* and *Microsoft* signed a „multi-annual global partnership agreement" (Smart Car 2017) on Monday 26 September 2016, in order to collaborate on the development of future connected services for vehicles.

Smart Cities: The 'smart cities' are today pioneers in the use of connected objects to improve the daily life of city dwellers. Public utilities in the city take advantage of connected objects to make public intervention more efficient and allows to save money. For example, the Lyon metropolis uses waste containers equipped with pressure sensors that allow to know their filling rate and to guide the rounds of the cleaning services of the community. With the data collected, the services can adjust the location and the number of containers to better meet the needs of the inhabitants.
Analysis of the strengths and weaknesses of France in IoT

While it is difficult to accurately count the number of startups in France, given their high volatility, it is possible to quantify the success of this form of entrepreneurship today. According to the EY-France Digitale barometer published in 2016, two main conclusions can be drawn:

- A 'Sustainable hyper-growth': the start-up companies' growth is increasing, regardless of their size (€ 3 billion in 2014 and € 4.2 billion in 2015, an increase of 39% in one year). Growth comes both from the turnover in France and internationally. France now has international champions, but also a generation of companies that have quickly tackled the world market, and which are known as 'born global';

- Increased workforce, mainly located in France. The startups were employing 13,809 people in 2015, an increase of 27% compared to 2014. In average, 13 jobs were created in each startup. The trend is also expected to be on the rise in 2016, with 94% of startups that are ready to hire again.

There are many French innovation support schemes (regulatory, fiscal or financial). The following mechanisms can be used to encourage the emergence of innovative companies that focus on the production of connected objects: the innovation tax credit (CII), and the status of young innovative companies (JEI). The effectiveness of this last device is undisputed. The European Commission ranked the JEI status as being the top at European level, among the tax incentives for R&D applied in 26 of the Member States.

The most common observation made about young French companies is, on the one hand, the ease of doing business, and, on the other hand, the difficulty of developing their business. Thus, it is often diagnosed the difficulty of taking the „scale-up" step that allows a startup to switch to a larger company status, that found its economic model and is able to continue growing, in particular internationally. The main obstacles to the development of startups today are material obstacles: successfully raising funds, especially from foreign investors, or administrative obstacles: to manage an environment that becomes increasingly more complex while the company is growing.

2.2.3. Existing studies and analyses on the Internet of Things

Analysis note 22 – Tomorrow, the Internet of Things
Study of France Stratégie, January 2015.

- http://www.strategie.gouv.fr/sites/strategie.gouv.fr/files/atoms/files/notes_danalyse_22.pdf (accessed 06/06/2017).
- France Stratégie is a body for consultation and reflection. Its role is to propose a strategic vision for France, by exploring the major choices available to the country. Its work is based on four areas: assessing public policies; anticipating future changes in the economic, societal or technical fields; discussing with all the stakeholders to enrich the analysis; proposing recommendations to the government.
- This study presents the Internet of Things in the broad sense, from captors to usages and software platforms. Then it focuses on the economic maturity of the sector whether it is technical, social or economic. Finally, it ends by positioning France and its SMEs in the international landscape.
- Big data and connected objects – Making France as the champion of digital revolution.

Institute Montaigne

- http://www.institutmontaigne.org/res/files/publications/rapport%20objets%20connectés(2).pdf (accessed 06/06/2017).
- Institute Montaigne is an ideas lab - think tank - created at the end of 2000 by Claude Bébéar and directed by Laurent Bigorgne. It is free from any partisan bond and its funding, exclusively private, is very diversified, with no contribution exceeding 2% of its annual budget.

Independently, it brings together business leaders, government officials, academics and representatives of civil society from varied backgrounds and experiences.

- How to make France as a champion of digital revolution? This report identifies four axes for coordinating the actions of public authorities and private actors: disseminating technological excellence in the economic structure, guaranteeing trust among stakeholders, strengthening digital governance and the influence of France, and finally meeting to new needs in skills.
- Big data and connected objects: an opportunity for France.

ATKearney study

- http://www.atkearney.fr/documents/877508/879237/Big+data+et+objets+connectés.pdf/79d156fb-6bb9-4e37-b010-6b030f2940c1 (accessed 06/06/2017).
- ATKearney study for the Montaigne Institute in the framework of the previous report.
- This study is a modelling of the potential of the development of Internet of Things and Big Data on the French GDP by 2020-2025. This work is based on the estimation of GDP by expenditures, as used in the national accounts. As a reminder, this evaluation focuses on understanding the impact of the connected objects on the consumption of companies, public and private investment and the trade balance.

Information report on the connected objects

Assemblee Nationale: Rapport d'Information

- http://www.assemblee-nationale.fr/14/pdf/rap-info/i4362.pdf (accessed 06/06/2017).
- This mission is composed of Ms Corinne Erhel and Laure de La Raudière as reporters.
- This report of the parliamentary mission is broken down into two main parts. The first part is about the subject itself i.e the change of paradigm implied by the IoT and the evolution of its everyday uses. The second part reports more on the French entrepreneurial landscape with a focus on the position of the expertise of higher education and research in this field and then emphasizing the pool of startups and of SMEs that support IoT in France. Finally, it reviews the expertise in this field of French higher education and research and then emphasizing on the pool of startup and SMEs that support the IoT in France. Finally, it assesses the support actions carried out and the challenges that still need to be addressed.

Connected objects: The new digital revolution

Objets connectes la nouvelle revolution numerique

- http://www.editions-eni.fr/livre/objets-connectes-la-nouvelle-revolution-numerique-9782746099906 (accessed 06/06/2017).
- Book published by ENI and written by Yves-Marie BOULVERT - Eric DOSQUET - Eric BARQUISSAU - Jérémy PIROTTE - Frédéric DOSQUET - Renaud ACAS
- This book provides a global view of the integration of those objects into our personal and professional lives. The technical, marketing and legal aspects are favored here.

Analysis and prospects of the connected objects (CITC)

- http://www.citc-eurarfid.com/uploads/citc%20publication%20HD.pdf;

- http://www.citc-eurarfid.com/uploads/CITCEuraRFID-Analyse-Perspective-d-avenir-de-l-Internet-des-Objets-Horizons-2013-2020.pdf (accessed 06/06/2017).
- The Center for Innovation in Contactless Technologies (CITC) is a key player in the Internet of Things and Ambient Intelligence. It is a center of resources, experiments and technical expertise in terms of identification, traceability, mobility and geolocation, integrating environmental requirements, ethics and security. It supports the adoption of contactless technologies and the Internet of Things, the emergence of innovative and standardized solutions, and the development of new high-potential activities.
- Those two reports (2011 and 2013) present the strategic orientations of research and innovation around the Internet of Things. Then they focus on the regulatory issues and technological challenges that impact this field. Finally, they address the issues of public governance and economic models.

Observatory of the connected objects

- http://www.ifop.com/media/poll/2846-1-study_file.pdf (accessed 06/06/2017).
- Study by Raphaël Berger, Director of the Media & Digital Department at the FIFG in November 2014
- Online survey carried out from September 26 to October 10, 2014, taken by a sample of 2000 Internet users representative of the French population with the aim of explaining the overall understanding of the market. This study was supplemented by 2 focus groups of „Early adopters“ with a presentation of concepts of new objects in order to identify the projections and intentions of use with early adopters

Markets of connected objects: Health, housing, leisure, business and city: markets prospects and new competitive landscape by 2020

- Markets of connected objects: http://www.xerfi.com/presentationetude/Les-marches-des-objets-connectes_5EEE21(accessed 06/06/2017).
- This study draws attention to the disappointing balance of the markets of the connected objects that explains the reasons for the relative failure and the hoax around connected devices that tended to exacerbate expectations. The analysis then focuses on the most promising products as well as on the key factors of success and the obstacles to be lifted in order to achieve the revolution of the connected objects in the medium term. Finally, the study helps better understand the competitive game and its likely evolution in the medium term.

White *Paper IoT: what reality for the industrial sector in France?*

- https://www.cgi.fr/sites/default/files/files_fr/brochures/rapport_mcs_iot_manufacturing_france_-_vf_-_cgi.pdf (accessed 06/06/2017).
- Written by Franck Nassah and David Gautier. March 2016.
- The results presented in this report are the outcomes of a survey conducted by PAC in February 2016 among 150 industrial companies with more than 500 people who had already reflected on the subject of IoT. All industrial sectors are represented, in particular manufacturing of equipment and high-tech (15%), aerospace and defense (14%), automotive (13%) and manufacture of machinery (13%). This survey was carried out both among the IT

teams and the professions (CDO, R & D manager, IOT manager, industrial manager). The report findings show that French industrial companies are now at a relatively low level of maturity and few have implemented an IoT strategy (around 10%). However, there is a real dynamic, most certainly linked to a real growing awareness of the importance of the IoT, both in terms of strategy development and reflections/projects.

2.2.4. Performed research projects on Internet of Things

ANR (National Agency for Research) projects (started in 2015 or 2016):

MoReOver

- Realistic modeling of the radio channel and radiation test for the reliability of the Internet of Things
- Central Commission of nuclear energy – LETI
- The objective of MoReOveR project is to develop a multidimensional model of the radio channel and a new radiation pattern of measurement ('Over-the-Air') for the design and evaluation of performances of radio systems in order to facilitate the deployment of 5G and of the Internet of Things in challenging environments for wave propagation and heterogeneous mobility. MoReOveR proposes a global approach to this issue from the measurement and modeling of the radio channel to the emulation of the channel and OTA tests.

EPHYL

- Improvement of the waveforms in low-power cellular networks for the Internet of Things
- CentraleSupélec, Inria - Grenoble Rhône-Alpes, Office of Atomic Energy and alternative energies, ISEP EDOUARD BRANLY, SEQUANS COMMUNICATIONS
- The EPHYL project is encompassed within the Internet of Things and aims to propose, evaluate and experiment cellular network improvements of the connected objects. Starting from the very active standardization in the field (which is followed by the industrial partner), laboratories will evaluate the solutions being defined and will suggest improvements, whether at the level of the physical layer or at the level of the more general issue of the management of radio resources.

Greco

- Resource Manager for objects cloud
- Centre de recherche Inria Rennes - Bretagne Atlantique, Grenoble INP / LIG, QARNOT COMPUTING
- The ambition of GRECO project is to build a reference resources manager for objects clouds. The manager must act at the level of the IaaS, PaaS and SaaS layers of the cloud.
- One of the main difficulties is to take into account the execution context of the connected objects. Unlike traditional cloud nodes, connected objects have new types of networks and computing media, different sensors and new constraints such as human interactions. The great mobility and variability of this context implies that it is difficult to model the quality of service. In this context, GRECO project intends to innovate by developing task scheduling and

data management approaches, which, based on automatic learning, will dynamically adapt to the observations made on the execution context. The adaptation here requires a dual modeling on the one hand, recurrent uses of the cloud of connected objects, and, on the other hand, of static and dynamic topology of the platform.

DAPCODS

- Data protection of Connected Objects and Smartphones
- Centre de recherche Inria Grenoble Rhône-Alpes – PRIVATICS, EURECOM, Université Paris-Sud
- DAPCODS project will contribute in several ways: 1) by analyzing the internal functioning of a significant set of connected objects in terms of leak of personal information; 2) by studying the privacy charters of manufacturers of connected objects according to several criteria (eg accessibility, precision, object focus, privacy risks); 3) by understanding the underlying ecosystem, with regard to economic perspective; 4) by proposing a public website that will classify those connected objects and will inform the citizen.

ARTEFaCT

- Flexible circuits and approximative calculation for the Internet of Things
- CEA Laboratoire d'Electronique et de Technologie de l'Information, Centre de recherche Inria Rennes Bretagne – Atlantique, Centre Suisse d'Electronique et de Microtechniques SA, INSA RENNES
- EPFL Integrated Circuits Laboratory (ICLAB) ARTEFaCT proposes to coherently address the entire design flow, from the design of the hardware to the physical level, to the analysis of the application software, to the optimizations of the compiler, and to the dynamic management of energy. They believe that the combination of under/near-threshold design with inaccurate circuits on the hardware side with intelligent and adaptive power management on the software will produce remarkable results in terms of energy reduction, that is to say of at least one order of magnitude, making it possible to consider objects that are effective for IoT.

WONG5

- 5G waveforms for machine-to-machine communications
- CentraleSupélec; Office of Atomic Energy and Alternative Energies – LETI; National Conservatory of Arts and Crafts; Thales Communications & Security SAS
- The objectives of WONG5 project (Waveforms MOdels for Machine Type InteGrating 5G Networks) are the study and proposal of the waveform (FO) best suited to the physical layer of Critical Machine Type Communication (C-MTC). The MTC market is estimated at 50 billion connected machines by 2020, with the emergence of the internet of things. C-MTCs will represent an important part of the activity and the transmitted flows.

POLLUSCOPE

- Participatory Observatory for Monitoring Individual Exposure to Air Pollution related to Health

- AIRPARIF; Center for studies and expertise on hazards, environment, mobility and development; Data and Algorithms for an Intelligent and Sustainable City; School of Engineers of the City of Paris; Research team in social epidemiology, Pierre Louis Institute of Epidemiology and Public Health; Team Epidemiology of allergic and respiratory diseases, Institut Pierre Louis d'Epidemiologie et de Santé Publique; Research Institute of the Naval School; Laboratory of Climate and Environmental Sciences.
- Polluscope project should lead to a significant contribution from the state of the art with a strong social impact, thanks to the multidisciplinary expertise of its members. More specifically, the expected results of this research are: 1) to propose and develop an innovative community-based system specifically designed for observing individual exposure to environmental hazards; 2) to provide effective techniques for integration, cross-referencing and enrichment of individual exposure data; 3) to cover air pollution both indoors and outdoors (home, work, transport, etc.) while automating the detection of context; 4) to apply data mining and pattern recognition methods to extract rich and useful knowledge; 5) to provide techniques and tools to identify the effect of pollution on individual health and in particular on respiratory and cardiac functions; 6) to provide an online access to the information system so that the public can obtain up-to-date information on pollution or be able to publish its own measures.

European projects

Trustworthy Wireless Industrial Sensor NETworks – TWISNet

- http://www.twisnet.eu (accessed 06/06/2017).
- Project partners: dresden elektronik ingenieurtechnik gmbh (Germany, Project Coordinator), Commissariat à l'Energie Atomique (France), Électricité de France S.A. (France), University of Applied Sciences Dresden (Germany), Universitatea Politehnica din Bucuresti (Romania), SAP (Germany), Cisco Systems International BV (Netherlands, Associated Partner)
- The TWISNet European R&D project addresses the security concerns raised by the deployment of wireless sensor networks (WSNs) into industrial environments. The goal of the TWISNet project is to provide a platform for an efficient, secure and reliable integration of sensor networks into large scale industrial environments.

Azea

- http://www.dewiproject.eu (accessed 06/06/2017).
- The 58 DEWI project partners are from Austria, Belgium, Finland, France, Ireland, Latvia, Netherlands, Poland, Portugal, Spain and Sweden.
- DEWI will provide key solutions for wireless seamless connectivity and interoperability in smart cities and infrastructures, by considering everyday physical environments of citizensin buildings, cars, trains and airplanes, thereby significantly contributing to the emerging smart home and smart public space.

BUTLER

- http://www.iot-butler.eu (accessed 06/06/2017).
- The 21 Butler project partners are from France, Italia, Spain, Luxembourg, Swiss, Belgium, Finland, Germany,

- BUTLER is a European Union FP7 project focused on the Internet of Things researches. This purpose is enabling the development of secure and smart life assistant applications thanks to a context and location aware, pervasive information system.

ClouT

- http://clout-project.eu (accessed 06/06/2017).
- The overall ClouT consortium is made of 13 partners, 6 from 3 different European countries (France, Italia, Spain) and 7 from Japan of which: 2 research centres, 2 universities, 5 large industrials and 4 cities.
- ClouT's overall concept is leveraging the Cloud Computing as an enabler to bridge the Internet of Things with Internet of People via Internet of Services, to establish an efficient communication and collaboration platform exploiting all possible information sources to make the cities smarter and to help them facing the emerging challenges such as efficient energy management, economic growth and development.

2.2.5. IoT awareness in selected businesses

Public trade shows

SIdO

- http://www.sido-event.com (accessed 06/06/2017).
- The largest international showroom dedicated to the Internet of Things, free access for all professionals! 2-day conferences + solutions + networking + showroom techno & uses to imagine the uses of tomorrow and reinvent your business models. On 5 & 6 April 2017, in Lyon, European capital of smart objects.

IoT World

- http://www.iot-world.fr/ (accessed 06/06/2017).
- It has been designed to be the annual event of this market, made of exchanges, sharing of information and business between its various stakeholders, manufacturers of connected objects, developers, telecom operators, hosts, integrators ...

Research and professional days

National Day of the Internet of Things

- https://ido2016.sciencesconf.org (accessed 06/06/2017).
- This day dedicated to the new challenges of the Internet of Things is the opportunity to evaluate, on the one hand, the issues related to human and technological factors and, on the other hand, the question of the role of connected objects in everyday life such as health, housing, automobile, insurance, which are being overwhelmed by this change in the network.

SIF Day „IT Challenges of the Internet of Things"

• http://www.societe-informatique-de-france.fr/les-journees-sif/jounee-sif-defis-informatiques-de-linternet-de-objets/ (accessed 06/06/2017).
• The theme of this day focused on the scientific and technical challenges of the Internet of Things (IoT). Through presentations and exchanges, this day was to allow the academic and industrial worlds to share scientific and technical elements and to discuss the technical challenges due to the wide deployment of the internet of things in the coming years.

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2.3. Italy

2.3.1. Overview of present and future Internet of Things technologies

Present IoT technologies in Italy

The Internet of Things 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.

In Figure 1 the present scenario of pilot studies and experimental application is depicted. The figure highlights the encouraging result that the main part of the starting and experimental experiences meet the IoT standardization.

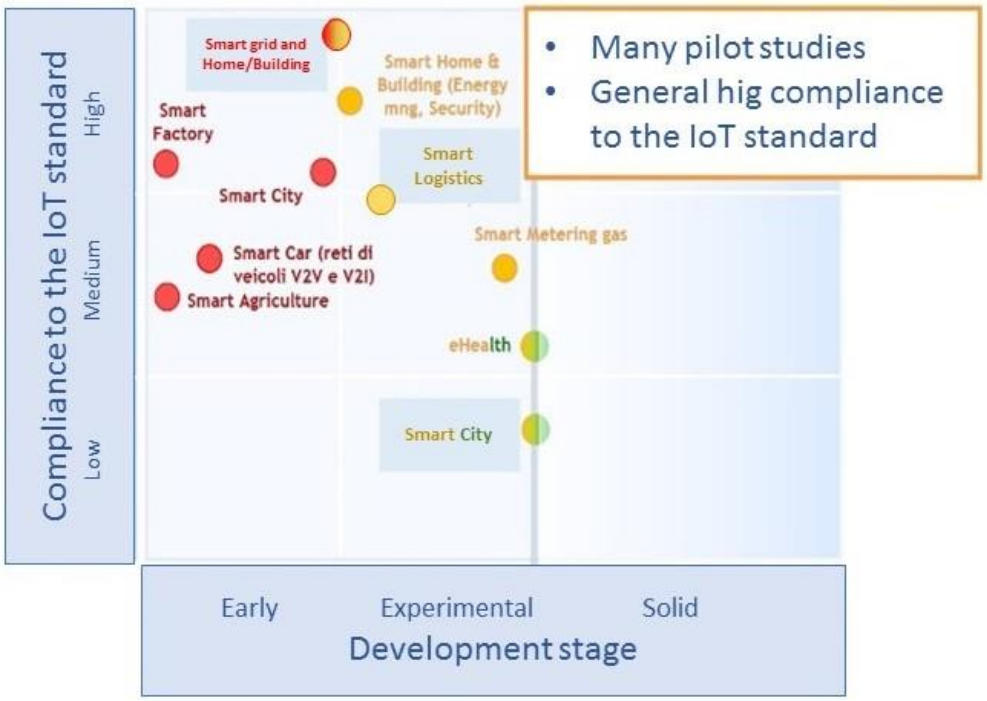

Figure 1: Scenario of pilot and experimental application.

In Figure 2 the scenario of consolidated application is reported, where we can notice that the results meet the IoT standard at different levels.

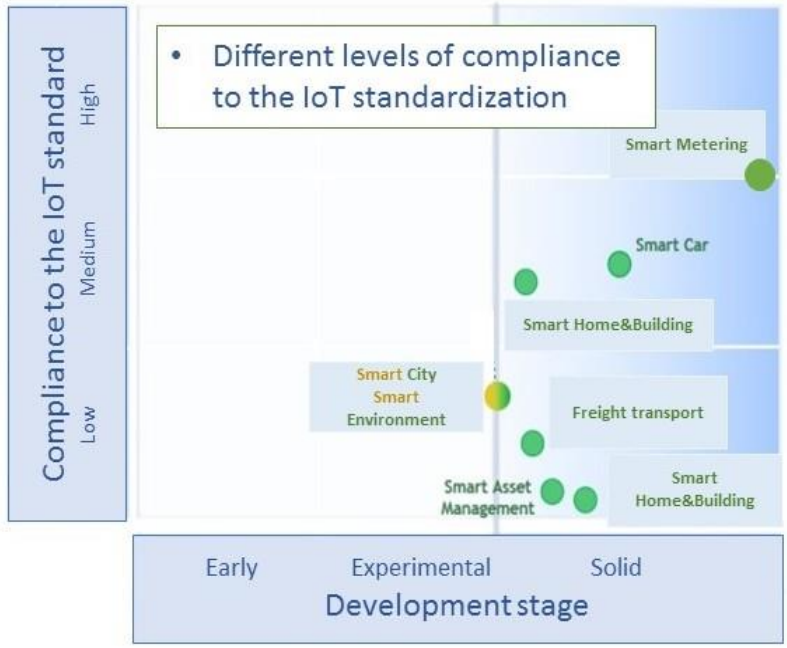

Fig. 2: Scenario of consolidated area application.

The sector and its potential appears limitless, however, for now, to support them are 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 *School of Management of Politecnico di Milano*.

The main market anchors are:

- **Smart Metering:** means a control system based on sensor networks for real-time monitoring of electricity, gas and water, with the ability to interface with information and communication technologies. This enables action on the plants by adjusting the exchange of both energy and information on the operation of the plant, also offering the opportunity to intervene in case of problems or failures in immediate mode, without having to resort to the intervention on the spot. Therefore, the user is put in communication and the distribution, by sending and collecting data in digital format, for a rational management of the consumption in favour of an effective method of measurement. This can be applied to the distribution of water, gas and electricity so it is a key technology for energy efficiency projects because it allows the measurement of the achievable savings and checking the performance of various systems undergoing redevelopment. Its application allows to accompany any work efficiency from the design phase, with the measurement and evaluation of consumption and energy losses of a plant or a building before the redevelopment, through the monitoring during the construction phase and end with measurement and control tele power management after the 'intervention of the savings. It is also an essential tool in the evolution of traditional power grids: smart grid with perfect efficiency, no waste and lower costs for the necessary infrastructure.

- **Smart Asset Management:** it defines the scope of application solutions aimed at the monitoring, management and optimization of different processes such as smart meters and systems for remote fault management, tamper, localization and other applications. The

remote management of value in order to collect real-time information on consumption goods carried, monitor the operation of the device was promptly detecting any malfunctions, the need to control charging of electric distributors for machinery, counteract the occurrence of possible fraudulent actions of third parties. The areas supported with regulatory requirements have resulted in a park of 350 thousand gas meters already installed for industrial users and 1.2 million for residential. 5% of the smart asset management is used for the management of 340 thousand gaming machines, elevators, and 80 thousand 200 thousand vending machines.

•**Smart Car:** the Smart car, with 5.3 million vehicles of its kind in Italy, one seventh of the total fleet, 88% of these, however, is connected with a box GPS / GPRS for location and recording parameters driving for insurance purposes, but are growing rapidly with an increase of + 135% cars designed factory connectivity: looking at new registrations, now one in five is equipped in this way.

•**Smart Building:** 18% of resources is responsible for the surveillance and management of photovoltaic systems, as well as logistics, in particular as part of fleet management and satellite alarms. The smart city is a reality, with 200 thousand public transport monitored remotely and 600 thousand smart lighting poles. 60% of Italian municipalities with population exceeding 20 thousand inhabitants has also initiated a project at least the last three years and 75% are planning initiatives for the current year. Italian cities are still far from becoming really smart because the projects are small, experimental and less of a common three were started within a structured program to improve liability, sustainability and economic dynamism of the territory.

•**Smart Home:** 6% of market applications that they basically leverage intrusion detection systems and thermostats as in the field of home automation.

Researchers and scholars state that these numbers denote an explosive growth of the Internet of Things in Italy, even more important is the consolidation of the bases for the development on all fronts: cities, consumers and businesses.

The installation of new communications networks dedicated IoT early Italian cities, the development of supply in the field of smart home, more and more integrated with insurance services is also ready to land in the supermarket chains. The IoT is always a reality in Italy, innovative services are the important prerequisites for the future based on the industry 4.0 or an industrial automation trend that integrates some new production technologies to improve working conditions and increase productivity and production quality of the facilities.

At present, 79% of Italian consumers are willing to buy products for the smart home and 72% also related services, 33% more than the previous year. However, the path is announced along: only one in five already have at least one smart object in your home and buying intentions are indeed smoky 25% of those who state they want to buy a product will do within 12 months.

Future IoT technologies in Italy

The world IoT is expected to grow in 2016, thanks the multi-service initiatives carried out by the Utility regulatory obligation starting on Smart Metering gas and thanks to new communication networks dedicated to IoT, already present in the raw Italian cities. In about 40 cities is SigFox the

network, installed in partnership with Nettrotter (EI Towers Group), and is scheduled covering the entire national territory. In Milan, Bergamo and Brescia, the A2A Group is installing a multi-protocol network where match The Wireless M-Bus protocol 169 MHz (chosen primarily for metering) with networks Low Power Wide Area, in order to support a wide range of citywide services. (*Internet of things: Smart Present or Smart Future? (Observatory Internet of Things)*

In Milan the „The Things Network" initiative was also launched in January 2016. It involves the construction of a low-concentrators network consumption that use the technology for the coverage LoRaWAN of the city. It expects, with more time, the arrival of solutions based on Narrow-Band IoT (NB-IoT), which in some countries Europeans have already started the first trials. These (and other) initiatives are candidates in fact to be the real key from time to implement Smart City projects economically sustainable, optic Smart Urban Infrastructure (SUI): side offer remains to be worked on business models and understanding of synergies. The Industrial IoT, within the major national programs digitization of the industrial-manufacturing sector plays a leading role, especially for the centrality given by the German reading (and by extension could say European) to the Cyber-Physical Systems (CPS). The common trait of these applications is the ability to enable new operating models based on the interconnection and cooperation of resources (people, equipment, information) used in production processes within the factory and along the value chain.

2.3.2. The IoT state of the art and its adoption in Italy

IoT developers and providers

In 2015, the commercial IoT market in Italy has come to touch the 2 billion euro, an increase of 30% compared to 2014 driven in a balanced way is by applications more consolidated, which exploit the „traditional" connectivity (1.47 billion euro, + 28% compared to 2014), both from those which use other communication technologies, such as Wireless M-Bus and Bluetooth Low Energy (530 million euro, + 33% compared to 2014).

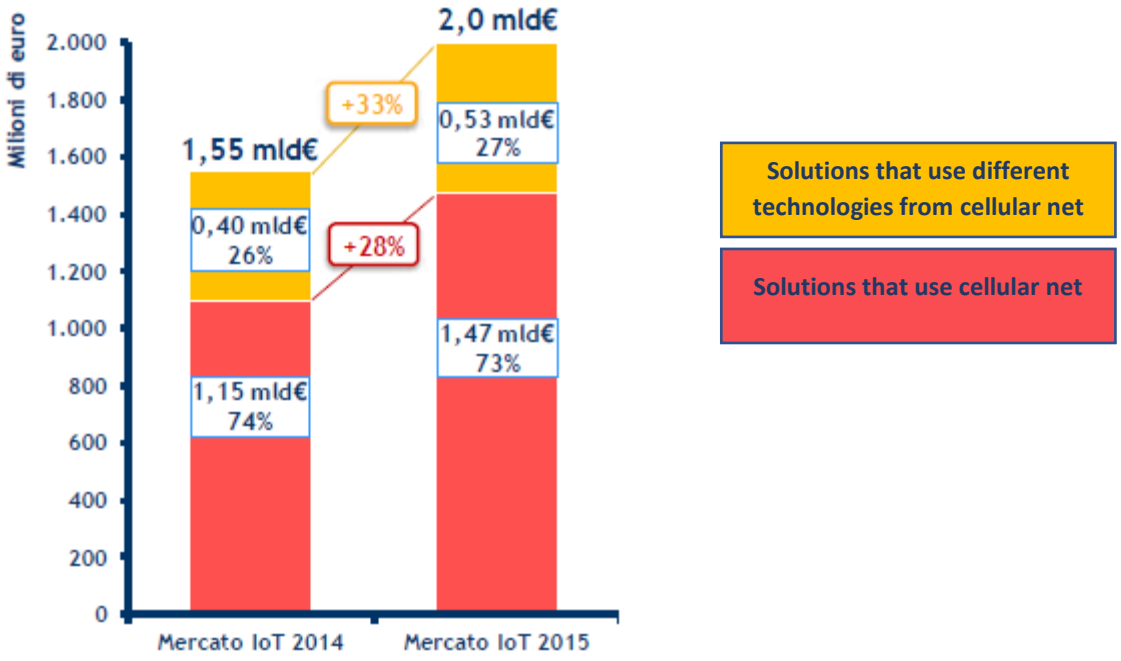

Figure 3: IoT market: the growth of 2015

The change of IoT step in Italy is not yet enclosed only in the numbers of the market (positive): the fact still more important is that in 2015 the way has been consolidated for development in the coming months, on all fronts: cities, consumers and businesses. The installation of new networks of communication dedicated to IoT in Italian cities makes the offer in the field of intelligent home growing and the integration with insurance services also ready to land in the major retailers, up to innovative services for the 'Industry 4.0'.
More and more cases of reality thanks to Industry IoT and Industry 4.0 projects have been able to invent and define new business models and establish itself as cases studies for Industry 4.0. (see: IoT-Industy 4.0).

We can think of **GS1 Italy** and its project that allows trains and cars being controlled by IoT technologies; or to the connected machine of *Cimbali coffee*; or even automation in healthcare with *Impeco*. But there are many other cases that affect the lives of every day and our homes, where for example the safety and power consumption are increasingly important. In Smart Building and Metering areas *BTicino* and *Qlik* applied IoT to develop a solution to reduce energy consumption. Facility Management and Real Estate are enabled with the IoT and Cognitive Computing to completely changed their perspective of management and service delivery. An example of this comes from IBM that developed IoT solutions and strategies to change the Facility Management and Real Estate Management, SAP and Fujitsu through IoT partnerships have focused their attention on the world of building automation and smart metering. Schneider Electric with the IoT has developed solutions for the energy saving and safety in homes.

Another great example of collaboration in IoT world is represented by **Octo Telematics** and *CRI* (Croce Rossa Italiana) which through the drone Management opens completely new chances to

develop new competencies and new career. It 'a necessity and at the same time an opportunity (see: IoT-smart-agrifood).

Part of this consideration is the initiative that was started in Bologna to create a center for the training of air ambulance pilots and drones for emergencies. The initiative comes from the Italian Red Cross, it reflected in the Emergency simulation training academy *Luigi Gusman*, a real simulation of techniques based on training facility. First of all, the structure prepares to the operations of the emergency room, ambulance, it employs two full-scale reproductions of an emergency room and a rescue helicopter of Leonardo-Finmeccanica AW169 type. But the center also looks at the issue more timely and increasingly important drone. The formation extends also to the piloting of the fleet of drones that the Italian Red Cross uses for a number of emergency activities such as inspections in emergency situation in the event of earthquakes, in the case of accidents in tunnels or when there are environmental disasters.

Octo Telematics is one of the partners who decided to support the *Italian Red Cross* (CRI) and has signed an agreement with CRI for research and development applied to drones to improve the ICT platform of Octo Telematics. The devices will be tested on board the drone fleet in service with the *Italian Red Cross*.

Thanks to this agreement the center of piloting aircraft Unit operational training **Sapr** (Remote Systems) will be designed to train pilots of various models of drones with the support of a flight simulator that is controlled by an instructor, which is in position to manage even a simulator of control and with this support tower can vary the conditions of the simulated mission.

IoT Adaptors

The market linked IoT is characterized by about 8 million items interconnected mostly regarding smart car (38% of the market) and smart home & building (23% of the market). In the last year, we can see an increase in the number of Italian consumers willing to purchase products Smart Home (79% of respondents, up 33% compared to 2014), unequivocal sign of awareness and interest. However, the spread to date still remains limited (only 1 Consumer of 5 has at least one smart object in your home), and intentions purchase are quite distant in time: only 25% of those who say they intend to buy a product intended to do so within 12 months.

Just about Smart Home, the section Global IT Innovator of the company NTT DATA has conducted a survey on a sample of homeowners in Italy and obtained the following results:

- 50% of homeowners probed bought or would buy intelligent objects to protect their own house;
- 52% of homeowners probed bought or would buy intelligent objects for the energy efficiency;
- In Italy 54% of homeowners probed bought or would buy objects smart for comfort.

Principal issues which to be focused on are:

- Customers are currently not able to identify the presence of an integrated reference solution and that entirely meets the present needs and future. More than 150 solutions (products and services) for IoT smart home sold in Italy and abroad.
- They perceive it difficult to understand the operation of the technology. What items can I connect? How many applications do I need? What do I connect them via Wi-Fi? Powerline?
- Difficulties in the installation and commissioning field;

- Maintenance problems: The thermostat is supplied with power? How long is stack of the sensor to the window and that the door? How do they change? Every how much? And if it does not work the phone line?

The response to the challenge NTT DATA IOT SMART HOME: a suite of smart modular and coordinated device enabling one or more services of home automation for your house - Automation, Security, protection.

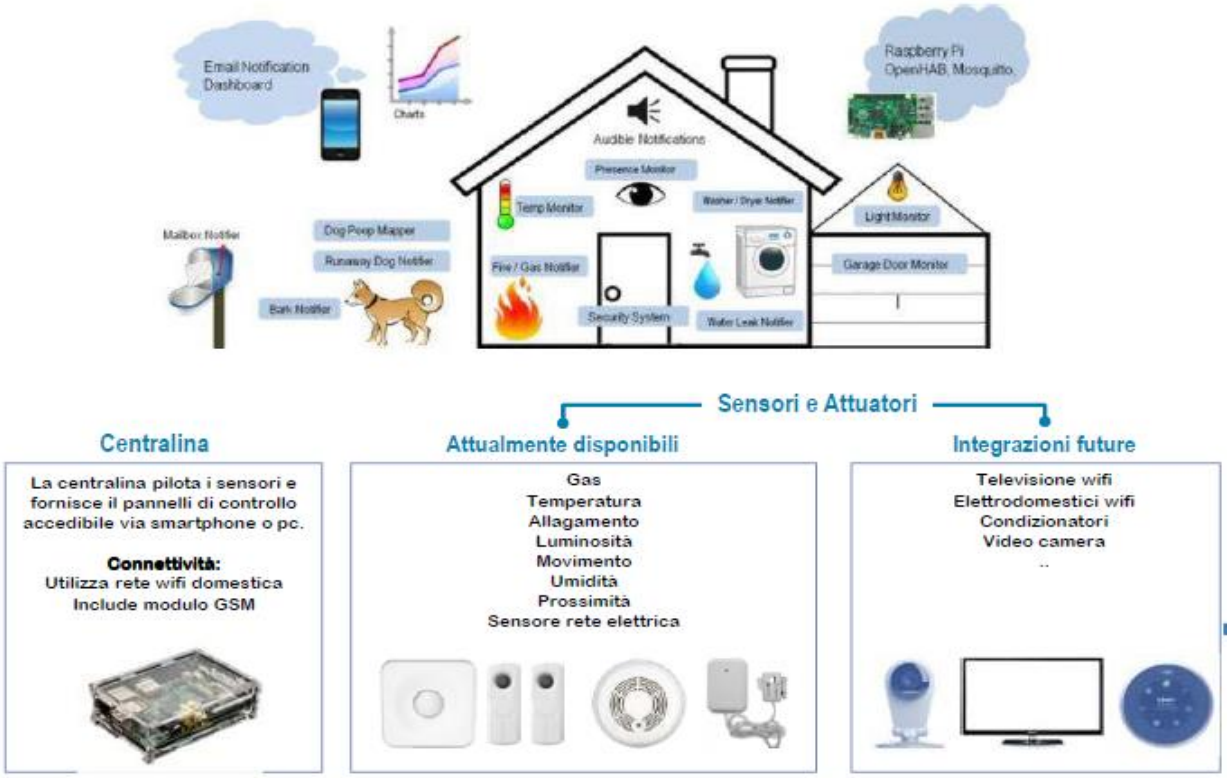

Figure 4: IoT Smart Home NTTD proposition (*PROPOSITION NTT DATA NELLA DEFINIZIONE DELLA STRATEGIA DI INGRESSO NEL MERCATO SMART HOME)*.

The solution in Figure 4 proposes:

- **Multi Sensors:** to acquire data capacity without distinction of objects (sensors, RFID, GPS, etc.) and via framework OPENHAB software infrastructure;
- **Extendibility:** no limitation to the number of sensors and devices connectable to the platform, both provided by the product that already available to the client;
- **Plug & Play:** self-scanning in the process of all devices of the smart controller installation IOE in the home through NTTD platform;
- **One Gateway:** unified and neutral concentrator for communication with all interconnected devices (sensors, counters, routers, etc.) through framework OPENHAB;
- **Safety:** for the proactive capabilities (garage door openers, doors, windows, etc.) at high rate risk, security will be guaranteed through the signing of smart-contract block chain;
- **Ease of Management:** You can change the behaviour of the platform independently without the intervention of IT personnel, SELF RULES;
- **Smart Management:** Centralized management of all process steps through an only software usable on smart devices.

2.3.3. Existing studies and analyses on IoT in Italy

A study focused on strong growth in the number of IoT/M2M devices envisages in the e-SIM distribution. e-SIM will surpass the traditional SIM cards over the next few years. In particular, in the automotive industry adoption of the standard e-SIM it has several advantages for the majority of stakeholders: manufacturers can build devices with SIM 'empty' that could be activated in the destination country/registration.

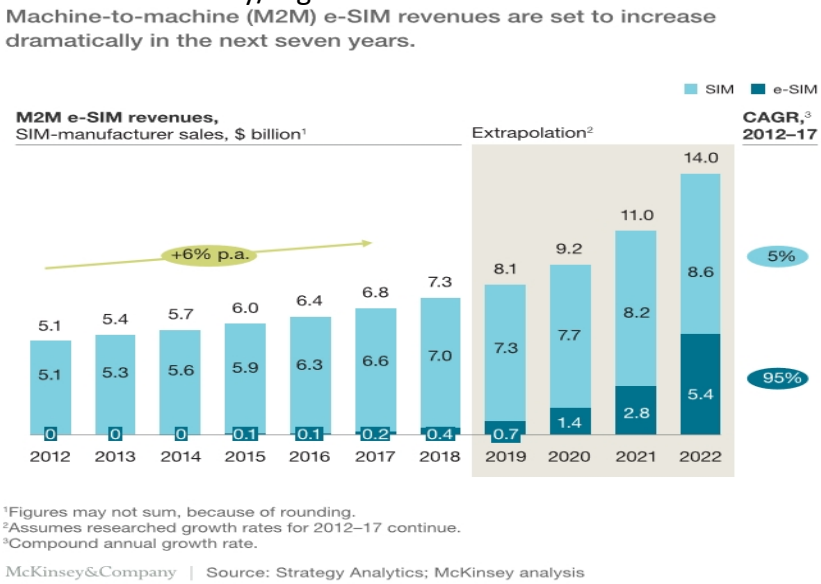

Figure 5 5: e-SIM Revenues (McKinsey)

Mobile network operators can deliver converged services to multiple devices more easily than using traditional SIM and will benefit from immediate activation services and the addition of 'secondary' IoT-enabled devices to be connected to the e-SIM tariff plan thus increasing customer adoption rates. It also true that device manufacturers, catalyzing the relationship with the customer may disintermediation network operators; ease of use when changing operator, could weaken their position in the value chain. But it should be emphasized that more freedom for customers does not necessarily mean a tendency to spend less, indeed, guests will enjoy the most rewarding and engaging user experiences and higher quality with a propensity to increased spending.

Telecomitalia and Ericsson IoT & M2M

Telecomitalia and *Ericsson* have signed a collaboration agreement with a duration of three years for the joint development of innovative solutions in the Internet of Things services and Machine to Machine. The partnership aims to achieve vertical services for the automotive industry, utilities and agriculture exploiting enabling technologies offered by Ericsson Device Connection Platform for the management of M2M connectivity and Service Enablement Platform for enabling digital services (see: Telecomitalia 2015).

The agreement was signed at the headquarters of *Telecomitalia* by Mario Di Mauro, Head of Strategy & Innovation of *Telecomitalia* and Alessandro Francolini, VP Sales Director of *Ericsson.* The projects will be conducted within the Foundry, 'the workshop' Innovation of *Telecomitalia* where, together with selected partners, identify, test and develop the most innovative solutions that will underpin the next TIM offers in the digital sector life.

In particular, *Telecomitalia* will be responsible for defining, testing, and evaluation of services on Ericsson platforms, conveying the jointly created solutions to business and consumer markets in which it operates. Simultaneously *Ericsson* will act as the provider of the solutions and technology

services, making available its expertise in the design and integration of end-to-end Machine to Machine, and the Internet of Things. Furthermore, *Ericsson* will ensure the interoperability of its solutions with the systems and networks of *Telecomitalia.*

Smart city and its diffusion in Italy

As previously told Smart City is an application of IoT for monitoring and management of elements of a city (such as the means for the public transport, lighting public, monuments, parking lots, waste bins) and the environment surrounding environment (such as rivers, forests, mountains) to improve the livability, sustainability and competitiveness. (*Smart city report – Definizione, valutazione delle ricadute economiche e modelli di business per le Smart Cities in Italia e in Europa* – Politecnico di Milano)

In Italy has been conducted a study on 50 cities with a focus on:

- classification of these cities based on the smartness degree for each one;
- the identification of recurring business model through which these initiatives are made and the comparison with the best practices in Europe.

Preliminary analysis of this sample showed that in 16 cities was not undertaken any significant project in the field of Smart City. Therefore, subsequent analyses have focused on the remaining 34 cities.

To calculate the 'degree of smartness' two parameters were taken:

- The level of coverage of enabling technologies (amplitude),
- The level of technology penetration within the town (depth).

First, the analysis was performed with respect to only the Italian context. In the second place, the Italian reality has been inserted within the European framework.

Lista delle prime 50 città italiane			
Roma	Padova	Foggia	Vicenza
Milano	Trieste	Rimini	Terni
Napoli	Taranto	Salerno	Bolzano
Torino	Brescia	Ferrara	Novara
Palermo	Prato	Sassari	Piacenza
Genova	Parma	Latina	Ancona
Bologna	Modena	Siracusa	Andria
Firenze	Reggio Calabria	Monza	Udine
Bari	Reggio Emilia	Pescara	Arezzo
Catania	Perugia	Giugliano in Campania	Cesena
Venezia	Livorno	Bergamo	
Verona	Ravenna	Forlì	Barletta
Messina	Cagliari	Trento	

Figure 6: List of first 50 Italian cities (Smartness degree).

In Figure 6 the cities in red are the 16 previously mentioned cities that have not been undertaken any projects in the field of smart city. Threshold values of amplitude and depth have been defined as: low, medium, high. This has led to the definition of a classification matrix represented in Figure 7.

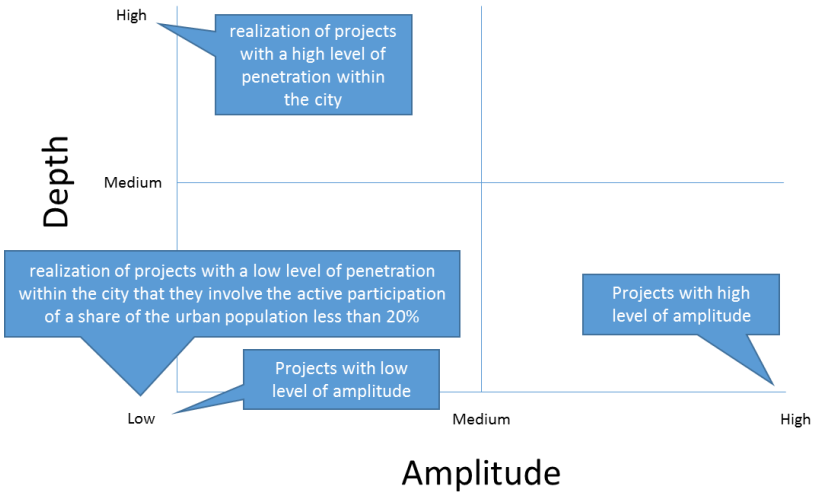

Figure 7: Classification matrix.

On the subject of study cities, it was possible to make a distinction between „eagle cities“, „gazelles cities“and „turtle cities”. In the first case, there are the leading Italian cities where a large number of projects covering different technological areas affecting a significant portion of the urban fabric has been made. „Gazelles cities” are the cities in which it was made a large number of projects covering different technological areas, but which nevertheless have a reduced impact on the urban fabric. Finally, we have ‘turtle cities’ that show a reduced interest in the topic „smart“: they were developed through little relevant projects, with a limited impact on the urban fabric and related to a small number of technologies.

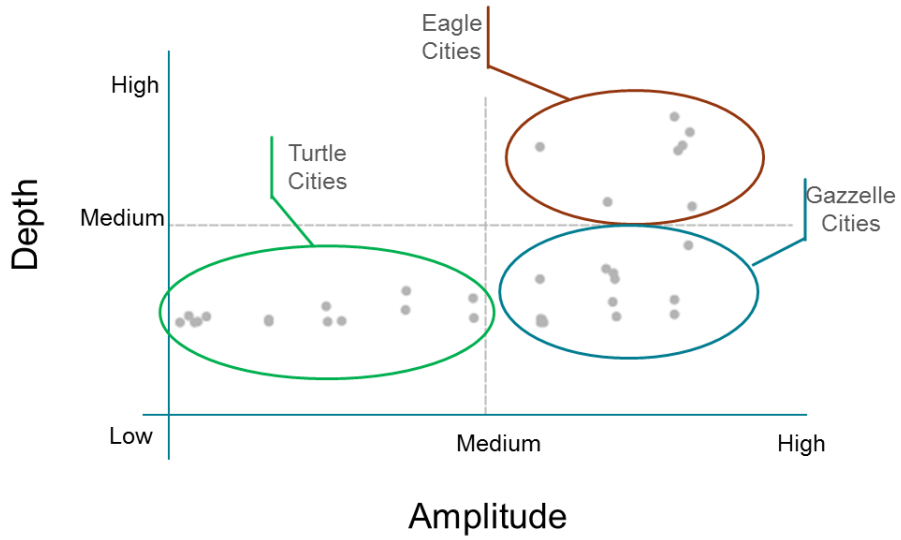

Figure 8: Typologies of cities.

This type of analysis was conducted in 51 European cities of which 30% (15 cities) have not started significant projects in the field of Smart City. The comparison was then conducted on the remaining 36 cities.

In European cities, the organic development model has emerged. It is primarily characterized by the presence of a ‘control room’. This room usually consists of all parties involved in the implementation of smart city projects. These parties coordinate the activities from the beginning and during planning

and implementation. This structure is typically formalized, with own governance and thus assumes a formal role in project management.
There is a roadmap that lays out the goals to be achieved and the method and timing. The technological fields covered are varied. This model of development means that the requirements of individual enabling technologies are established and 'optimized' through a 'organic'. The preferred financing model is the PPP, which allows public bodies to attract and secure the financial resources not available internally. The organic development model used in Italy also sees the presence of a 'control room' that deals with the planning and project management. However, this organization and its governance are typically still being formalized, also compared to the European context there is a lower level of involvement of the lenders.

Also in consequence of the relatively recent diel process 'smartization' of this reality, the development roadmap is often not yet consolidated. Based on the current development status of these plans has shown a high degree of coverage of the various technological fields that characterize a 'smart city'. The preferred financing model refers to the use of European Structural Funds and national public funding. This is the main difference that characterizes the organic model 'Italian' than Europe, where the PPP is the predominant funding model, while in Italy its application is found in a limited number of cases.

2.3.4. Performed research projects in Italy

On December 10, 2014, it was held in Santander the final review of the European project *Butler*. *Butler* (Ubiquitous, Secure Internet-of-things with Context and Location-Awareness) is a European FP7 project in the Internet of Things (see: IoT Butler). The project has duration of 37 months and was attended by about 20 partners from 8 countries and belonging both to the industry than academia. Among the most important partners: *Ericsson, ST-Microelectronics, Gemalto, ISMB, CEA, iHomeLab, Santander City Council*. The IoT application domains that the project has faced are different: Smart Home/Office, Smart Shopping, Smart Mobility, Smart Health, and Smart Cities (see: Telecom Italia/ jolscube).

Italy was involved with the collaboration of Telecom Italia group through the *JOL S-Cube* receiving a € 580K funding, with the role of Work Package leaders and developing two software components (Smart Server): Context Manager (for the aggregation of context data) and the User Profile (for user identity management). The *S-Cube JOL* also took part in the definition, development and implementation of a trial in the field Smart Office, presented on the occasion of the final review.

Parts made in the project and trials are available in the European portal IOT OPEN PLATFORMS, which collects software libraries, web components, tools to build the Internet of Things applications. The final review was held in the city of Santander, one of Europe's best examples of Smart City and was attended by some local authorities including the mayor of the city. The Commission has expressed a positive opinion on the project, underlining once again the importance of the related to the Internet of Things trend and the European Union's intention to promote further investment in this field as part of the Horizon 2020.

Almanac

- http://www.almanac-project.eu/news.php

- The *ALMANAC* project *A reliable, smart and secure Internet of Things for Smart Cities*, is co-funded by the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no 609081, objective ICT-2013.1.4 Duration: 1st September 2013 to 31st August 2016.
- The project aimed at developing a service delivery platform that integrates Smart City Information System for green and sustainable Smart City applications. http://almanacproject.github.io/
- The *ALMANAC* Lab is a full deployment of the *ALMANAC* Smart City Enablers which can be used to experiment with IoT in a Smart City context. Users can utilize components to build IoT solution, experiment with the OPEN data published or add their own. User can download the platform, and get started with things like storage, messaging, security. Components can be used individually, or together as a comprehensive Reliable Smart Secure Internet of Things for Smart Cities platform.

Butler

uBiquitous, secUre inTernet-of-things with Location and contEx-awaReness is an IoT project that involves 18 different societies and have different application sectors like:

- Smart Home

Smart shopping list (Ex: As you leave home, a shopping list on your mobile is automatically updated…) Smart Energy (Ex: As the last person leaves home, the thermostats in the bedrooms are tuned down…)

- Smart Health

Smart Preventive Care (Ex: Elder people have their day-to-day activities monitored, triggering automatic responses when needed…) Smart Case Sheet: (Ex: Medical personnel are given contextualized information on patient's conditions…)

- Smart City

Smart Event Management (Ex: Information about occurring and future events are automatically available to patrons and citizens) Smart Parking (Ex: Parking information and suggestions are made available real-time events.)

- Smart Shopping

Smart Sales/Advertisement (Ex: The shop offers you personalized discounts on items outside your list but you are likely to buy) Smart Cross-referencing (Ex: Your wife is informed of the items you are buying and their prices…)

- Smart Transport

Smart Navigation (Ex: Traffic information such as the approaching of an ambulance is broadcasted to vehicles on the route…) Smart Updating (Ex: Your peers (office, clients, family, etc.) are informed of significant delays…)

BUTLER's concept is one of active, pervasive, continuous, real-time and progressively personal context-awareness.

Today: Domain-centric smart solutions:

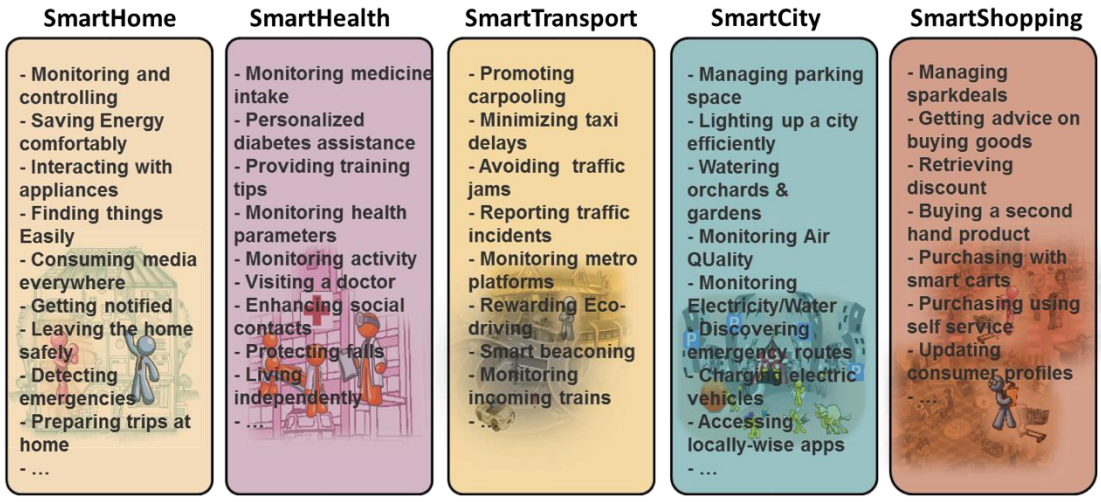

Figure 9

BUTLER's future vision SmartLife:

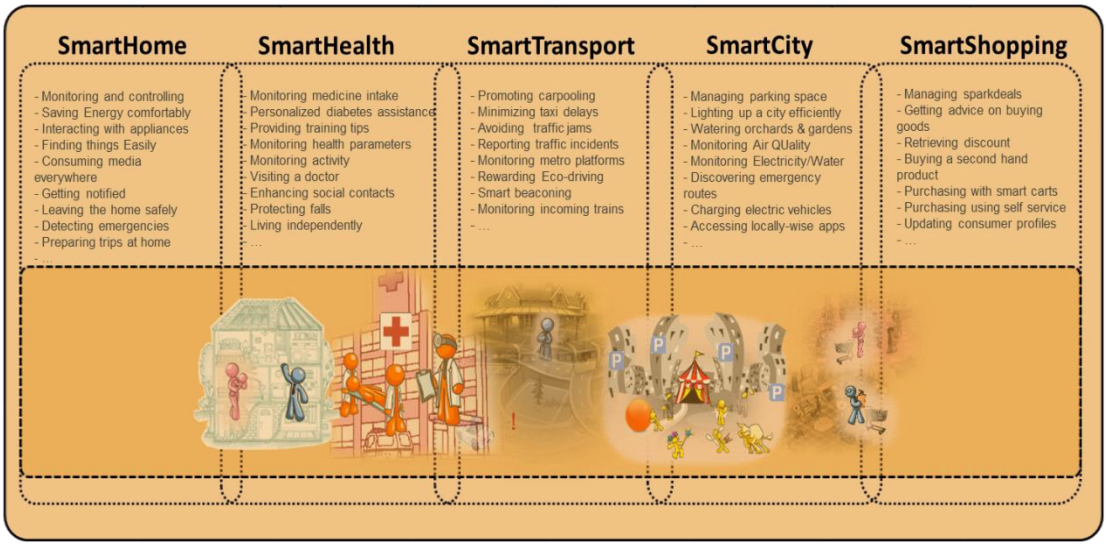

Figure 10

High level objectives are design and demonstrate prototype of a comprehensive, pervasive and effective Context-Aware information system, which will operate transparently and seamlessly across various scenarios towards a unified smartLife environment.

Technical and Technological objectives are due to:

•**Modelling context and behaviour:**

- Contextualized Navigation,
- Contextualized Advertising/Warning,
  - Contextualized Crowd Management.

•**Middleware architecture:**

- Service-oriented approach for dynamicity, interoperability and modularity,
- Complex event processing.

•**Security and privacy:**

- Contextualized security and privacy.

Operational Objectives:
•Integrate the requirements from 5 use cases: Smart Mobility/Transport, Smart Healthcare/Wellness, Smart Shopping, Smart Home/Office and Smart City;
•Involve users: evaluate novel IoT applications and their associated business models from a minimum of 10 field trials based on BUTLER architecture;
•Develop and publish an open networked architecture integrated with existing business platforms.

The way to have success in these objectives is to consistently use human centric design elements for documentation (throughout the project); persons, needs, customer use cases, storytelling and visualization (prototyping) to enhance communications with customers.

Other ways can be depth customer insight interviews with selected customers:
•to verify needs from the use cases and story line and extract additional needs,
•also find out about triggers and barriers.

Market research (e.g. with questionnaires):
•to widen customer base,
•to cover different topics like price sensitivity or general acceptance likelihood.

Map the ecosystem:
•looking at the customer life cycle and possible business partners or stakeholders,
•to develop the value proposition, exploitation strategy and possible business models.

Città Educante (see: cittaeducante):
The Educating City: teaching and learning processes in cross-media ecosystem is a project that aims to help the creation of an 'educating city', i.e. a model in which education is based on the reciprocity of the involved parties: the educator is also educated and his own knowledge takes shape in the act of educating. Education is not only a school matter, it helps building our identity and our future. Educating City provides the technological environment where everyone can contribute to viral sharing of culture and greater sense of citizenship.

'Educating City' identifies three main thematic areas:

•**School/Education:** it provides to all school levels a set of knowledge, strategies and technological applications that establish a new educational approach to help young people to become active citizens, welcoming and aware. It is aimed at adults as well, as subjects of life-long learning, aging processes and acceptance of diversity.

•**Society:** development of new connections among schools, business and territory.

•**Technology:** development of new ICT platforms, services and applications supported by specific research activities in cloud computing and collaborative sourcing, social networks, automatic text analysis, video and 3D data, big data analysis tools, natural and interactive interfaces, robotic aids, sensors and pervasive networks, machine learning and search systems.

Internet of Things Accelerator (see: IoT-Acc) in cooperation with *Deutsche Bank AG*:

The goal is to finance and facilitate the go-to-market strategy of IoT start-ups, focusing in two main sectors: Consumer Finance, in the areas of Home, Cars, Consumer Goods and Payments, and Corporate Finance, in the areas of Inventory, Equipment, Supply-Chain and Trade. The 4-month Accelerator, starting in October 2016 is focused on selecting the best 5 International teams leading innovation in this hot field.

During the IoT Acceleration Program, start-ups will have the possibility to develop their projects with our support and services, among which are tutoring & mentoring activities, board and lodging and an initial seed investment of €20.000. The IoT Accelerator will grant support to the selected start-ups, providing them a faster validation of their business models and a faster go-to-market strategy through ad hoc meetings, mentorship, workshops, business development sessions, consultancy activities and pilots.

In order to increase the value of the program, 5 Industry Partners from the Automotive, Manufacturing, Consumer Goods, Tech and Logistics sectors will contribute to the Accelerator. The Industry Partners are committed corporates willing to innovate through start-ups, in order to increase their competitiveness, to create important business synergies and to facilitate the market entry of start-ups thanks to their network and brand recognition. During the Program, Industry Partner's top managers will organize meetings, workshops and business development activities, with the support of their clients and network, being conscious of the opportunity they have of working with start-ups and present them to their clients. At the end of the Program, Industry Partners have the opportunity to invest in the start-ups, in order to exploit the commercial and technological synergies.

•**IOTEXPO** the first Italian digital Virtual Expo that maps, catalogs and certifies all the companies in country and in the European basin that adopt solutions, develop projects, services and products based on the Internet of Things. (see: IoTExpo)

IOTEXPO is a platform dedicated to the creation of a business community on all the topics of the Internet of Things, a vibrant „virtual marketplace" that provides IoT state of the art visibility, thanks also to a communication campaign on all media

•**VEGA** the VEnice GAteway for Science and Technology – is a science and technology park. (see: Vegapark)

Its mission is to promote scientific research and technological development initiatives, facilitate the transfer of knowledge and more in general the networking between universities, research centres and business. Its action focuses on the leading-edge technological areas: Nanotechnologies, ICTs, and the Green Economy. VEGA includes an incubator and two nanotechnology laboratories: NanoFab and Civen.

VEGA intends to offer the companies based in the Park an innovative system for networking, community-building and technological platforms to stimulate synergy, partnerships and project-making among the entrepreneurs who work in the Park. The objective of VEGA is to favour the relations among the companies based in the Park and to support their

technological and competitive development through applied research work, performed in its innovation laboratories, in particular in the fields of nanotechnologies, ICT and the green economy.

The main activities of the park are to:

•Assist businesses in the innovation path of innovation and finding new solutions for competitiveness;
•Activate, promote and manage RDI projects;
•Foster relationships between businesses, universities and research centers, government and financial institutions;
•Provide incubation services and promote the creation of spin-offs.

2.3.5. IoT awareness in selected businesses of Italy

IoT protagonist in Expo 2015

It used to:
•Monitor power consumption;
•For remote control of lights and air conditioners;
•For security systems;
•Monitor the clinical situation of some visitors;
•Outside the exhibition site will enter the Future Food District dedicated to the integration of food production and technology with Smart Logistics applications and Smart Agriculture. (*Industrial Internet of Things - As the technology of objects able to create real economic value*)

Confindustria careful to monitor and help the Italian industry in the era of *Industry 4.0.* in which human beings, machines and objects for the intelligent management of manufacturing systems are connected in real time. Important national programs in several countries were activated to stimulate industrial policies consistent with this scenario. Europe, too, in its Technology Platforms, gives him now for granted. For the industrial fabric which must more than ever be strongly suited to technological innovation, deal with the scenarios from these strategic initiatives is crucial. The 'smart' factories of the future will become similar to a social network: the cars, the workforce and production resources will communicate and interact with each other automatically and the same will happen at the level of industries worldwide.

Challenges are enormous and require a transformation that involves every area of the business: from the procurement of raw materials and semi-finished products to the procurement and use of human capital, from finance to controlling markets, the internationalization of the industrial relations, from innovation to growth in size, from governance to alliances.

Italian SMEs are the backbone of the economy and society. *Confindustria* is whether: They will be ready to meet these challenges? How they must transform themselves to overcome them and face the world again?

No longer enough to the culture of doing that has been the engine of Italian development in the post-war period. In the new Renaissance that promises Businesses Must own a new culture guided by a

strategic look increasingly turned to the transformation of the business model, corporate strategies, solutions adopted. The transformation, however, is not only an attitude of response to changes in the context. Companies are now required to transform but also to transform, responding to the changes taking generating but at the same time new ones. The company is active player in the transformation of customers and society itself, it must therefore adopt a proposed approach by identifying and affirming its own very specific and distinctive identity.

2.3.6. IoT challenges for Italian companies

Internationalization: Although the Digital Agenda must intervene on competitive factors discriminating for the internationalization of SMEs. Manufacturing 4.0, and especially the ability to use e-commerce, it is not realized with narrow or minimum bandwidth as it is today in many realities of Italy. If we think our average download speed has a 17 megabits per second gap with the United Kingdom, 13 to Germany and 7 with the rest of the world, we have the measure of the distance that should be filled.

Finance: The Quantitative Easing which was finally implemented in the eurozone, thanks to the constant defined by the President of the *ECB* Mario Draghi, and the resources of *TLTRO* can actually transfer liquidity to firms if the banking system and SMEs will become. The banking system must enhance the creditworthiness of those intangible assets and intangible factors that are part of the DNA of the winning companies. We talk about the innovative capacity, the quality of human resources, being part of global value chains and the national and international supply chains.

Talents: We can say that the new Italian manufacturing is back to the future, an original combination between the 'Renaissance tailoring' and production in high tech series. Why grow and face widespread system needs creativity, knowledge and skills. The winning path for growing young people learning from reality is the alternation between active learning on the job and classroom lessons. So, it is important also to adopt in Italy the German dual model, which is proving to be the best.

Innovation: is the true discriminating competitiveness. Before a new product or a new process is a way of thinking, it is the ability to live the transformation, to adapt to the changing environment and, if possible, to guide them. The ability to innovate is a valuable asset useful to the whole community. It is our social responsibility. We must learn to bet on innovative companies and their ability to generate ecosystems and alliances with other companies. We must enhance the competence capital and know-how of which Italy is rich. For this the Investment Compact is a strong signal of the Government's attention to the needs of the economy.

Where IoT can improve?

It should be given as soon as possible to make use of tax benefits even to those who invest in innovative SMEs with more than 7 years. They are the ones who know what it means to be on the market and they are the ones that can attract significant liquidity in the markets.

It should be encouraged the emergence of innovation created by SMEs and promoted its capitalization by providing the ability to write off in full and in the same year they are incurred research expenses incurred and innovation.

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2.4. Lithuania

2.4.1. Overview of the existing and foreseen IoT technologies in Lithuania

State-of-the-art IoT technologies are focused and are able to provide significant benefits to industries and companies that achieve critical mass. Entities that fall below such threshold are not able to gain significant benefits from IoT application due to the fact that IoT is not a mature technology and has a high risk associated with it, security being the focus of its problems.

Additionally, *R&D* associated with IoT deals with low complexity/high volume with competition of significant proportions and capabilities. Lithuanian businesses tend not to focus on such markets due to the lack of resources and ability to enforce intellectual property rights worldwide. This fact stifles

the development of IoT technologies in Lithuania and business focuses on providing solutions developed by foreign companies.

A *Lithuanian Cybercrime Competence and Research Center* (L3CE) has been established to create hub of competence for law enforcement agencies to fight and prosecuted cybercrimes. Thus Lithuania is readying its agencies with future developments of technologies and possible new problems that will be introduced by them.

The existing IoT technologies in Lithuania are (see: ukmin.lrv):

- Vehicles tracking (track's, Cars, Citybee, e'Spark);
- Smart street lights;
- Buildings security systems;
- Smart metering infrastructure (electricity, heating, gas);
- Distributed power generation monitoring and control (solar, wind, hydro);
- Water supply/ water treatment;
- Smart grid elements (reclosers, overhead line fault indicator, secondary substations);
- Smart factories (smart machinery, energy management, products conditions monitoring, overall equipment efficiency).

In Lithuanian market the top 3 IoT solutions have been applied in the field of:

- Vehicles tracking;
- Buildings security system;
- Energy management.
- Vehicles tracking

The most notable solutions in this area are:

Fleet monitoring and control solution (see: teltonika). This solution gives real time tracking of companies' fleet and provides information that helps to reduce vehicles operating costs and save employee time. Fleet monitoring and control is made of hardware and software products that allows to monitor key vehicle activity parameters and provides means to control drivers.
All information is accessible on a web based platform. Solution is designed for various sized business and can be applied to all types of transport.
The solution monitors and controls:

- Speed;
- Route;
- Mileage;
- Fuel level and consumption;
- Working status and hours;
- Trip history;
- On-board computer data;
- Vehicle maintenance.

It works by using GPS tracking device which is installed in the vehicle. Web based real time transport monitoring and control system is configured. The data collected by GPS tracking device is sent to your web account, processed and presented for analysis.

This solution is designed for companies with large fleets and business with few vehicles. The solution can be implemented in trucks, light vehicles, agricultural machinery, special building machinery, buses etc.

Eco-Drive (see: ruptela):
The aim of this solution is to teach drivers fuel efficient driving and to cut transport operation costs. The main principles of Eco-Drive are to drive safely and not to waste fuel also reducing damage to the vehicle, environment and people health. This driving style also depends on opportunities provided by modern engines and vehicles.

A variety of reports on fuel efficient driving allow to analyze drivers' performance and improve places where needed. Moreover, an additional accessory – Eco-Drive panel gives the driver real time information about his actions that result in an uneconomical driving.

The data to enable Eco-Drive can be gathered from vehicles on-board computer, accelerometer and GPS. Collected data is processed in real time transport monitoring and control system which provides you with the insights on how to reduce and optimize fuel consumption.

Eco-Drive benefits:

•Economic benefit – up to 20% reduced fuel consumption and vehicle maintenance costs;
•Environmental benefit – lower exhaust gas emission and noise pollution;
•Social benefit – improved driving skills and more comfortable trips to passengers;
•Safety benefit – calmer driving style reduces risk of vehicle accidents.
Fuel monitoring and control. Fuel control and management solution is designed to monitor, save and optimize fuel related costs. Information about fuel level and consumption is obtained in two ways – connecting GPS tracker to on-board computer (CANbus) or installing fuel level sensor directly in the fuel tank.

This solution generates detailed reports which identify drivers who waste company fuel and vehicles that use too much fuel. It also shows when fuel tank was filled and when fuel theft is being done. In case of fuel theft, a warning email or SMS is sent to the responsible persons.

Practical application:
•Fuel theft protection;
•Vehicle fuel efficiency assessment;
•Drivers rating according to fuel usage;
•Mapping out routes that require lowest fuel consumption.
Table below shows vehicle tracking solutions providers in Lithuania.

Company name	Turnover	Products	Employed
Teltonika	30-50 mln. Eu	>1mln. devices/year	>500
Ruptela	10-20 mln. Eu	>1mln. devices/year	>170

Baltic car equipment	2-3 mln. Eu	> 100 k devices/year	>50
Mobiliųjų sprendimų centras	1-2 mln. Eu	>100k devices/year	9
UAB „AKTKC"	<1 mln. Eu	<100k devices/year	>20
UAB "Eljunga"	<1 mln. Eu	<100k devices/year	>20
UAB „Ecofleet Lietuva"	<1 mln. Eu	N/A	>10

Table No. 1. Vehicle tracking solutions providers in Lithuania (see: ukmin.irv)

Buildings security systems

The most notable solutions in this area are:

Cell phone as a remote keypad for intruder alarm system (see: trikdis). The control module functions the system in the same way as the extra keypad and emulates basic features of the keypad. So, after the control module is called, your cell phone becomes a remote keypad. When the connection is established via the GSM network, in order to access the alarm system, the user must enter a valid CODE on the cell phone keypad and then enter the number of the alarm system's function. Function 0 is used to disarm the system, function 1 is used to arm it, function 00 is used to clear the alarm and function 007 starts the microphone. If the user CODE is changed on the keypad, the new CODE must then be used on the cell phone. In case of intrusion or technical fault the GSW2 will call the user, sound an alarm melody and send a text message with the nature of the alarm.

System for offices and computerized workplace supervision (see: mokslolietuva). It is economic and efficient solution of the problem-monitoring system, which enables periodic saving of computer display screenshots at workplaces, registering duration of active computer use, viewing daily reports on computer use, transmitting images from office premises over to administrator's computer via web cameras. If the company has more than 5 computers - investment into purchasing the solution software usually returns within several days, and the Manager of the company can find out what his employees are engaged in at any time. In case of any disagreements, there is always a possibility to review monthly archives from a particular workplace, resulting in greater discipline at work and reduction of mistrust.

Carbon monoxide (CO) detector (see: kodinis). The solution is wireless electrochemical-based carbon monoxide (CO) detector combined with photoelectric-based smoke detector designed to detect smoldering fire. When the concentration of smoke/CO exceeds a given threshold, the system will cause alarm, resulting in built-in siren activation and SMS text message and phone call delivery (by default) to the listed user's phone number. Main features:

- Photoelectric sensor for slow smoldering fires and carbon;
- Non-radioactive technology for environmental friendly;
- High and stable sensitivity;
- Quick fix mounting plate for easy installation;
- LED operation indicator;
- Built-in speaker for audio alarm indication;
- Tamper switch: for device detachment from the wall detection;
- Electrochemical-based carbon monoxide (CO) sensor;
- Lifetime 7 years.

Table below shows buildings security systems solutions providers in Lithuania.

Company name	Turnover	Products	Employed
Eldes	3-5 mln. Eu	<100k devices/year	>60
Trikdis	1-2 mln. Eu	<50k devices/year	>30
Kodinis raktas	1-2 mln. Eu	<50k devices/year	>30

Table No. 2. Buildings security systems solutions providers in Lithuania (see: ukmin.irv)

Energy management
The most notable solutions in this area are:

Heating, water and electricity network telemetry systems (see: elsis). *Elsis TS UAB* implemented the project during which the system control centre equipment of *Litgrid AB*, the electricity transmission system operator, was upgraded. During the project implementation, the *ELSIS TS* installed a new Clarity LED3 Series video wall designed by 'Planar Systems' consisting of 36 video cubes instead of the out-of-date operational video wall. Also, new working stations as well as electricity supply, uninterrupted supply and ventilation systems were installed for operators working 24/7. Installation of new technologies resulted in enhanced safety and reliability of the system control centre.

The video wall displays data not only from Lithuania, but also from surrounding power systems. Operators are able to monitor real-time volumes of electricity generated in power plants and wind mills, operating electricity transmission lines as well as the ones disconnected for repair, transformer substations and switchgears, system frequency, import data, electricity demand and consumption. In 2016, when power links between Sweden and Poland start operating, the video wall will enable displaying data of Polish and Swedish power systems. The video wall serves as an information field which generalizes data. In the event of emergency, automated units transfer signals to the general system which processes information received not only from the Lithuanian electricity transmission network, but also from other power systems the Lithuanian power grid is connected to. Information displayed in one or more places helps make decisions more promptly and organize the system control activities more efficiently.

Controller for GAS consumption measuring (see: elsis):
Elsis TS UAB implemented the project during which the system control centre equipment of Litgrid AB, the electricity transmission system operator, was upgraded. During the project implementation, the ELSIS TS installed a new Clarity LED3 Series video wall designed by „Planar Systems" consisting of 36 video cubes instead of the out-of-date operational video wall. Also, new working stations as well as electricity supply, uninterrupted supply and ventilation systems were installed for operators working 24/7. Installation of new technologies resulted in enhanced safety and reliability of the system control centre.

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displayed in one or more places helps make decisions more promptly and organize the system control activities more efficiently.

Controller for GAS consumption measuring (see: valsena):
MPC-123 controller developed by Valsena is designed for GAS consumption measuring, contains hermetic enclosure and internal batteries -for uninterruptable work even on power failure. MPC-123 is created for data reading, archiving and analysing in a real time. Using GPRS/GSM controller sends save saved data and reports to remote users.

Controller supports most of protocols and interfaces (RS232, RS485, MBUS, Opto, Current loop, Analog and Discrete inputs), so it can be used with different brands and models of meters. Our special 'TRANSPARENT' data transfer protocol enables controllers to use with practically any device.

Device supports wide range of protocols (and can be extended by our programmers, if you need some special). For data exchange over GPRS/GSM any Serial interfaces, controller uses Modbus TCP/IP, Modbus RTU, IEC60870-5-104:2000, SNTP and other protocols.

Our clients – GAS, Heat, Watering suppliers, Industry companies in EU, Ukraine, Central Asia.
Default features:

- Reading data from energy carrier meters;
- 'TRANSPARENT' remote data reading from counters (special manufacturers protocols);
- Analog and Discrete input ports;
- Independent data log (up to 8MB) with real time stamp;
- Remote configuration and upgrading possibilities over GPRS/GSM;
- Wide range of interfaces: GSM/GPRS, RS232, RS485, Current Loop, USB, Opto, Mbus;
- Galvanically isolated interfaces and power supply;
- Hermetic enclosure for quick installation, no need to use additional rack;
- Device secured by opening alarm.

Table below shows energy management solutions providers in Lithuania.

Company name	Turnover	Products	Employed
AXIS Industries	50-100 mln. Eu	>100k devices/year	>600
Elgama sistemos	1-2 mln. Eu	>100k devices/year	>20
IRTC	2-3 mln. Eu	<50k devices/year	>30
Sigmatelas	1-2 mln. Eu	<50k devices/year	>40
Valsena	<1 mln. Eu	<50k devices/year	>10
Elsis TS	5-10 mln.Eu	<50k devices/year	>40
Aedilis	3-5 mln. Eu	>50k devices/year	>60
Connecty	<100 Eu	>50k devices/year	4
BENCO	<1 mln. Eu	>50k devices/year	7

Table No. 3.Energy management solutions providers in Lithuania (see: ukmin.lrv)

Presented companies are developing their products iteratively with minor focus on R&D. The cost of R&D and market reach of Lithuanian companies, coupled with limited production capabilities puts them at a disadvantage and dissuades investment in such activities.

2.4.2 Existing studies and analyses on IoT in Lithuania

- **Intellectualized Home Enviroment as a Complex System** (Raimundas Jaisnevičius, Egidijus Kazanavičius, Vytautas Petrauskas; Interdisciplinary Symposium on Complex Systems, 2014):

Abstract. In the analytical part of this report several EC projects, developing an idea to create the intellectualized home environment (IHE) serving for peoples' comfort on the base of multiple internet things and services (IoT&S), are discussed, and the EC HORIZON 2020 program perspectives in this field are presented. The IHE itself is presented as a complex sociotechnical fabric with the inherited mixture of real human and elements of artificial intellect as well. Multi-agent-system-based intellectics is used for the IHE's training, retraining, self-training, and functional behavior. Three aspects of human being's behavioral features, usually considered as intellectual actions, were practically realized, and they introduced new additional dimension to the systems complexity. The IHE's complex systems model implementation was simulated to demonstrate the practical vitality and efficiency of the theoretical approach to the realization of intelligent environment of IoT&S for usre's comfort in two projects: ,,Research and Development of Internet Infrastructure for IoT&S in the Smart Environment (IDAPI)", and „Research on Smart Home Environment and Development of Intelligent Technologies (BIATech)".

- **Ontology for Robot Programming domain** (Ignas Plauska; XV International PhD Workshop OWD 2013, 19–22 October 2013):

Abstract. Robot programming requires knowledge of embedded systems, mechatronics, principles of kinematics and locomotion, sensors and actuators, control algorithms, behavior planning and communication protocols. A complexity of robotics domain underscores the need for developing a domain ontology that describes domain concepts, their properties, restrictions and relationships between concepts. The paper describes an on-going effort to develop ontology for robot programming domain, presents a draft version on ontology, describes its structure and discusses it validation.

- **Intelligent Decision Support System for Leadership Analysis** (Renaldas Gudauskas, Saulė Jokubauskiene, Edmundas Kazimieras Zavadskas, Arturas Kaklauskas, Arune Binkyte, Lina Peciure, Loreta Budryte, Darius Prialgauskas; Operational Research in Sustainable Development and Civil Engineering - meeting of EURO working group and 15th German-Lithuanian-Polish colloquium (ORSDCE 2015)):

Abstract. An Intelligent Decision Support System for Leadership Analysis (IDSS-LA) was offered as an example for demonstrating the integration of advisory, negotiation and decision support systems. Development of the IDSS-LA database was by providing a comprehensive assessment of alternative versions from economic, legal/regulatory, technical, technological, organizational, managerial, quality of life, social, cultural, political, ethical, psychological and other perspectives. IDSS-LA enables a user to analyze alternatives quantitatively (by a system of criteria, units of measure, values and weights) and conceptually (textually, by a formula, scheme, graph, diagram, video tapes). The Case Study presented illustrates the efficiency of this System.

- **Innovative research projects in the field of Building Lifecycle Management** (Leonas Ustinovičiusa, Romas Rasiulis, Lukasz Nazarko, Tatjana Vilutienė, Marius Reizgevicius; Operational Research in Sustainable Development and Civil Engineering - meeting of EURO working group and 15th German-Lithuanian-Polish colloquium (ORSDCE 2015)):

Abstract. In the era of the great development of information technologies and telecommunications, a natural need to develop and implement a unified system of digital building information modelling has arisen. The rapid development of design technology in the field of architecture, engineering and construction leads to the continuous adaptation of the conceptual apparatus for building information modelling (BIM). BIM technology adopts a new definition as a universal tool for describing various elements of intelligent virtual 3D model of a building combining a series of sequential steps related to the investment, such as requirements of design, construction, operation and demolition optimizations and preparations. In the paper, the authors propose directions of research in the field of BLM (Building Lifecycle Management).

- **Educational Robots for Internet-of-Things Supported Collaborative Learning** (Ignas Plauska, Robertas Dmaševičius; Information and Software Technologies, 2014):

Abstract. Vision of using educational robots as smart mobile components ('things') of Internet-of-Things is presented. Such robots, beside their primary mission to facilitate learning, are able to communicate; have computing capabilities; as well as have sensors and actuators to sense and change their physical context. The robot serves both as the educational service that allows to visualize knowledge through explicit actions and behaviour as well as the enabler of learning and providing student engagement through immersion and instant feedback. The vision is based on the principles of contextualization, physicality and immersion. The pedagogical background is the proposed Internet-of-Things Supported Collaborative Learning (IoTSCL) paradigm based on constructivism, which provides a highly motivating learning environment in university, promoting collaboration among students, and achieving the creation of new knowledge in a reflexive process directed by the teacher. We demonstrate the implementation of the paradigm in the project-based setting at the university course and evaluate it using the Four-Phased Model of Interest Development.

- **Modelling of Internet of Things units for estimating security-energy-performance relationships for quality of service and environment awareness** (Algimantas Venckauskas, Vytautas Stuikys, Robertas Damasevicius, Nerijus Jusas; Security and Communication Networks, 2016):

Abstract. Complexity of Internet of Things (IoT) applications and difficulty to predict their behaviour in wireless communications make modelling of IoT units an important research topic. The IoT unit is considered here as the two-node IoT model that supports bi-directional wireless communications. There are many approaches to model security and energy awareness; however, little is known about the synergistic effect of those factors at the application level under the influence of environmental factors such as noise. The paper introduces a modelling framework to model the security-energy-environment issues as main attributes to allow defining quality of service (QoS) for the IoT-based applications. Among others, the healthcare ones are regarded as predominant now. We model IoT units using the feature-based modelling methodology adopted from the software engineering domain. The result of modelling is a set of feature models with valid configurations that describe the

energy-security-environment-performance relationships and possible constraints to support various IoT applications. Having feature models, we can select a configuration that is best suited for a given IoT application with respect to QoS requirements.
As feature models represent abstract relationships of domain factors, we need additionally to provide experiments to determine concrete values of modelled features. We describe the experimental system to measure energy consumption under the influencing factors. Both models (abstract and concrete) allow reasoning about QoS of the IoT applications.

- **A Concept of Fuel Tank Calibration Process Automation Within IoT Infrastructure** (Mindaugas Knyva, Vytautas Knyva, Žilvinas Nakutis, Vytautas Dumbra, Marius Saunoris; Mapan, 2016):

Abstract. The Internet-of-Things (IoT) and Cloud technologies today provide new options for remote measurement data collection, storage and processing. Fuel tank calibration process automation by adapting IoT infrastructure model is explored in the article. The impact of geometric and volumetric fuel tank calibration methods upon hardware and communication channels requirements in IoT infrastructure are considered in the paper. A distributed certified metrological laboratory establishment in the field of fuel tank calibration concept is introduced and explained by system architecture view description and sequence diagram of its operation.

- **WiFi Field Monitoring for E-Pollution Detection** (Tatjana Sidekerskienė, Robertas Damaševičius; 2016)

Abstract. The paper presents an outline of the development of WiFi field monitoring maps using the Internet-of-Things (IoT) technology. The negative impacts of signals generated by the WiFi access points on health and measurement metrics are discussed. The experimental system for collecting WiFi signal data is presented. Finally, the construction of WiFi signal strength heatmap is discussed and some preliminary results using a combination of real worlds and simulated data are presented.

- **A Review of Cyber-crime in IoT: Technologies, Investigation Methods and Digital Forensics** (Dr. Algimantas Venčkauskas, Dr. Robertas Damaševičius, Dr. Vacius Jusas, Dr. Jevgenijus Toldinas, MSc Darius Rudzika, MSc Giedrė Drėgvaitė):

Abstract. The Internet of Things (IoT) is a novel design paradigm, which allows communication among different kinds of physical objects over the common Internet infrastructure. Operations and application models of the IoT, which differ from the traditional networks, have brought great challenges and opportunities to digital forensic technology. In this paper we analyse the state of cybercrime in the IoT, current methods and tools of digital forensics readiness and investigation and possibilities of their application for the investigation of cybercrime in the IoT.

2.4.3 Already performed in research projects in Lithuania

- **Startup Scaleup** – Startup Europe's IoT Accelerator – this project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 644023.

Startup Scaleup is the 6 month IoT accelerator of Startup Europe powered by the European Commission which is combining physical and virtual acceleration, and looking for talented startups aspiring to take their business to the next level and expanding to international markets.

An acceleration programme was launched in 2015 with an aim to find European startups developing cutting-edge IoT innovation. During the past two years, programme ran 2 batches in 4 European locations simultaneously and supported 133 startups.

Startup Scaleup is building a European ecosystem connecting the players of four consolidated entrepreneurial hubs (Cartagena, Dublin, Vilnius and Zoetermeer) in order to provide a greater range and quality services to ambitious entrepreneurs who want to launch and grow companies focused on the IoT. (Web-link: http://startup-scaleup.eu/.)

Research and Development of Technologies and Infrastructure for Smart Environments Applied for Internet of Things and Services – this project has received funding from the ERDF under the grant agreement No. VP1-3.1-ŠMM-08-K-01-018 and has been implemented by Kaunas University of Technology. Implementation period: 2012 – 2015.

Objectives of the project: 1) to create a methodology and technology for integration of things in smart environment; 2) to create and explore design and testing methodology for applied smart internet services and interfaces; 3) to create internet services based on human's physiological models and to explore medical application of such services in analgesia.

The work group of the project consisted of 37 scientists who created software framework for smart environment which integrates devices of IoT, smart services and contextual user's interfaces; 5 prototypes (e.g. technology wich enables write down text into computer by blinking). 30 scientific publications have been published, 21 reports have been announced in international conferences (see: Startup Scaleup)

- **Development and Implementation of National Science Popularization System** – this project has received funding from ERDF under the grand agreement No. 09.3.3-ESFA-V-711-02. Implementation period: 2016 – 2019. Project is led by Lithuanian Academy of Sciences with a support of universities with scientific background.

Project aims to foster and implement the system of science popularization in Lithuania by creating traditions of science popularization and forming new modern measures for science popularization. The target group of the project contains of teachers, pupils, students, scientists, other researchers.

In 2016 a science festival called „Space Ship Earth" was held 8 cities in Lithuania. A special attention has been paid to IoT and in each city one day has been dedicated to this topic. Students were invited to the workshop „IoT. Create a smart Environment by Yourself" (see: Development and Implementation of National Science Popularization System)

• **Popularization of Technologies and Innovation** – this project received funding from ERDF under the grant agreement No. 01.2.1-LVPA-V-842-01. The implementation of the project started in 2016. Project is led by Agency of Science Technology and Innovation in Lithuania.

The aim of the project is to popularize progress of technologies and innovations by informing business and enterprising society about the benefits of research and development of innovation thus promoting Lithuania as the country of technologies and innovations. Main objectives of the project: 1) to stimulate enterprises (more than 3 years old) to implement scientific research, innovations, apply advanced technologies; 2. To stimulate enterprise (up to 3 years old) to implement scientific research, innovations, apply advanced technologies; 3) to increase a consciousness of enterprising society, promote entrepreneurship, creativity, interest towards innovations.

Several IoT related research and development project have been funded by this project. It is worth to mention a breathalyzer jointly developed by scientists from Vilnius Gediminas Technical University and engineers from a private enterprise „Innovative process solutions". The breathalyzer is a part of system which controls employees' working hours and sobriety. The recognition system of faces embedded into the breathalyzer does not let employees to take the test for each other (see: Popularization of Technologies and Innovation).

• **AppSam** – a project in the CareSam R&D network – this project received funding from Swedish Institute Baltic Sea Cooperation Programme. The implementation of the project started in 2016. Project is coordinated by Malmö University, Sweden and represented by Klaipėda University in Lithuania

AppSam´s intention is to promote innovation, learning and development of skills in the field of elderly care through the exchange of knowledge between countries with different welfare logics. AppSam focuses on dementia care and applied digital technology. The project departs from the Swedish-Danish CareSam project (2011-13) which defined a number of areas, showing significant needs to achieve sustainable development: a) technological innovation in the field of elderly care, b) qualifying the future education and learning aiming at work in elderly care sector, and c) development of skills in practice with a special focus on dementia. These three areas are supposed to be explored in collaboration with new partners.

Objectives of AppSam: 1) to further develop the established CareSam network with two new partner countries: Poland, Lithuania and Moldova, 2) the development of IoT concept in the Elderly care that can help improve the quality of life for older people, families and support for health professionals, 3) to examine how the participation, cooperation and communication can be facilitated by digital technology to meet regional challenges in the elderly with focus on technology, learning and skills in dementia care 4) to prepare an EU-funded application within Horizon 2020 based on the results of the research (see: appsam).

2.4.4 IoT awareness in selected businesses of Lithuania

The general awareness of IoT in Lithuanian business is low and generated solutions or its applications remain outside of main stream business practices. The interest is expected to grow with the benefits

of IoT becoming more apparent as technology matures and develops outside of Lithuania. The exceptions to this trend might be introduced by International Corporation (IC) operating in Lithuania. Companies such as Microsoft Inc. could import technologies and business practices developed in other countries and adopt them in Lithuania.

Possible applications and benefits generated by IoT in the future include, but are not limited to the following items:

- Closer integration of IoT solutions with enterprise IT systems.
- Creating new services rather than just the traditional operational cost savings;
- Increasing need for holistic approaches to security;
- Iot solutions are becoming a strategic necessity;
- IoT is moving from monitoring to control, requiring much larger amounts of real time data;
- Richer applications associated with connected devices require more data, more frequently;
- Increasing intelligence at the network edge;
- Increased use of data across sector boundaries.

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2.5. Portugal

2.5.1. Overview of IoT technologies in Portugal

The development of IoT in Portugal is 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*.

To confirm it is that Lisbon have been chosen to host the IoT Week in June 2015. With the coordination of Peter Mack, the three-day meeting gathered in the capital 500 specialists and others interested in understanding the phenomenon and its application in real life. The event brought in Brussels the announcement of EUR 100 million for the financing of six large-scale pilot projects to boot in 2017. Involved in several projects with national implementation, the investigator sees three possible directions for the IoT in Portugal: the first relates to the investigation, which, driven by European funds as the Horizon 2020, will, secondly, result in several pilot initiatives in the country. Hence national technology development will „very good and with a very large export potential„. Finally, there is the opportunity linked to large-scale European projects – „if we do something to go in line with these projects or complement, we can multiply the effect of innovation and scale and get good visibility while at the same time can create something substantial, long-lasting and notable in Portugal," he said.

European funding has given an important boost in the realization of projects, putting the industry at universities, which, for Indra, 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.

It is also important to refer that Portugal created the first local platform to empower IoT. The AIOTI Portuguese Mirror Platform, sponsored by the Faculty of Science and Technology of the New University of Lisbon (FCT-UNL), the Technology and Systems Center (CTS) of Uninova and Tice.pt, was presented at IoT Week 2015 Lisbon.

The Internet of Things has been at the top of the agenda of investing in innovation and business development in various sectors such as energy, automotive, telecommunications and technology. The goal is to „aggregate all the national entities to which IoT theme matters, so as to enhance the collaboration and involvement of the national entities with the global *AIOTI*platform.“ AOTI, which was launched to put Europe in the lead in the IoT, brings together companies from different technological areas, namely telecommunications, network operators, platform providers (IOT/Cloud), security, service providers, operating in different sectors such as energy, utilities, automobile, mobility, lighting, buildings, health, supply chain, cities, among others.

Alcatel, Bosch, Cisco, IBM, Intel, Nokia, Orange, Philips, Samsung Telecom Italia, Telefonica, Vodafone and *Volvo* are some of the companies that integrate this organization. Pedro Maló, a professor at *FCT-UNL*, a researcher at *UNINOVA-CTS* and one of the people responsible for launching this entity in Portugal explains that the project „arises in the context of the“ Platforms Mirror „initiative of TICE.PT (Information Technology, Communication and Electronics)”, which aims to extend contact with European Technology Platforms in the TICE area to the maximum extent possible of Portuguese entities.

Also in the cities, the IoT applications must also make sense, even by the large investment that involve, warns Peter Mack. „On the one hand, people who do know the collection standards and have done to your adaptation and, on the other hand, in the case of organic waste, even without the full container, you cannot stop the collect for public health issues, smells, etc. You lose all the advantage to put there the technology”, he argues. However, admit it, this can be a win-win solution for the recyclable waste and even containers of organic waste in rural environments, where these are not as close to the population.

The location, in particular, through the geographic information systems (GIS), plays a key role in the implementation of these projects. According to the Esri Portugal, expanding the use and combination of GIS and sensors, IoT, given the proven benefits, is today a reality. In the case of utilities, in particular, in the water sector, „the combination of GIS with smart sensors has been used to reduce losses and the costs of maintenance and planning„, said Nuno Parry. „The activation of these sensors allows you to incorporate the location of acoustic, electromagnetic and thermal readings – finding fast losses and damaged infrastructure. The sensor data are captured and integrated with GIS applications that alert and show, to service technicians, the damaged network section on a digital map (often in a tablet, rugged laptop or other mobile devices). GIS applications allow service technicians view, located, damaged and any other network infrastructure in your immediacy, which saves a lot of time and money spent searching for the problem, allowing timely repairs which limit damage.

2.5.2. IoT applications in Portugal

There are several application domains which are mostly impacted by the emerging Internet of Things in Portugal:
1.Smart Cities,
2.Smart Farm,
3.Gold Chain (Hospitals, Restaurants, Street Food, etc.),
4.Geo Tracking (outdoor mapping and indoor mapping),
5.Logistics (end-to-end supply-chain),
6.Industry 4.0 /Industrial IoT (Machine monitoring and malfunction prediction).
It is important to refer that there is an increased market for the IoT applications in Portugal. Examples of some companies operating in Portugal are *SIGFOX Network, Sensefinity, Philips, ABB, Legrand, Voltimum* and *Schneiner Electricity.*

NarrowNet was the network operator chosen to implement the *SNO* (*SIGFOX* network operator ™) network in Portugal, a technology that extends the implementation of IoT solutions, with high cost effectiveness and energy efficiency. With this, Portugal will be, until the end of the year, one of the first five countries in the world to have an exclusive communication network for the Internet of Things.

In addition to implementing the *SIGFOX* network in Portugal, *NarrowNet* will also develop the IoT ecosystem for manufacturers of sensor objects, integrators and service providers and solutions. The goal is that by the end of the year, the offer of connectivity to IoT is a reality throughout the country and at affordable prices, thus encouraging Portuguese entrepreneurs, engineers and other entrepreneurs to create new applications and projects in this area. *NarrowNet* CEO Enrique Zorzano predicts. The global *SIGFOX* network has already been deployed in France, the Netherlands, the UK and Spain, as well as in major cities in other countries.

„Portugal is a fast-growing Internet of Things, and our partnership with NarrowNet is an important part of SIGFOX's plan to establish a global cellular network dedicated to IoT," said Rodolphe Baronnet-Frugès, executive vice-president for development of international business.
There are four main factors which will affect the IoT market. These four factors are:

•the economy, because it determines the ICT investment available for new technologies such as IoT, so whether the economy is healthy or not, it will have an impact in the IoT market;
•the embedded computing, which allows the connectivity between objects and networks;
•the internet usage, wherein people use the internet for browsing, communicating, social networking and commerce, however, when the internet connects to everything, the usage will increase immensely;
•the regional growth and government support as there are significant differences among the several regions in the world in terms of ICT insertion, government support in that area, particularly in IoT, and economic development. With the support from governments and action within European Union to achieve standardization will be possible to have a clear impact in the IoT development for the region (Aguzzi et al., 2014)

The four factors mentioned previously, in addition to the dynamics of member states and economic situation, divide the countries in the EU28 in four clusters. Divide as fast growth, good growth, low growth and very low growth countries, with Portugal being in the cluster of the very low growth countries in comparison to the rest of Europe in the IoT market (Aguzzi et al., 2014). Even though all countries will take part in the coming of the IoT, the countries that invested more in ICT are more likely to return the benefits from the IoT than those that did not. Consequently, countries like UK, Germany and France are more likely to be the first ahead in the market, taking more than half of the IoT revenues in combination with Spain, Italy and the Netherlands, making it around 75%.

A study elaborated by *Accenture Strategy (2015)* in collaboration with *The Economist Intelligence Unit*, aims to understand the strategies in the digital investment scenario and the prospects of IoT for the Portuguese companies. The conclusion is that most of the 27 Portuguese companies that have participated in the present study, identify a positive impact the IoT can bring both to the economy and to their businesses. About 54% say the main impact is in the increase of operational efficiency while others said it was the direct augment of business revenue. Besides, the impact in an operational view, the executives believe the IoT will bring also better working conditions through the increase of job positions (around 96% agreed) and employee salary (about 86%). Furthermore, 66% stated they understand the concept of the Internet of Things and 92% believe this technology will bring new sources of income, although only 14% said they already have defined a strategy for the IoT. However, around 82% are in the initial stage of the strategy and 2% not yet reached that point. Portuguese managers appointed the key barriers for the IoT growth, namely the lack of access to funding and to the technology. The main benefits identified in the study include better internal control and a supervision level in the enterprise, operational security, optimization of the assets and productivity. Generally, the executives believe that the IoT will bring those benefits and most of companies refer to follow the belief that this technology will make a difference. The principal question is which companies are going to exploit this opportunity and be successful and which ones are going to be left behind this digital transformation (Accenture Strategy, 2015).

The overall problems mentioned in the analyzed articles were the security and privacy due to the number of devices always connected to someone or something, and the increasing number of hacker attacks. Other concerning issue is the digital illiteracy caused by demographic changes and population aging, leading to decision based only on technology from people that are more comfortable with it which may not be the best decision for the rest of the individuals affected by it. Besides, the advantages mentioned throughout the articles, it is highlighted how to take advantage of the Internet of Things, treating the data and information in the most beneficial and profitable manner to improve the possibilities for enterprises strategy and citizens' lives.

The Portuguese market seems to have received enough of something very characteristic features of the philosophy of IoT: to be based on the ability of universal communication between devices and the ability to produce and consume data, the IoT favors the emergence of initiatives and companies that seek to address a particular need. And, in this way, create a true ecosystem with the integration of various solutions is essential. This 'democratization' in access to data, the IoT itself, it is essential to understand the vitality that can be found in different areas, from home automation to social solutions, and is energized by start-ups and research centers linked to the academic world. There is a growing awareness of public bodies to the potentialities of the IoT, as an essential component of strategies for improving service to citizens, often encompassed in the vision of smart cities. This development has, moreover, been notorious in the conferences *Cities of the future*.

Portugal has become very active in taking initiative projects for IoT, but does not show the required capabilities when it comes to infrastructure, knowhow and connectivity (Aguzzi et al., 2014). The Smart Cities magazine has an article written by the author mentioned about the IoT in Portugal where she interviewed several entities that gave their opinions about its' prospective. One of the opinions is that Portugal is already using the IoT in a very connected urban environment. At the pace, the IoT is emerging and being adopted in Portugal, it cannot show much of a difference from the evolution in other countries since the IoT possesses the capability for intercommunication, creating a reduction of distances and allowing the opportunity of developing both global and local solutions.

Indra, an information technology enterprise, shares from the same perspective as Pedro Maló, saying that Portugal is well positioned. The director of *Soluções Tecnológicas*, Vasco Mendes de Almeida adds although it is required to know how to arrange the implementations of the technology in a form that it has applicability, makes sense and added value in the citizens and organizations life (Filipa Cardoso, 2016).

It was stated that the sectors like health, transport, utilities and safety and security could adopt different patterns due to the integration of information more easily, as for instance smart cities that already shows that kind of integration taken into account by decision makers. For Indra, there are two main components, sensors and data analytics. It is stated that the IoT may work as an infrastructure for the smart cities having as a foundation of interoperability of real world objects with the virtual world and at the same time process that information through big data.

Esri Business Director in Portugal, Nuno Pereira Leite, indicated the exponential increasing of the utilization and combination between GIS and IoT sensors is a case of success, and it already exists nowadays. For example, this arrangement was applied in the water sector and it is helping to reduce losses, maintenance and planning costs. In addition, the technology can assist in detecting, alerting and showing to the employees at service the damaged water network section through a digital map, which saves large amounts of time and money for technicians to find the source of the problem. Furthermore, it will also help to avoid future damages and problems (Filipa Cardoso, 2016).

In a different interview conducted by Célia Marques for the newspaper *Económico*, Pedro Maló said the main forms where Portugal can have a significant impact in the handling of large amounts of data gathered by the IoT technologies is by mining useful information from all that data for posterior exploration by diverse entities. One different approach in which Portugal can be successful while leading with IoT is in the development of hardware technology for devices that collect information and data for specific applications (Célia Marques, 2016).

2.5.3. Future of IoT in Portugal: chances and challenges

For the beneficial use of IoT networks, Portuguese companies still need to realize that digital transformation only makes sense if understood as „transformation through digital" and not „digital transformation," says Bruno Horta Soares. The IDC consultant notes, however, that in Portugal it is already possible to find some projects that are centered on an internal dimension of organizations: the search for efficiency with greater connectivity of the assets.

In Portugal, some IoT projects can be found mainly related to the internal dimension of demand for greater efficiency through the reinforcement of the connectivity of the assets (mainly in industrial processes), and there are still few cases with a scale of use of IoT to reinforce the consumer experience of partners or even in identifying new products and services.

IDC recently launched the *FutureScape: Worldwide*'Internet of Things 2017' Predictions where it highlights four key themes. *The Low-Power Wide-Area Network* (LPWAN) conflict is one of them. Despite the 'hype' created with the benefits of *LPWAN*, such as *LoRA* and *Sigfox*, the inability to license and the lack of quality of service (QoS) mean that companies are moving ahead with non-critical applications.

Another case is the emergence of the *Open DataPalatform*. In 2018 *Open Data Palatform* will emerge in the discussion of IoT support platforms creating some confusion in organizations that have already invested in IoT platform solutions. In addition, there is the convergence of IoT with analytic. In 2019 IoT-related projects will lead to a convergence of streaming analytics with automatic learning or machine learning supported in data lakes, marts and content stores. Finally, in 2019 at least 40% of the data created with IoT will be stored, processed, analyzed and used near or at the edge of the networks.

Portugal is still being in a phase of dating with IoT where there is a lot of enthusiasm, a lot of promise, a lot of experimentation but where there is still a lack of vision to assume that digital solutions and innovation accelerators can and should represent unique opportunities for real (r) evolution in people, organizations and society as a whole.

Another main problem continues to be security. One of the major game changers of security organizations is precisely related to the incredible 'de-metering' that connected devices have brought. Security previously viewed as the perimeter protection of the organization is now increasingly 'containerized' (in the sense of encapsulation) at the device scale, which is why issues such as security, privacy and regulation will be directly associated with the success of IoT. It is estimated that by 2019 more than 75% of the solution producers will improve their solutions so as to ensure better management and control by design and thus can be seen as true partners in the digital transformation of their customers. (Bruno Soares, IDC).

Agenda Portugal Digital applies the ambition from *Europe Digital Agenda* into national perspective and summarizes the main challenges for the future in R&D and innovation for ICT in Portugal, also mentioning specific measures for development. In the case of IoT it will focus in R&D on the technology, national industry of 'things connected to the internet', public infrastructures for things connected to the internet in different domains (smart cities), smart transportation, smart grids and smart healthcare, connectivity with enterprises, private infrastructures and Internet of Things service market interoperable at European level (FCT).

„Today the 'things' are already all linked together: cars, roads, bridges, tunnels, stations, water networks, energy, communications and buildings„, says Nuno Parry. The reason is simple: „optimize time, costs, resources, planning preventive actions, monitor security aspects and, simultaneously, to maximize the services to the citizen„. But, aware of all this potential, the IoT is haunted by some ghosts, ranging from the power of communication, interoperability, storage, etc. In the opinion of experts, the security and privacy are unavoidable themes. „The increase in the number of connected

devices and the ignorance of the potential security needs by their corresponding users will cause an increase of 'market' of hackers and these same devices may work as gateway“, elucidates *Vasco Abdullah*, pointing to the use of standards and styling as possible solutions. The answer seems to pass in any event by weighing the pros and cons, but also points out the head of Indra, for having a community involving all parties, including the citizens, willing to overcome challenges and enable the community to enjoy the benefits.

But it's not just the technological issues of concern to the experts. Digital illiteracy and consequent exclusion, which are often accented by issues such as demographic change or the aging of the population, are also part of the challenges of this new technological phase. Peter Mack, Professor of the *Faculty of science and technology of Universidade Nova de Lisboa and Uninova investigator*, adds a more critical point: „We're being managed by technocrats that see only numbers and the IoT is to give them even more information to justify its decisions; It turns out that not always the decisions you take [based on numbers] are best for people, to society„. Given the speed of advancement of technology, the Professor believes that it takes „who think critically and responsible”, and says that „we need to build more efficient and orderly cities but at the same time fairer and supportive, we have this duty to our children„.

The future looks promising for this innovation with the potential to drastically change the way we live. *Cisco technology* forecasts pointed out that, in 2020, 50 billion devices connected to the network, a business potential that amounts to 1.7 trillion dollars estimated by IDC consultant. However, the road to success may not be so regular. In August 2014, *Gartner HypeCycle* for emerging technologies put the IoT at the peak of inflated expectations. „Is the phase in which it thinks the IoT will solve all the problems of the world and in which anyone thinks she can do something for IoT„, explains the Smart Cities Peter Mack. „Then let's get on realism, in which you will realize that, indeed, the IoT is not going to solve everything and then we will enter the area where, in fact, we will see the real worth of the IoT„. This process will serve as a filter for what really works and makes sense and for those who are able to remove the effective value of the IoT, believes the expert. Only then the true potential of the IoT will be achieved.

Managing the extremely large volume of information generated by IoT devices, estimated to be in excess of 400 ZB per year by 2018, is going to be an increasingly relevant issue. Most of the approaches to IoT information management proposed so far, based on the collection of IoT-generated raw data for storage and processing in the Cloud, place a significant burden on both communications and computational resources, and introduce significant latency. IoT applications would instead benefit from new paradigms to enable definition and deployment of dynamic IoT services and facilitate their use of computational resources at the edge of the network for data analysis purposes, and from smart dissemination solutions to deliver the processed information to consumers.

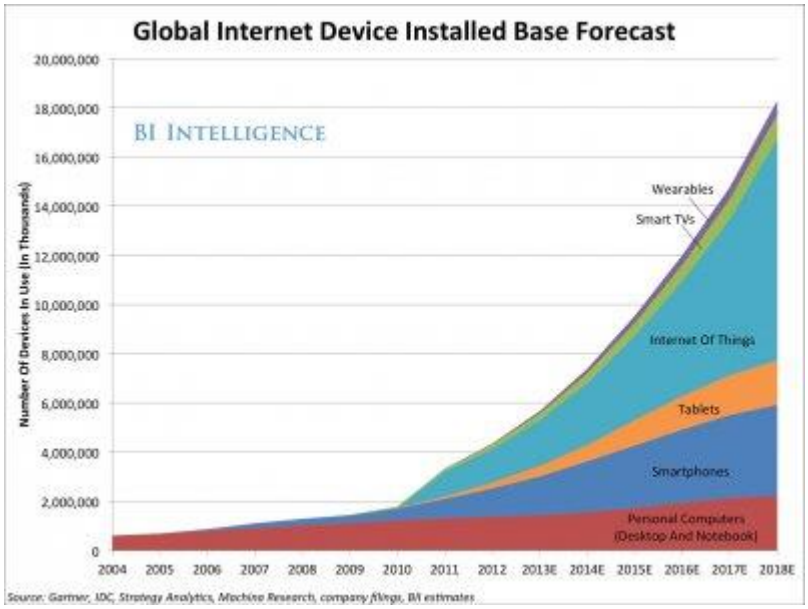


Figure 1 Forecasts for 2018; IoT = smart phones + PCs + Tablets; 24 thousand connected devices.

Portuguese companies estimate the future of IoT in Portugal as follows:

***Microsoft*:** „Being Portuguese, we are going to follow the trend from the more developed countries because they are in a larger stage of maturity. The startups are going to be differentiators and knowing the Portuguese market, they are going to have plenty of opportunities for their projects. In Portugal, in particular, we are going to have to adapt to the Portuguese reality, meaning, investing in the more profitable areas as tourism, for instance. The first projects will be directed for costs reduction, mainly in the government. All the other sectors are going to accelerate, improving their processes. It is possible that in a few years the products we consume will show a price reduction because the IoT allowed the process improvement of product manufacturing. We also have good companies in this area and in the IoT solutions so I believe we are going to keep up with the rest of the world."

***Sensifinity*:** „The suppliers will be global as it happens in the computer market. In the beginning, there may be some local solutions but very rapidly, they are becoming global solutions. American or Chinese companies may dominate the market with the global solutions. There are going to be many services/products since this technology is going to be applied everywhere, agriculture and services at our homes are some examples."

***Mainhub*:** „I hope the Portuguese companies will be successful, they will have to sell the products in a different manner. I do not know if through traditional selling models, if Amazon is an adequate place to sell this kind of products, for instance, as the market may become entirely online or if there are going to exist specialized stores. Nevertheless, I hope the companies are successful and remain in Portugal, which is the most important aspect. I hope the startups remain in their country of origin and produce wealth from there instead of going to other country. "

***Cisco*:** „The national and international markets are gradually grayed. Things are global and the IoT and digital transformation bring that paradigm, which is when we launch an enterprise in Portugal we have to think at a global scale. We cannot think just in the local market. We have to consider that a company in order to survive, grow and be healthy, cannot focus just on one market. It has to be

created from the ground and think at a global scale because if not it 'is only a matter of time until it is completely surpassed by other competitors. "

FEUP: „The national market in these areas may develop and be at pace with the countries we have as reference and I think we are at a good promptness. I hope there are going to be more entrepreneurs from small companies to larger ones to have vision of being able to use the last innovations. "

Porto City Hall: „Here we have a huge challenge and only have one way to overcome it which is going in the frontline. If not we are going to have many difficulties and are not going to have as many opportunities as other countries that have positioned themselves. The vision of the market on a national and international scale is very positive as Portugal is at the same pace as every other developed country in levels of development and implementation of the IoT technology. However, since there is no exact distinction between the several countries in this matter, it is imperative to start thinking on global scale in order for companies to survive and expand. On the whole, it would be best for Portugal to position itself in the frontlines and eventually change their approach and business models as it would be much more difficult to standout and be successful otherwise."

2.5.4. IoT research in Portugal

Portugal will have a structuring project on IoT under the umbrella of TICE.PT. This is a large-scale pilot project, which has support in the context of Horizon 2020 and aims at designing companies, scientific institutions and national public sector in the field of IoT.

There are two aspects in this area where Portugal can make a significant contribution, with application and potential export: to treat large volumes of data in order to remove information of value that can then be exploited by various entities, and in the development of hardware technologies for devices that capture information and data for specific application.

The project *PROTEUS* consists of using an intelligent sensor system which measures in real time the physical and chemical factors for consumable, residual and pluvial waters. This project started in February 2015 and had an investment of 4 million euros (Célia Marques, 2015). One very successful Portuguese startup in the Internet of Things area is *Sensefinity*. This startup focuses on the Internet of Things for the masses. The main projects they worked on are the Smart Farm, where a customer wanted to compare the quality of the milk with the feeding ground of the sheep and at the same time monitor them. Therefore, the startup through the technology enabled the customer to study historical data and compare the best batches of milk with the feeding ground used. This will help farmers, with basis on data, to take the best decisions for a better product quality.

Other projects from this startup include the *Sensorice Cold Chain Monitoring*, which helps in the monitoring and control of vaccines, food or sensitive chemicals storage and handling conditions by automatically sending alarms and onset crossing notifications. It also analyzes the performance of 28 fridges in the supermarkets and can help hotels to save energy and even elaborates HACCP reports. This project was applied to Delta Cafés, Yonest and Fragoleto.

Furthermore, the *Sensorice Cold Chain Monitoring* won the first prize in the EIT Digital Idea Challenge (Sensifinity, 2016). The company NEC announced it is developing a solution to apply to the

agricultural sector in order to collect and analyze large sets of data. This idea was implemented in January 2015 into a tomato plantation in Castanheira do Ribatejo. The purpose of the solution was to generate a virtual agricultural field with every morsel of information about the weather, soil and vegetation conditions assembled using drones, sensors and satellites.

All of this combined allowed for the possibility of creating simulations or forecasts for those virtual fields, which later were used to make customized recommendations about cultivation and productivity estimations. This technology was developed having considered the optimization of agricultural resources and enables us to make scientific modulations in accordance with crop growth levels and environmental conditions (NEC, 2016. Besides these examples, there are innumerous projects for small and larger enterprises and universities focused in developing and implementing IoT all across the country by creating new and innovative solutions with the objective of improving the functioning of other enterprises and society.

Below we represent the most relevant IoT projects in Portugal:

PROTEUS Project

The PROTEUS project (see: Proteus-Sensor) is an example of one of IoT applications. At issue is the development of a sensory system for real-time monitoring of physical and chemical parameters of water consumption, wastewater and rainwater. The international project, which began in February 2015, involves the UNINOVA, UNPARALLEL Innovation and SMAS Almada entities which fit a financing of 1,278,000 euros, compared with a total investment of about four million euros.

PROTEUS is a project funded under the Horizon 2020 framework program for research of the European Commission. It investigates the smart integration of chemical sensors based on carbon nanotube, MEMS based physical sensors together with a cognitive engine providing on the fly configurability. Produced devices will be tested in the context of water monitoring.

PROTEUS mix competences from integrated smart systems area, Internet of Things, cloud based computing, long range wireless sensors in the field of water utilities.

IoTiP Project

The current emerging IoT presents several challenges concerning time and costs associated with the development and production processes. Having this in mind, **'IoTiP'** (Internet of Things in Package), a new project promoted by NANIUM S.A. together with Fraunhofer Portugal AICOS, addresses these problems by presenting a development ecosystem that combines extremely integrated and modular hardware, firmware and software components. These will contribute to the creation of new IoT solutions that aim to address otherwise unreachable markets.

The integration of sensor technology, processing power and radio connectivity in the objects that support our daily life is now a reality. Despite the increasing number of smart devices, the time and costs associated to hardware development have a negative impact in the sustainability and dissemination of it. The 'IoTiP' project is a solution to these problems.

The 'IoTiP' embeds sensing, processing, energy management and radio communications in a **System-in-Package (SiP)**. This 'SiP', based on the emerging Wafer-Level Fan-Out (WLFO) technology, sets a new standard in miniaturization. It will provide a physical interface to enable a modular architecture

that allows adding new features to cover a huge variety of applications. Moreover, 'IoTiP's ecosystem will provide a hardware abstraction layer that will allow developers to seamlessly interact with the 'SiP' and its features. This will contribute to simplify and speed-up the development of new IoT solutions.

For Manuel Monteiro and Hugo Gamboa, Fraunhofer Portugal *AICOS*' researchers, „the current development platforms are still far too complex and require expertise in several fields, such as electronics, firmware and software development. Moreover, these platforms are not suitable for developing end products, as reengineering resources are needed to make them ready for the production phase. By creating a development platform based on a modular SiP architecture, conceived for mass production, IoTiP aims to facilitate the development of new IoT solutions".

„Combining Fraunhofer's and NANIUM's expertise allows disruptive solutions to be offered in the IoT market. The IoTiP project offers an ultra-small, energy efficient, easy to integrate and ready for production platform. It will materialize our common vision of an interconnected world," said Rui Pedro Silva, NANIUM's IoTiP project leader.
The project goal is not only to offer a development platform that stimulates the creation of new IoT solutions ready for production, but also to enable former traditional industries, such as footwear or textile industries, to embed technology in their solutions yielding a differentiated product. NANIUM and FhP-AICOS are, with this, committed to contribute to IoT growth on a global scale.

IoTiP is a two-year project, co-funded by the European Regional Development Fund (ERDF) under COMPETE 2020 (see: IoTiP).

2.5.5. IoT awareness in Portuguese companies

A study was made by *CEO Briefing Portugal*, in 2015 about the main challenges faced by Portuguese executives in this digital age, regarding the new expectations of customers (30%), compete with new players (20%) and improve operational agility (18%).

The main levers recognized by Portuguese executives to improve the competitive position of their companies are increased efficiency (54%), diversification (46%) and improving service to the customer (42%). Currently, the investment in digital technologies in Portugal has the objective to improve operational efficiency. However, recognizing the importance of experience customer service, executives change the focus of this investment.

Digital technologies continue to be a strategic priority for Portuguese companies. Most of respondents admit to invest currently with the objective of improving the efficiency of their processes and reducing costs (62%). However, they recognize that the main challenges that digital transformation brings for their companies are the satisfaction of the customer's new needs, the competition of new players and the operational agility. As such, Portuguese executive's future strategy of investment focused on the satisfaction of customer needs (46%), improving its competitive position vis-à-vis new players (46%) and the improvement of operations (46%). Similarly, the counterparts of Western Europe will also direct efforts to the satisfaction of its customers (50%) and improvement of operational agility (48%), but will prioritize the improvement of efficiency of its costs (53%).

Portuguese executives believe that IoT will make their companies more efficient and will contribute to the improvement of job conditions. More than half believe that the main impact of IoT is the

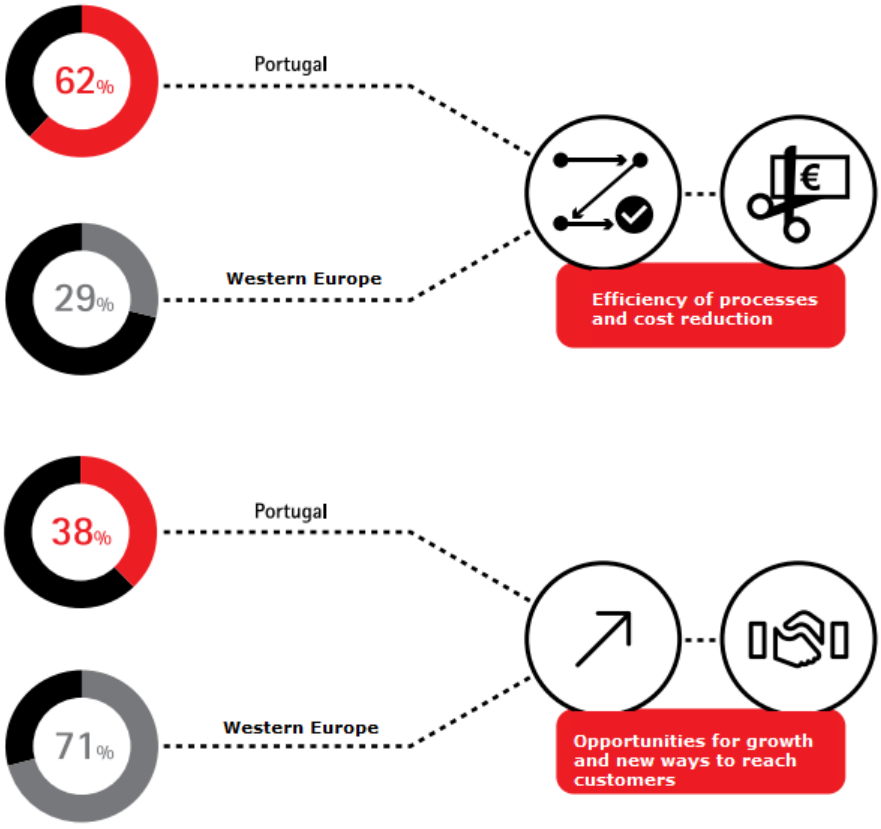
operational efficiency (54%), in opposition to the other executives of Western Europe that indicate the increase of revenue as its main impact (63%).

In the labor market, 96% of Portuguese executives believe that IoT will bring about an increase and 86% think that there will be an increase in the average salary of contributors. Although the rest of Europe Western countries agrees with the increase in jobs (89%) and more than half believes that the salaries of employees will decrease (59%).

In operational terms, Portuguese executives stated that benefits of IoT for their business improved levels of supervision and internal control (66%), the increase in employee safety (50%) and the optimization of asset utilization (48%). Comparing with their peers in Western Europe countries, in addition to optimizing assets (47%) and increased safety of employees (44%), also the improvement of productivity (45%) is one of the main benefits of IoT. Still so it is important to note that 100% of executives in Portugal and the rest of the Western Europe believe that IoT will bring benefits for their companies.

The level of knowledge of Portuguese company's executives is high and higher than the average for Western Europe. Specifically, 66% of Portuguese executive's respondents admit that their organizations include in the concepts related to the IoT, as opposed to 37% of the counterparts of Western Europe. As regards the ability of companies to IoT, 92% state that their companies have the capacity to generate new sources of revenue through IoT, which is in line with the other executives of Western Europe.

Figure 2: ?



Although most Portuguese executive's respondents recognize the benefits of IoT and 92% have the necessary skills to its capitalization, only 14% of organizations operating in the country have defined a strategy for the IoT. Most of enterprises are still at an early stage strategy definition for IoT (84%), with only 2% still claiming not be at this stage. When it comes to Internet of Things, most of the respondents prefer to follow the trend of what make the difference. In some sectors, this may be a sensible focus, however, there are trends that point to a future in which the IoT will be an increasing force most influential, namely the fall of the price of technologies such as sensors, increasing the capacity of processing and storage data, as well as the proliferation of connections.

The main obstacles identified by executives to the development of IoT in their organizations are the lack of access to capital (50%) and technology (40%). To the remaining executives from Western Europe, beyond the difficulty of access to capital (48%), the weak support infrastructure to IoT (45%), namely information and telecommunications, and the demand from consumers (45%) are stated as other major challenges.

The short-term agenda
Operational efficiency is the central theme on the agenda of Portuguese executives related to the IoT, since only 16% refers to the opportunity to generate new sources of revenue through new products and services. However, in some industries are already being explored, not only how the IoT may increase the operational efficiency, but also as may generate new revenue streams. In the automotive industry, for example, vehicle diagnostic systems that monitor the driving pattern are preparing the way for the insurers can offer products depending on the type of driving. Also in health, remote monitoring service providers offer a greater portfolio of services at home. Another concrete example is the German manufacturer *Bosch Group*, who created the *Internet of Things Lab* in partnership with the *Swiss University of St. Gallen* to explore the potential of IoT to change business models.

About the study

Accenture's CEO Briefing study was conducted in partnership with *The Economist Intelligence Unit(EIU).* This report analyzes the views of 1,400 executives worldwide, in 32 countries and 25 industries, on their forecasts for the global economy, as well as such as the strategy of their organizations and the impact of digitization on their business. In addition to the results of the survey, the *EIU* conducted individual interviews with various business leaders.

2.5.6. Case Studies on IoT in Portugal

AI, bots, biosensors, IoT, robots and more – Acceleration is back to Braga (see: robots-acceleration)
Once a year Startup Braga runs an edition of its acceleration program, gathering startups coming from the digital health field, nanotechnology and digital economy.

Portuguese Startups bringing the IoT to the manufacturing industry (see: manufacturing industry)
Two Portuguese companies, *Prodsmart* that focuses on developing process optimization systems for industrial production, and *Sensefinity* that's specialized in integrating sensors with other systems, just announced a partnership. Their goal is to bring the advantages of the IoT to the factory floor.

From now on, it is possible to see all the factory floor operations in real time, from people's work to everything that is produced in each machine in every production line.

Apis Technology – The Internet of Bees (see: apis-technology)
Apis Technology came to the rescue. Miguel Bento, beekeeper and electronic engineer, developed a solution that avoids the premature death of bees and also allows beekeepers to effectively manage their hives in real-time, even far from them.

The solution is pretty global: there is the possibility of adapting a monitoring technology to any hive, consisting of a control system and sensors in a box placed inside. The sensors are connected to a central system that aggregates all data from the multiple hives and sends it to a Web platform that the beekeeper can access all the time.

SIGFOX Makers Tour is coming to Portugal (see: Sigfox)
SIGFOX, the global leader in cost-effective, energy-efficient Internet of Things connectivity, has recently kicked off a European road trip with its SIGFOX Makers Tour. The tour is a series of workshops all around Europe, to support communities of developers and makers to use SIGFOX's technology and network to create new use cases. Following the swift deployment of the network in Portugal, which already covers more than 90% of the population and 75% of territory, the tour will stop in Lisbon's top incubator, *Startup Lisboa*, on February 11, in collaboration with Productized. *UPTEC,* the Science and Technology Park of University of Porto, will host the tour on February 12.

EDP IoT Hackaton (see: edpiothackathon)
EDP and *Microsoft* have created a hackathon to find out who are the best hackers in town. They want to have your brains not only to hack a device that is able to get charge data from an EDP Box and deliver the data to the cloud, but also to build an app that is able to explore this data in the cloud. For this they will want to see a lot (and they mean the IoT) of creativity.

IDC Portugal (see: IDC)
The *IDC* classifies IoT as one of the main innovation accelerators of the 3rd technological platform, being one of the areas with the greatest transformation potential of society and economy. More specifically, and in business terms, the IoT allows us to transform business processes, a way we work, a way we interact with customers, and transform and create new products and services.

Globally, as *IDC* estimates point to an installed base of IoT equipment in excess of 10 billion in 2014 (excluding human-managed equipment such as PCs, Smartphones, etc.). IDC expects an installed base of equipment to exceed 30 billion by 2020 worldwide, corresponding to a compound annual growth of 24 percent.

In Portugal, *IDC* estimates point to an installed base of 900 thousand IoT devices in 2015, with only 2G/3G/4G connectivity. *IDC* expects the installed base of IoT devices with 2G/3G/4G connectivity to reach almost 2 million by 2020. This corresponds to a compound annual growth of 16%.

In addition to the 900,000 IoT devices with 2G/3G/4G connectivity, *IDC* estimates that there are almost 30 million devices connected through the fixed and mobile network, including WiFi and other technologies (e.g. PLC and UNB/LPWA).

Advantages for national organizations:
•Reduction of costs,
•Improvement of customer service,
•Improvement of the decision-making process,
•Creating new business revenue.
Challenges for national organizations:
•Fear of complexity,
•Security concerns,
•Operating cost growth.
In this context, *IDC* Portugal held the 'Internet of Things Forum' on April 28, 2015 in Lisbon, where it analyzed how this set of technologies can help organizations rationalize their IT resources and optimize processes, expand their activities, innovate in communication with customers, and develop new products and services.

IBM (see: IBM)
'The Internet of Things' is certainly one of the areas that greater support is in the strategy that *IBM* has developed in recent years, seeking to move to new areas of value. Being the IoT, in a way, a new 'frontier of value', to open completely new horizons for instrumentation and universal communication of all kinds of devices, touch areas as diverse as communications, infrastructure, data models, processing standards and integration and, above all, the ability of the analytical processing exponentially greater amount of data produced. The fact that the IoT present challenges on so many different fronts-but ultimately related – is, in a way, what multiplies the opportunities and allows us a unique positioning, as *IBM* have solutions that touch all these areas and which constitute a cross-cutting, integrated response.

The focus on analytical solutions, as is the maximum exponent of the cognitive computing, *IBM* Watson, it is essential to respond to one of the main challenges that result from the IoT, namely, the need to work out the information in order to make it truly useful. This area is of course as important in the international market as in the national one and *IBM* has been developing in Portugal, in partnership with customers and partners, this type of technology. Interconnection with mobile devices and sensors, to give another example, is something that has been also worked on in Portugal. The platform developed by *IBM* at the time of the fire drill do Chiado in Lisbon in August of 2013, is demonstrative of how the IoT is essential for obtaining data dispersed – fire sensors, GPS devices, ambulances, etc. – and your transformation into information actionable analysis for immediate action. *IBM Bluemix platform* is essential here, while allowing fully integrated rapid application development on IoT.

The infrastructure that supports communication with sensors and other devices is another very important area in the national panorama. The growth of connected devices becomes untenable in the long term, the use of the GSM network or to other current solutions, so technologies that enable long-distance communication and with low consumption (such as the *LoRaWAN* technology that *IBM* offers openly) will be key to the growth of the IoT.

UNINOVA (see: Uninova)

SPOTNET (see: Spotnet)

SPOTNET wants to be „the first Portuguese start-up operator in IoT“ and „help build this ecosystem in Portugal“. The experience and inspiration of SPOTNET comes from another technological company, which has already given evidence in the area of Information and Communication Technologies (ICT), Lusolabs. „Taking advantage of Lisbon's exciting environment for the launch of new technology solutions, we decided that it was time to take an important step and we created a solution for start-ups and cities to have a completely independent Internet of Things communications provider,“ (see: Spotnet) stressed Filipe Lacerda and Miguel Casimiro, founders of Lusolabs and SPOTNET promoters.

Virtusai (see: virtusai)
Virtusai is a startup that is focused on developing solutions that are innovative, versatile and efficient. Virtusai team has a strong background on software development and R&D specially within the field of Big Data and IoT.
Virtusai is striving to offer its clients complete, full stack solutions that integrate all aspects of their needs, thus contributing for an accelerated product time to market.

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2.6. Spain

2.6.1. Overview of the existing and foreseen IoT technologies in Spain

Smart Agriculture project in Galicia to monitor vineyards with **Waspmote**:

Siega System has been firstly deployed in a vineyard in Pontevedra (Spain). Siega System is able to monitor environmental parameters such as ambient temperature and humidity and other parameters related to agriculture such as precipitation, wind or leaf wetness. Thanks to this project, 3 different plagues can be predicted: mildium, oidium and botritis though statistical model is expandable to integrate more plagues in the future.

On the one hand, the system allows to monitor vineyard conditions in real-time, being able to predict the appearance of a plague in the next hours/days. This feature allows vineyard technicians to take the measures to minimize the impact of the plague in the vineyard, minimizing time and money lost due to this plague.

On the other hand, the system also allows monitoring and controlling the grape from its beginning to the end user, also called as traceability of the grape. In this way, grape can be monitored in real-time from its plantation to wine manufacturing in the wine cellar. RFID technology allows accomplishing this goal, improving viticulture to a level not known ever before.
Siega System nodes use Waspmotes and are able to measure different parameters: Ambient temperature/humidity; Atmospheric pressure; Pluviometer; Anemometer; Ultraviolet radiation; Solar radiation; Soil temperature; Soil moisture; and Leaf wetness.

<u>Saving water with smart management and efficient systems in Spain:</u>

The smart water project aims to develop and deploy a demand-side cyber-physical system (CPS) to optimize the water consumption efficiency and safety in living areas. The system consists of:

•High-accuracy water flow meters installed in the main water supply pipe of the living area to provide real-time water flow data.
•Solenoid-based electric valves to control (open-close) the water supply into the living area.
•Waspmote OEM Sensor Platform to gather the information and the **Meshlium** Gateway to store and transmit it.

•*FEEP IoT&Big Data Platform Sofia2*, where data is received from the sensors, stored and analyzed in real-time, extracting meaningful insights for the demand-side. Based on this information Sofia2 is also able to send orders to the actuators, modifying their operation according to defined rules and alerts.
•Disaggregated consumption data will be analyzed through the integration of *Novelti* real time analytic service that provides autonomous machine learning capabilities able to learn the behavior patterns of each individual data stream corresponding to appliance, personal hygiene or green areas water usage.
•*A-CING* Web Application to visualize the processed information and to allow users to interact with *FEEP IoT&Big Data Platform Sofia2*.
•*A-CING* Consumption Awareness Application (*FEEP IoT & Big Data Platform Sofia2* based) to allow users to be informed about the water consumption habits.

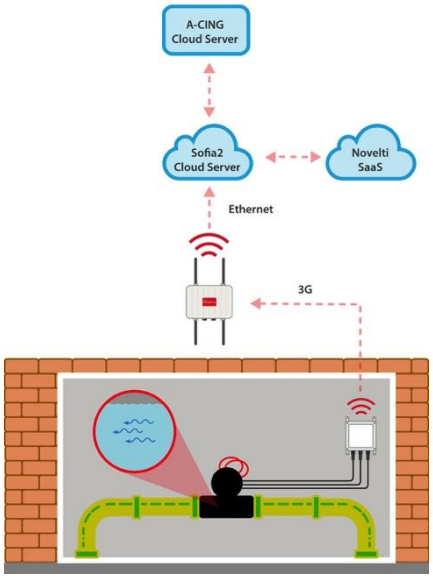

Figure 1: Diagram of iWesla deployment (Source: Libelium Comunicaciones Distribuidas S.L. (www.libelium.com)

The communication between the sensor platforms and Meshlium is carried out through 3G communications. The IoT Gateway collects data and sends it to the *FEEP IoT & Big Data Platform Sofia2* through Ethernet connection.

The water efficiency and safety solution designed in *iWesla* could help saving up to 50% of the water consumption in living areas thanks to the detection of abnormal water consumption. When detected, the user is warned using alarms and given the possibility to actuate over the electric valve to close the water flow. Apart from the reduction in the water consumption, this early detection can lead to the reduction of potential damages caused by leakages or open taps.

Health monitoring through a wearable system

The e-Physio project is an open hardware and software system designed to analyze muscular effort to provide training improvements. It consists, on the one hand, of a wearable device has been developed using Arduino and an EMG sensor to monitor muscular activity. And on the other hand, a mobile app that receives the user muscular data to perform analytics. This system may be used for muscle injury monitoring, postoperative muscle recovery, high performance sports monitoring and advances disease predictions through muscular databases.

3D printing remote lab for educational purposes

The *LI3D system* is a low cost remote laboratory for 3D printing based on open hardware and software. It is based on *Arduino and Raspberry Pi. The LI3D* helps to increase the functionality and availability of 3D printers eliminating the time limitation imposed in workshops and classrooms.

The experimentation has been realized in a Vocational Training Center in Valladolid (Spain), with students of superior degree. The *LI3D* arises as a consequence of the long printing time required for printing some objects. Therefore, morning time for pupils is insufficient in order to print the necessary parts for their project: create an UARM robotic mini-arm, which consists of 36 pieces. This experience has been realized with two printers 3D, *Prusa i3 Mendel©,* and *Prusa i3 Hephestos©,* both *RepRaps* printers in kit format.

It acts directly on 3D printers, compared to other cloud printing systems in which the users send their files and obtain the results without any control of the process. This project is an open system, which facilitates its implementation and portability.

LI3D users use 3D printers in a controlled environment, favoring the learning and handling of this technology, eliminating the fear of causing breakdowns or failure. The system has: User management, print engine control, real-time temperature monitoring, visualization of results obtained, system usage and energy statistics.

Smart calculation of hydric flow

UNED has developed a wireless system to improve hydric flow calculation in open foil with windlass hydrometer. The project adapted traditional hydric flow calculation methods to new technologies using an Arduino adapted to a traditional water reel. This device sends via Bluetooth and Android. A smartphone is used to collect data in order to calculate the flow and Bluetooth to avoid wires.

Gauging point is located through GPS and a report is sent instantly by e-mail, taking advantage of the features found in today's mobile.

Getaria: environment monitoring for a smart tourist destination

Getaria has a wireless WiFi/Wimax network that is ready to provide free public Internet access in different districts of the town and can also be used to self-provision other internal services for the city hall itself. This wireless network, combined with *Sigfox* network, has been improved to add new IoT services to citizens, such as environmental control of air, noise and water in real time to increase citizen’s welfare and to prevent problems that can cause a negative impact on the tourism attraction.

In fact, the network monitors the noise impact in ten leisure locations so that the municipality can confirm the complaints from neighbors and tourists lodged in the nightlife of the historic center.

Regarding water quality measurement, the objective of the Council is to control any spills on the public supply that can affect water quality to two main beaches, the port and rainwater locations. For that, the *Waspmote Plug & Sense! Smart Water solution* has been installed. In this case, the sensors used are: pH sensor, Conductivity sensor and Oxidation-Reduction Potential (ORP).

The network also includes two air quality monitoring systems to ensure that pollution levels are adjusted to European standards and to monitor areas at risk of emissions from the largest concentration of tourism using means of transport that emit CO, NO2, O3, SO2 and harmful particles.

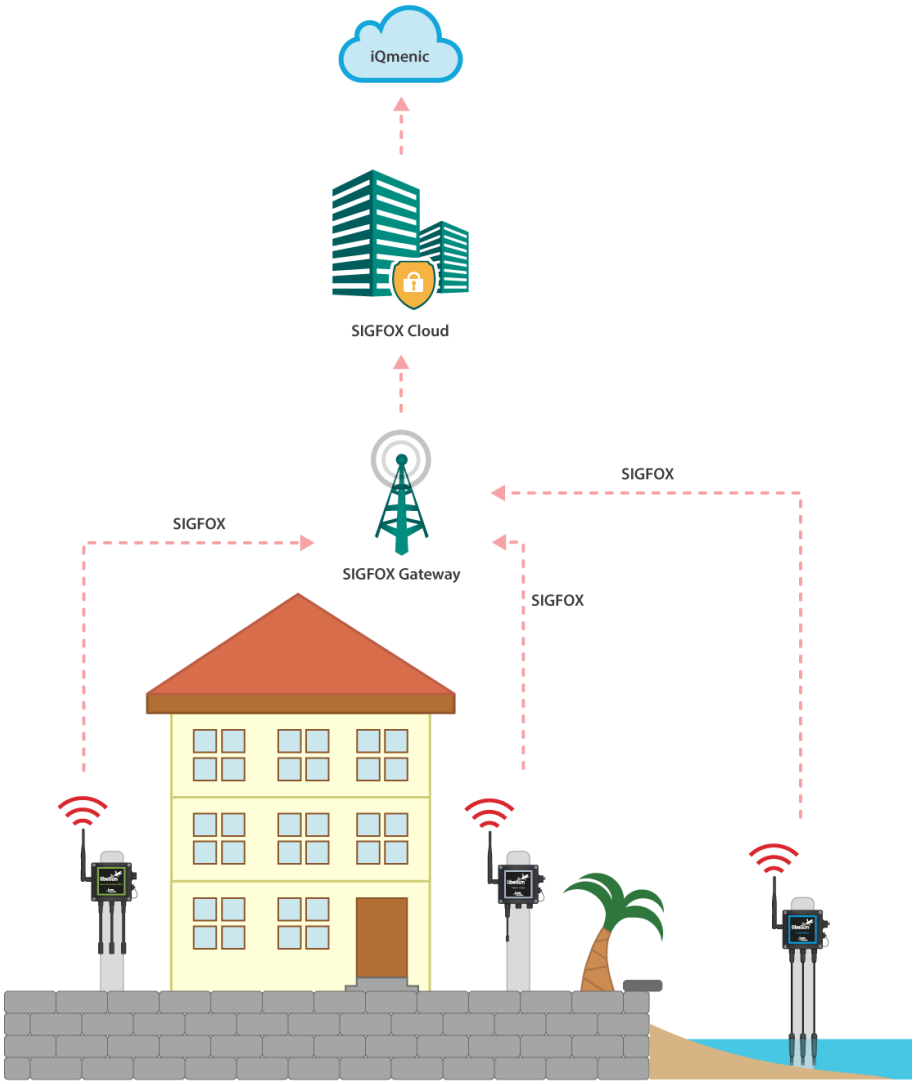

Figure 2: Getaria environmental control (Source: Libelium Comunicaciones Distribuidas S.L. (www.libelium.com).

Detecting Forest Fires using Wireless Sensor Networks

DIMAP-FactorLink has developed and integrated a forest fires detection system. The covered area is about 210 hectares in the North Spain region, comprising the Communities of Asturias and Galicia. The aim was to provide to different organizations of an environmental monitoring infrastructure, with capability to have alert management and to deliver early warning alarms. 90 Waspmotes were deployed in strategic locations. Four parameters are measured each five minutes: temperature, relative humidity, carbon monoxide (CO), and Carbon Dioxide (CO2).

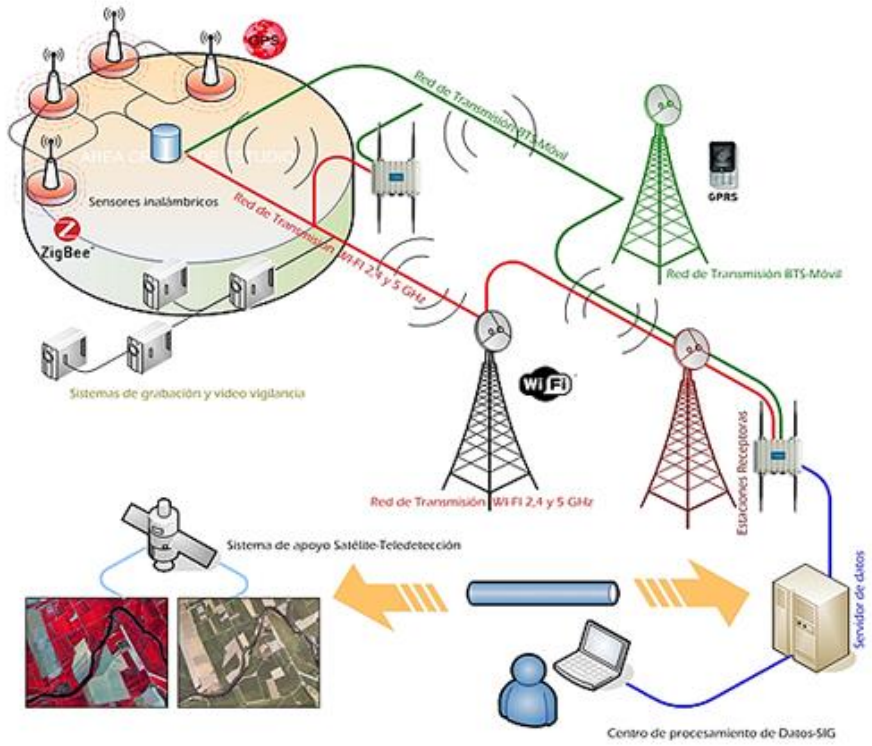

Figure 3: Forest fires detection system (Source: Libelium Comunicaciones Distribuidas S.L. (www.libelium.com)

Smart power outlet for remote control

UNED has developed a controllable plug based on *Arduino*. The plugin can be switched on and off through the Internet thanks to HTTP commands.
This project aims to allow the remote control of higher voltage electronic devices. Any device you normally plug into a wall outlet can be activated by a sensor or controlled in other ways with the Arduino. This project uses a 5V relay to switch on/off the current to a power outlet and the Arduino with an Ethernet Shield to control when the relay switches.

Smart Water project in Valencia to monitor Water Cycle Management

PRETESIC project is aimed at monitoring Valencia's network of sanitary sewers in real-time to determine the quality of water and thus, establish whether elements within the network are working properly. In this way, the system is able to react against unexpected situations, avoiding possible damages that natural disasters such as floods usually provoke in cities. This project can be better explained with the following diagram:

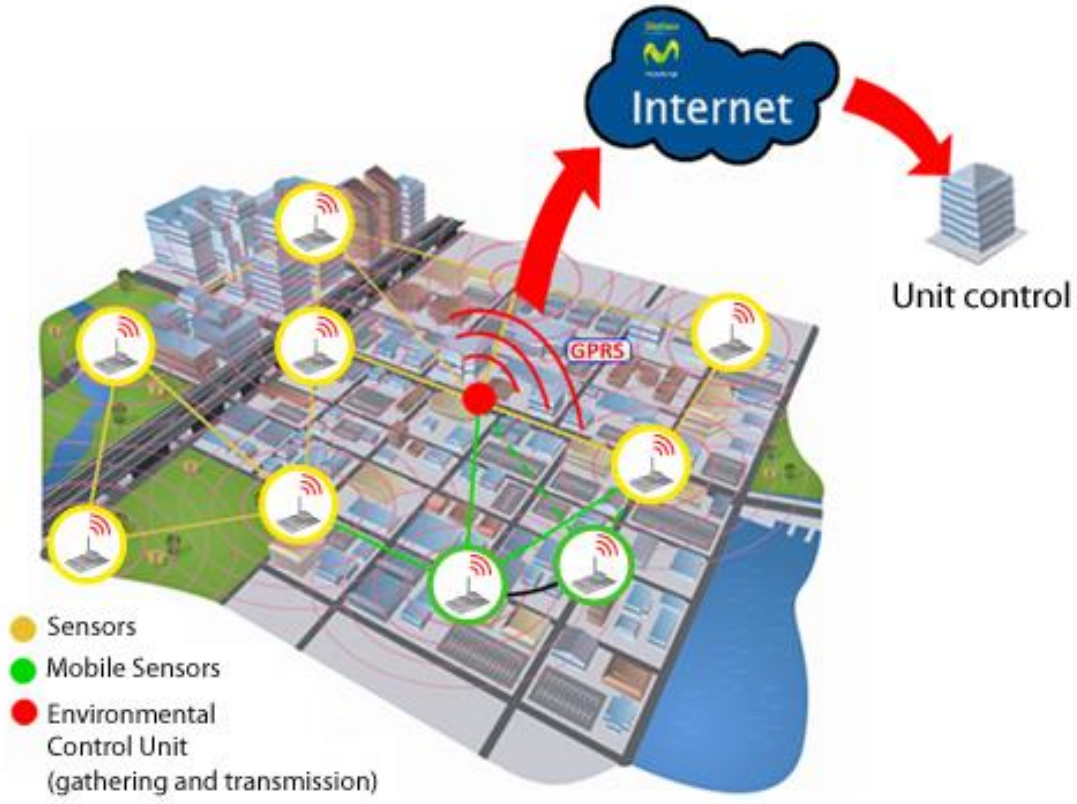

Figure 4: PRETESIC project (Source: Libelium Comunicaciones Distribuidas S.L. (www.libelium.com)

PRETESIC nodes use Waspmotes and is able to measure different parameters: temperature, PH, conductivity, redox, turbidity, chemical demand of oxygen, ammonia, and toroids to measure energetic efficiency.

FPGA remote lab for on-line education

UNED has designed an open platform devoted to allow students perform distance practices with a real *FPGA* device, an electronic device that has become very important for electric and electronics engineers.
The remote lab developed is based on a *Xilinx Spartan-3AN FPGA* with different kind of peripherals to support wide experimentation. This device has been made accessible through the Internet to be programmed by the students thanks to a Web server that receives student's code and execute it locally in the board. Finally, students can follow the *FPGA* execution results through an IP Webcam.

2.6.2. The IoT state of the art and its adoption in Spain

IoT Developers/providers:

Libelium

Libelium is a Spanish company with headquarters in Zaragoza. It delivers a powerful, modular, easy to program open source sensor platform for the 'Internet of Things'. This fosters the implementation of reliable 'Smart Cities' and 'M2M solutions' with minimum time to market. Its aim is to allow implementation of any Wireless Sensor Network, from Smart Parking to Smart Irrigation solutions.

The main products that Libelium offers are:

- **Waspmote**: It is an open source sensor platform in which developers have a total control over the hardware device. They can physically access to the board and connect new sensors or even embed it in own products as an electronic sensor device.

- **Waspmote Plug and Sense!**: It allows developers to forget about electronics and focus on services and applications. It is an encapsulated solution of Waspmote that allows deploying of wireless sensor networks in an easy and scalable way ensuring minimum maintenance costs. The platform consists of a robust waterproof enclosure with specific external sockets to connect the sensors, the solar panel, the antenna and even the USB cable in order to reprogram the node. It has been specially designed to be scalable, easy to deploy and maintain.

- **Meshlium:** It is a Linux router which works as the Gateway of the Waspmote Plug&Sense! Sensor Networks. Meshlium receives sensor data from Waspmote Plug & Sense! and forwards it directly to the Internet via a suitable radio interface (e.g. 4G/LTE...) protocols depending on the connectivity options available in the area. Meshlium is ready to send sensor data to Cloud software platforms including MQTT, Axeda, Thingworx, and ESRI. If you prefer to implement your own Cloud/Server solution you can still configure Meshlium to send data into any data base on the Internet or inside the Meshlium device. Meshlium can also integrate a GPS module for mobile and vehicular applications and be solar and battery powered. These features along with an aluminium IP-65 enclosure allows Meshlium to be placed anywhere outdoors. Meshlium comes with the Manager System, a web application which allows the quick and easy control of radio configurations along with storage options for the sensor data received.

- **MySignals:** It is a development platform for medical devices and eHealth applications. It can be used to develop eHealth web, Android or iOS applications or even to add own sensors to build new medical devices. MySignals allows to measure more than 20 biometric parameters such as pulse, breath rate, oxygen in blood, electrocardiogram signals, blood pressure, muscle electromyography signals, glucose levels, galvanic skin response, lung capacity, snore waves, patient position, airflow and body scale parameters (weight, bone mass, body fat, muscle mass, body water, visceral fat, Basal Metabolic Rate and Body Mass Index).

Telefonica

Telefonica's IoT main solutions are:

- ***ThinkingThings*:** It is a modular end-to-end and Plug & Play solution for building intelligent and connected products in the IoT area. It combines Plug & Play modules with different capabilities – sensors, actuators, connectivity, power – to create custom connected devices. It offers different kits with several features:

  -Ambient kit: Location Tracking and Condition Monitoring. It includes a Communication and a GPS module.
  -Presence kit: Easy Room Monitoring. It offers a Plug & Play and cost effective solution to the customer at home or in any other place. Thinking Things provide users with an

affordable and easy-to-install solution for room or object monitoring. The built-in SIM provides independence from any communication infrastructure which also makes it ideal for remote locations.
-Gardening kit: Smart Device Control. It includes a Communication module and ambient sensors: Temperature + Humidity + Light.

• ***GSM Shield for Arduino***: This solution easily integrates the open-source electronics prototyping platform offered by Arduino and Telefonica's managed connectivity solutions. GSM Shield is an end-to-end service with a pre-payment model that allows anyone developing m2m solutions to focus on the design and features rather than on the technical details (HW, SW or Connectivity). Our GSM Shield has been developed together with Arduino. This shield's libraries are mostly based on the Arduino Ethernet Shield, which is the best-known shield offered by the Arduino Community. This means changing or adapting already developed applications from the Ethernet shield to GSM shield is really easy.

• ***Telefónica Open Future*****:** It supports entrepreneurial talent worldwide and helps turning innovative ideas into successful businesses. It promotes and invests in people, ideas and viable technology-based projects, in any phase of growth, openly and in connection with public and private organisations. Open Future specialises in each phase of the lifecycle of a project and contributes towards the optimal development of talents and projects, without creating or imposing limitations, in order to enable scalability of success. It invests in innovative companies with a technological base and considerable growth potential. It brings together a set of initiatives that adapts itself to you, according to the degree of maturity your project has reached. No matter what stage your project is at, you will find the help you need to promote your idea, accelerate your startup and attract investment for your venue.

-Boost: *The Think Big* and *Talentum Startups* initiatives were created to provide these new entrepreneurs with support in early stages.
-Accelerate: *The Crowdworking* spaces and *Wayra* help startups under development and entrepreneurs go one step further with initiatives that help them with acceleration and scalability, and have what is needed to aid entrepreneurs making progress with their business
-Invest: *Amérigo* and *Telefónica Ventures* are the investment funds that finance and invest in consolidated projects and startups

IOTIFY

IOTIFY is a Madrid-based company that offers a Software Defined Platform designed to allow ultra rapid IoT application development without investing upfront on hardware or requiring significant embedded expertise. Their goal is to speed the development of IoT solutions. It merges IoT with cloud computing to take virtualization to the last elements in IoT chain, i.e. embedded hardware and sensors. Once every element of the IoT chain is virtualized, it could be easily run onto the cloud and exposed to anyone with an internet access and a browser. This enables to move the entire development chain to cloud, thereby making IoT prototyping extremely easy and available to everyone having just a browser and internet connection. In particular, IOTIFY offers:

• Virtual Hardware and Sensors: Drag and drop the virtual hardware and sensors in our lab and start writing code to develop proof of concept. Develop full stack IoT solutions in your browser with the power of virtual IoT.

- Virtual Databases: Generate massive data based upon customizable templates. Host with us or push directly to MongoDB or Elasticsearch installation. Develop your predictive analytics or machine learning solution with ease.
- Virtualized Networks: Use our cloud-based tool to simulate massive virtual IoT endpoints in the cloud, emitting customizable MQTT/RESTful messages just like real IoT devices. Develop streaming analytics solution with ease.

Innovatec

Innovatec Sensing & Communication S.L. is an engineering company from Alcoi, with venue also in Barcelona. It is focused on the research and development of technology devices, systems, and related services. *Innovatec* was founded in 2006 by a group of engineers with an extensive background in running R&D projects at national and international level for many years. Since then, the company has established itself as a major player internationally as a developer of high value technologies, working either for private companies or for the public sector.

Innovatec has expanded their activities to a wide range of sectors: industrial control & automation, medical devices, advanced textiles, wearable monitoring, environmental monitoring, and ambient assisted living, among others. These activities involve consultancy and project management, custom hardware and software/firmware development, and the development of built-in complete systems and devices. The company is often involved in the full life-cycle of a project from conception to completion.

Its main proposal in the IoT environment is *Thercom*, a global solution for temperature monitoring in the health and industrial context. It allows the constant control of the temperature in real time through a wireless communication system and a storage system that allows storing information for several days to be analyzed later. In addition, the possibility of long-term monitoring and detection of infrequent events as well as the correlation between temperature and activity model. The main products behind *Thercom* are *T-clinic* (body temperature monitoring in sanitary environments), *T-elec* (temperature monitoring of power stations) and *T-wine* (wine temperature monitoring).

Worldsensing

Worldsensing is a market leader in Internet of Things solutions. Its headquarters are in Barcelona, although it also has a venue in London. The company has built on its expertise in low-power wireless sensing networks and has created comprehensive vertical solutions in sectors where IoT is making a measurable impact.

The company focuses on two key markets:

- **Worldsensing Industrial:** It provides complete and fully supported turn-key monitoring solutions for ground-breaking projects in Civil Engineering, Oil & Gas, Industry, Environment & Natural Hazards, and Mining. Its aim is to detect and prevent possible risks to structures and infrastructures by monitoring their operations and status in real time.
- **Worldsensing Mobility:** It maintains a unique portfolio that includes intelligent parking systems for Smart Cities and solutions that enhance traffic management and urban mobility through real-time flux information. It includes *Fastpark*, a smart parking system that allows drivers to find parking quickly while providing cities with the means to optimally manage their

parking spaces, and *Bitcarrier,* a real-time solution for managing traffic flow, and which is designed for both road and urban environments.

- Its expertise covers a wide range of topics inside IoT: Industrial Internet, Machine-to-Machine (M2M), Wireless Sensor Networks, Cloud Computing and Processing, Smart Parking, Traffic Flow Monitoring, Wireless Instrumentation, and Wireless Seismic Acquisition.

IoT adaptors

One of the main adaptors of IoT in Spain is the city of Santander with the *SmartSantander* project. It proposes a unique in the world city-scale experimental research facility in support of typical applications and services for a smart city. This unique experimental facility will be sufficiently large, open and flexible to enable horizontal and vertical federation with other experimental facilities and stimulates development of new applications by users of various types including experimental advanced research on IoT technologies and realistic assessment of users' acceptability tests. The Santander testbed is composed of around 3000 IEEE 802.15.4 devices, 200 GPRS modules and 2000 joint RFID tag/QR code labels deployed both at static locations (streetlights, facades, bus stops) as well as on - board of mobile vehicles (buses, taxis). Over the deployed testbed, several use cases have been implemented:

- Environmental Monitoring: Around 2000 IoT devices installed (mainly at the city centre), at streetlights, facades provide measurements on different environmental parameters, such as temperature, CO, noise, light and car presence).

- Outdoor parking area management: Almost 400 parking sensors (based on ferromagnetic technology), buried under the asphalt have been installed at the main parking areas of the city centre, in order to detect parking sites availability in these zones.

- Mobile Environmental Monitoring: In order to extend the aforementioned environmental monitoring use case, apart from measuring parameters at static points, devices located at vehicles retrieve environmental parameters associated to determined parts of the city. Sensors are installed in 150 public vehicles, including buses, taxis and police cars.

- Traffic Intensity Monitoring: Around 60 devices located at the main entrances of the city of Santander have been deployed to measure main traffic parameters, such as traffic volumes, road occupancy, vehicle speed or queue length.

- Guidance to free parking lots: Taking information retrieved by the deployed parking sensors, 10 panels located at the main streets' intersections have been installed in order to guide drivers towards the available free parking lots.

- Parks and gardens irrigation: Around 50 devices have been deployed in two green zones of the city, to monitor irrigation - related parameters, such as moisture temperature and humidity, pluviometer, anemometer, in order to make irrigation as efficient as possible.

2.6.3. Existing studies and analyses on IoT in Spain

•Title: ***Smart Cities: a first step for the internet of things*.**

Authors: Fundación Telefónica y Editorial Ariel
Summary: Shows the close relationship between the Smart Cities and the Internet of Things, and how the IoT is used in the development of Smart Cities projects to connect people and things with the objective of improving the efficiency of public services. Examples include urban mobility, energy efficiency and environment, infrastructure management and public buildings, government and citizenship, public safety, health, education, human capital, culture and commerce (see: Smart Cities)

•Title: ***Design of collaborative virtual objects oriented to services in the IoT framework***

Author: Jordán Pascual Espada. Tesis doctoral. Universidad de Oviedo.

Summary: A key piece in the development of the Internet of things is smart mobile phones. In most cases, the process of interaction between the smart phones and the physical objects or devices is managed by a specific software application. Due to the characteristics of this type of applications, they must be developed as native applications specifically for the target mobile platform. The use of native software applications in the interaction processes between smart phones and physical objects produces several unintended consequences, among others, the high costs and difficulties of development derived from the replication of developments in different mobile platforms. On the other hand, the management of the current mobile native applications involves a series of secondary processes, such as the download, installation and configuration.

In the thesis *Design of collaborative virtual objects oriented to services in the framework of the Internet of things* defines a model applicable to the development of mobile applications that base an important part of its functionality in the interaction with physical objects or near electronic devices, which overcomes the disadvantages mentioned in the previous paragraph. The proposed model is not linked to any mobile platform or specific development technology, so it allows the development of mobile applications valid for multiple platforms. In addition, the proposal includes optimizations related to the development of this type of applications, such as abstraction in the management of the hardware elements of the device that enable communications and the capture of context information. The proposal considerably reduces the times used by the secondary processes, allowing developed applications to be optimal for use in systems that rely on occasional interaction with objects or electronic devices (see: Design of collaborative virtual objects)

•Title: ***Connected Industry Initiative 4.0 (Iniciativa Industria conectada 4.0)***

Summary: The Ministry of Industry, Energy and Tourism has launched the Connected Industry initiative 4.0, led by the General Secretariat of Industry and SMEs in collaboration with the Ministry of Telecommunications and Information Society. Its mission is to define the strategy for the digitization of the industry, and pursues objectives aimed at strengthening the competitiveness of the Spanish industrial sector.

It also aims at research about digital transformation; establish lines of action with the objective of increasing the contribution of the industrial sector to GDP, employment and the positive balance of the trade balance, by encouraging the digital transformation of Spanish industry (see: Connected Industry).

•Title: ***Solution to ensure privacy in the internet of things***

Authors: José-Antonio Sánchez-Alcón, Lourdes López-Santidrián y José-Fernán Martínez

Summary: New products and services offered by the Internet of Things will make us more efficient, more able to understand our environment and take action, and new assistive technologies will allow us to extend our working lives. Nonetheless, we will coexist with a large number of devices collecting information about our activities, habits, preferences, etc. This situation could threaten our privacy. Distrust could be a barrier to the full development of these new products and services. This article offers a possible solution to ensure security and privacy for personal data on the internet of things, using techniques that result from a collaboration between the business, legislative and technological areas and are designed to build trust with all stakeholders (see: Solution Privacy).

•Title: ***Ubiquitous learning trends in the internet of things***

Authors: Marcus Specht, Bernardo Tabuenca, Stefaan Ternier Editor: Dr. Alfonso Infante Moro, Universidad de Huelva

Summary: Ubiquitous technologies and the Internet of Things have been identified in several reports as tendencies to assimilate in the coming years. The ubiquitous learning is the direct beneficiary of the rapid incorporation of mobile learning into daily tasks. Mobile devices are equipped with different tools that provide good support to the student standing in formal, informal and/or professional. This paper presents the development of ubiquitous technologies and the Internet of Things in the past decade. A representation model of ubiquitous learning ecologies combining physical and digital world is described. Relevant technologies are represented and cases focusing on applicability lifelong learner as an active and on mobile devices as a learning tool. Finally, the results of a survey of 21 principals are represented with content repositories about their intentions to support mobile technologies in the coming years (see: Ubiquitous learning trends).

•Title: ***Horizons and challenges of Internet of things.***

Author: Juan Ignacio Vázquez, Universidad de Deusto

Summary: The document makes a journey through the horizons and challenges that the Internet of Things must face. It begins by performing an analysis of the potential of the use of IOT to increase the value proposition of existing products or services. The IOT concept conveys the idea that the objects that surround us are producers and consumers of information, generated by themselves, by people or by other systems, whose application leads to contribute to the development of humanity given that they do visible the invisible: they allow to reveal data that have always been there, but they have never been measured.

The conditions for being able to implement the IoT have been the development of electronic devices of smaller size and weight, the existing worldwide coverage of the Internet and the existence of a digital lifestyle.

The IOT is driven by trends such as „Wikiciudad", „Smart Cities", „I qualified", „marker phenomenon" and business models based on object + service duality among others.
However, there are a number of challenges that need to be addressed such as the energy costs generated by the devices, which increases the more intelligent or more communicative they are. As well as guarantee the right to silence the chips and develop laws necessary to protect the privacy of people and grant them the full right to be the decision makers of the destination of such information (see: Horizons and Challenges).

•Title: ***Introduction to devices orchestration in Internet of things using SBPMN***

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Summary: In this research an architecture is provided that allows the orchestration of objects that are part of the Internet of things creating business processes. Internet of Things is still in full development; this implies that there is a lack of standards for its proper implementation. Among these gaps is for example the technology used to allow objects to connect to the network, since there are several options but none seems to end imposed that is why this work try to provide architecture that imposes an alternative solution to this problem. However, it is difficult to provide a common solution to all the objects used in everyday life because of its great diversity, it requires to classify them and thus create an appropriate architecture for each of the types. These architectures are designed to facilitate the devices orchestration in a similar way as is currently done with web services enabling business process modeling (see: SBPMN).

2.6.4. Performed research projects in Spain

•Title: ***Smart Energy Management and Strategic Decision-Making Platform***

Programme: H2020-SMEINST-1-2016-2017. Funding scheme: SME-1 - SME instrument phase 1.

Summary: The way industries manage and consume energy is currently unsustainable. Today the industrial sector accounts for one-third of world energy use and industrial energy consumption is set to rise by 50% in just 20 years. On average, an industry spends one-third of its operating budget on energy. This drastically increases electricity bills while reducing productivity. Up to 35% of total industrial energy, or 110€ billion could be saved every year, just through the application of energy-saving and low carbon practices. Heating, Ventilation and Air Conditioning (HVAC) is responsible for around 40% of the energy consumption in industrial plants. Frequently, this is the largest energy consuming type of equipment on a site and can therefore provide significant scope for saving energy and money.

W-THINK is an Industrial Energy Management System (IEMS) Software as a Service (SaaS) that optimizes and reduces energy consumption of HVAC and superheated water using state of the art Industrial Internet of Things (IoT), Big Data and machine learning algorithms. *W-THINK* collects the basic data from around the variety of sensors around the plant, analyses this data and compares it to external data, such as future weather patterns, takes control of the plant's systems for HVAC and superheated water, and optimizes their performance to ensure optimal use of energy. This is all done automatically and in real time.

Furthermore, as this software is hardware neutral and easily customisable to meet users' needs, it is a cost effective solution for any scale and type of industrial plant.

The aim of the project is to make *W-THINK* available to be used by all types of industries in Europe and worldwide. The IEMS market is set to from 12.3€ billion in 2015 to 32€ billion in 2024, and achieving the projections will provide an estimated overall profit of 9,7M€ within 5 years after the project ending, a return of 550% (see: Smart Energy Management).

•Title: ***Open transPREcision COMPuting***

Programme: FETPROACT-2016. Funding scheme: RIA - Research and Innovation action.

Summary: Guaranteed numerical precision of each elementary step in a complex computation has been the mainstay of traditional computing systems for many years. This era, fueled by Moore's law and the constant exponential improvement in computing efficiency, is at its twilight: from tiny nodes of the Internet-of-Things, to large HPC computing centers, sub-picoJoule/operation energy efficiency is essential for practical realizations. To overcome the 'power wall', a shift from traditional computing paradigms is now mandatory.

OPRECOMP aims at demolishing the ultra-conservative 'precise' computing abstraction and replacing it with a more flexible and efficient one, namely transprecision computing. *OPRECOMP* will investigate the theoretical and practical understanding of the energy efficiency boost obtainable when accuracy requirements on data being processed, stored and communicated can be lifted for intermediate calculations. While approximate computing approaches have been used before, in *OPRECOMP* for the first time ever, a complete framework for transprecision computing, covering devices, circuits, software tools, and algorithms, along with the mathematical theory and physical foundations of the ideas will be developed that not only will provide error bounds with respect to full precision results, but also will enable major energy efficiency improvements even when there is no freedom to relax end-to-end application quality-of-results.

The mission of *OPRECOMP* is to demonstrate using physical demonstrators that this idea holds in a huge range of application scenarios in the domains of *IoT, Big Data Analytics, Deep Learning, and HPC simulations*: from the sub-milliWatt to the MegaWatt range, spanning nine orders of magnitude. In view of industrial exploitation, we will prove the quality and reliability and demonstrate that transprecision computing is the way to think about future systems (see: Open transPREcision).

•Title: ***TagItSmart! - Smart Tags driven service platform for enabling ecosystems of connected objects***

Programme: H2020-ICT-2015. Funding scheme: RIA - Research and Innovation action

Summary: *TagItSmart* sets out to redefine the way we think of everyday mass-market objects not normally considered as part of an IoT ecosystem. These new smarter objects will dynamically change their status in response to a variety of factors and be seamlessly tracked during their lifecycle. This will change the way users-to-things interactions are viewed.

Combining the power of functional inks with the pervasiveness of digital (e.g. QR-codes) and electronic (e.g. NFC tags) markers, zillions of objects will embed cheap sensing capabilities thus being able to capture new contextual information. Beside this, the ubiquitous presence of smartphones with their cameras and NFC readers will create the perfect bridge between everyday users and their objects. This will create a completely new flow of crowdsourced information, which extracted from the objects and enriched with user data, can be exploited by new services.

TagItSmart will create an open, interoperable cloud-based platform with all the tools and enabling technologies, which will address the challenges related to the lifecycle management of new innovative services capitalizing on objects 'sensorization'. *TagItSmart* will empower all steps involved from creating smart markers, Functional Codes (FCs), to supporting secure and reliable acquisition and consumption of such contextual data, while preserving user privacy, to the provision of generic functionalities and a service composition platform which will allow even inexperienced users to create and deploy their FCs based services while maintaining system efficiency.

To boost the platform adoption, a set of industrial use cases will be used as a baseline for development, while additional stakeholders will be engaged through a co-creation Open Call approach. A carefully planned engagement activity will ensure the establishment and sustainable expansion of the *TagItSmart*ecosystem fostering long term innovation and exploitation capabilities well beyond the project duration (see: TagltSmart).

•Title: ***Cloud Collaborative Manufacturing Networks (C2NET)***

Programme: H2020-FoF-2014. RIA - Research and Innovation action

Summary: The goal of *C2NET Project* is the creation of cloud-enabled tools for supporting the supply network optimization of manufacturing and logistic assets based on collaborative demand, production and delivery plans. *C2NET Project* will provide a scalable real-time architecture, platform and software to allow the supply network partners: to master complexity and data security of the supply network, to store product, process and logistic data, to optimize the manufacturing assets by the collaborative computation of production plans, to optimize the logistics assets through efficient delivery plans and to render the complete set of supply chain management information on the any digital mobile device (PC, tablets, smartphones, …) of decision makers enabling them to monitor, visualize, control, share and collaborate.

The Project results will be: i) the *C2NET* Data Collection Framework for IoT-based continuous data collection from supply network resources; ii) the *C2NET* Optimizer for the optimization of

manufacturing and logistics assets of the supply network by the collaborative computation of production, replenishment and delivery plans; iii) the *C2NET* Collaboration Tools for providing support to the collaborative processes of the supply network, and iv) the *C2NET* Cloud Platform (*C2NET CPL*) to integrate the data module, the optimizers and the collaborative tools in the cloud.

C2NET will be designed to comprehensively cover the entire supply chain considering all stages of manufacturing, distribution and sales to supply a product to market. Different actors in the supply network as plant managers, planners, carriers, shop floor workers, shop assistants or customers are potential users of the services that will be offered by *C2NET*. A distinguishing feature of these services is to have complete visibility and real-time status of the entire supply chain at all times looking for an optimal response to maximize both local and global benefit (see: C2NET).

•Title: ***SWARMs (Smart and Networking Underwater Robots in Cooperation Meshes)***

Programme: H2020-2014-1-ECSEL.

Summary: *SWARMs* is an industry-led project, where large technology companies collaborate with SMEs specialized in the subsea, robotics and communication sectors, and universities together with research institutions ensure that the state-of-the-art innovations in these domains will rapidly make their way into market. This process counts with the perspectives and expectations of two industrial end-users, which are also part of the consortium

SWARMs consortium includes 30 partners from 10 European countries: Spain, Germany, France, Portugal, Norway, Sweden, Netherlands, Romania, Turkey, Italy.

The primary goal of the *SWARMs* project is to expand the use of underwater and surface vehicles (AUVs, ROVs, USVs) to facilitate the conception, planning and execution of maritime and offshore operations and missions. This will reduce the operational costs, increase the safety of tasks and of involved individuals, and expand the offshore sector.

SWARMs project aims to make AUVs, ROVs and USVs further accessible and useful, making autonomous maritime and offshore operations a viable option for new and existent industries.

The general approach is to design and develop an integrated platform for a new generation of autonomous maritime and underwater operations, as a set of software/hardware components, adopted and incorporated into the current generation of maritime and underwater vehicles in order to improve autonomy, robustness, cost-effectiveness, and reliability of offshore operations, namely through vehicles cooperation (see: SWARMs).

2.6.5. IoT awareness in selected businesses of Spain

•Project: ***Project to implement RFID technology in Inditex stores***

Company: Inditex

Description: This technological system allows the unique identification of each garment through radiofrequency waves that are recorded on a chip inside the alarm, which provides a greater agility in the distribution and a greater precision in the management of garments in stores, resulting in an increase in the quality of customer service.

The *RFID* system encodes each garment in logistics centers, which allows when shipments arrive to stores twice a week, it is immediately identified which sizes and models need to be replenished in the exhibitors. In the same way, a better service is provided to the customer, by immediately identifying the availability of specific sizes that customers request, either in the store itself in nearby stores or in the online store, thanks to a technologically advanced process (see: RFID).

•Project: ***Nexo***

Company: Endesa

Description: *Nexo* is an IoT system which allows, thanks to several devices connected to each other, the user to be connected to their home through the mobile phone, tablet or PC.

After nearly a year of pilot testing, with the participation of fifty real users, it has been possible to create a different product than an energy company usually offers. The solution consists of several devices, connected to each other with a hub that acts as the heart of the system and it allows remote control with the phone, tablet or PC equipment and household appliances of the home and to know their consumption.

This concentrator, a thermostat, a consumption meter, an opening sensor and several on plugs, make up this open Endesa kit that each customer can customize depending on their needs.

The hub allows all devices to communicate with each other; the thermostat informs about the temperature in the house which allows to raise or lower it depending on the weather conditions; the consumption meter, as the name implies, informs of the amount of energy that is being consumed in the home in real time allowing in this way to manage consumption expenditure efficiently; the opening sensor is included for those families who want to have the peace of mind of knowing who enters and leaves the house at any time; and finally the plug socket allows to turn on and off the electrical appliances at a distance (see: Nexo).

•Project: ***Halu (Intelligent Led Lamp)***

Company: BQ

Description: Under the appearance of a light bulb with a display, the lamp - named *Halu* - is a small computer. It operates under the Linux operating system, has Wi-Fi connectivity, Qualcomm processor and 64 MB of RAM.

The goal of the company is to build an ecosystem around the product being an open technology so that the developers can create functions that take advantage of it.

The lamp can create different lighting environments from the smartphone, the tablet or the PC through an application. It can also be programmed to go on gradually and wake us up in the morning. *Halu*, moreover, not only connects to the internet, but amplifies the Wi-Fi network, providing the internet to other devices (see: Halu).

•Project: ***Smart City Santander***

Organization: Ayuntamiento de Santander

Description: Santander is moving towards a new city model in which innovation is one of its main axes of development, as set out in the Strategic Plan 2020. At present it is the only city in the world where a Project of these characteristics that will make possible a coordinated and integral management of the city. To this end, thanks to the economic backing of the European Commission, the work of institutions such as the University and the Government of Cantabria, and the collaboration of many technology-based companies, Santander is putting in place a platform to integrate all the services of the city. The ultimate objective is to achieve greater coordination between these services, increasing their efficiency and sustainability, that is, to become a true smart city (see: Smart City Santander).

<u>In order to develop this model, Santander is developing three aspects:</u>

1. Cloud City Center (the brain)
The platform must have a brain, which not only controls all public services in the city, but also links them to one another to manage and manage that information in a coordinated way. This brain that in Santander will be created thanks to the collaboration with the company NEC, has not yet been developed in any city in the world.

2. Platform (the spine)
The backbone of the model will be the platform of sensors and communication systems that is already deployed and will continue to be deployed in the future by the city.

The foundations of the platform are made up of two major European projects under development:

• *SmartSantander*: the work being done through this project (surface parking, intelligent irrigation systems, augmented reality, environmental information, lighting control ...) will serve as a basis for the creation of the platform;

• *Outsmart*: the information that will be collected through this project will also be incorporated into the platform, in which Santander will focus on public lighting.

3. Technological projects: intensive work is under way in advanced technological systems that improve the efficiency of the administration and offer new services to the citizens. The implementation of applications such as *SmartsantanderRA*, which offers tourist information, cultural, commercial, public transport, beaches, monuments and places of interest, etc. The introduction of new payment modalities such as payment by mobile phone (NFC system).

Project: ***Smart Viticulture***

Organization: Vineyards Rias Baixas

Description: With this project, leaf precipitation, atmospheric pressure, soil temperature and humidity are measured. Data collection creates statistics that help to understand the evolution of pathogens and pests in the vineyard, as well as being able to monitor wine production.

Through devices developed by the Spanish company *Libelium*, sensors are measured and recorded temperature, humidity and humidity of the sheet, and with a GPS that has integrated you get the location and time. The collected data are sent to other devices called *Meshlium* in charge of transmitting the data through a 3G network until the central monitoring of the line.

The project includes an application for the end user. The system can be controlled through the Internet, as well as to visualize statistical predictions and to correlate climatic conditions with the appearance of diseases of the vineyard.

First results of the implementation: 40% of the winemakers (400/1000) implemented it during the first year, obtaining a greater and better production (increase of 15%), cost reduction, improvements in the management of the winery and attention to Cooperatives. Also, it was possible to be more respectful with the environment with a 20% reduction in the use of fertilizers (see: Smart Viticulture).

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