14 The Internet of Things. Impact on Society and Education

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14.1 Abstract

The Internet of Things (IoT) is experiencing explosive growth, and will impact almost every industry. I.n 2020, the worldwide IoT market is expected to be worth $3 trillion (Gartner Research). That amount is larger than any individual European country's Gross Domestic Product (other than Germany). However, enterprises (especially SME's and start-ups) must start taking proactive steps to address the changes brought by IoT. If European SME's/Start - ups don't soon take the necessary steps, they'll risk getting l eft behind and putting their businesses at a competitive disadvantage.
The paper is based on the work done inside the Multimedia Research Centre of the Politehnica University of Timisoara as part of the IoT Rapid-Proto Labs, a European transnational project, co-funded by the European Union Erasmus+ Knowledge Alliance Programme, that brings higher education institutions and businesses together to accelerate Internet of Things (IoT) product development.

Keywords: IoT, sensors, connectivity, people & processes, IoT ProtoLabs project

14.2 Introduction

Imagine yourself waking up in the morning fully recovered and relaxed. Due to the new smart alarm clock, your sleep cycles are monitored and the obtained data is analyzed by intelligent applications. Your goal of waking up earlier without feeling any anxiety or tiredness, can be achieved by the features of the new device.

Figure 1. *Sleeping monitoring devices (http://www.getkello.com/# [1])*

While in the kitchen, a blinking light is reminding you to take your daily vitamins. You can even postpone the action for a certain amount of minutes. If you forget to take them, the medicine bottle cap will go online and will send a notification to your doctor.

Figure 2. *Smart medication (www.vitality.net/glowcaps.html [2])*

While leaving the house, your intelligent umbrella is lit up meaning that it has checked the local weather reports and predicts showers during the day. You pick it up because you already know that in the past these devices has been of tremendous help.

Figure 3. *Smart umbrella*

While driving your car towards the workplace or even taking public transportation vehicle, your mobile phone will show you which is the best route to take in order to avoid traffic jams, but also the most polluted areas. This is all possible based on low-cost monitoring systems using the Vehicular Sensor Networks. Such systems collect, process and distribute data from sensors which are located on vehicles belonging to the public transportation bus fleet to a certain central server. The data can be collected from a set of pollution sensors, while the communication between the nodes and the central server can be achieved by means of cellular networks or radio links. Due to the mobility of the fleet, with fewer sensors, the entire area of a city can be monitored. Giving the fact that the same buses move on the same routes during the day, a pollution variation, but also coverage problems can be determined. The sensors will measure the concentration of different types of gases like ozone, carbon dioxide, carbon monoxide, but also volatile organic compounds.

Figure 4 presents the architecture of a typical Vehicular Sensor Network for air quality monitoring. It can be noted that such a system is formed by vehicular sensor nodes (in our case the public buses each equipped with a microcontroller, pollution sensors and communication devices), access points (receives data from each vehicular node and sends it to the central server) and central server (stores the received data from the access point, processes the data and sends back a certain result).

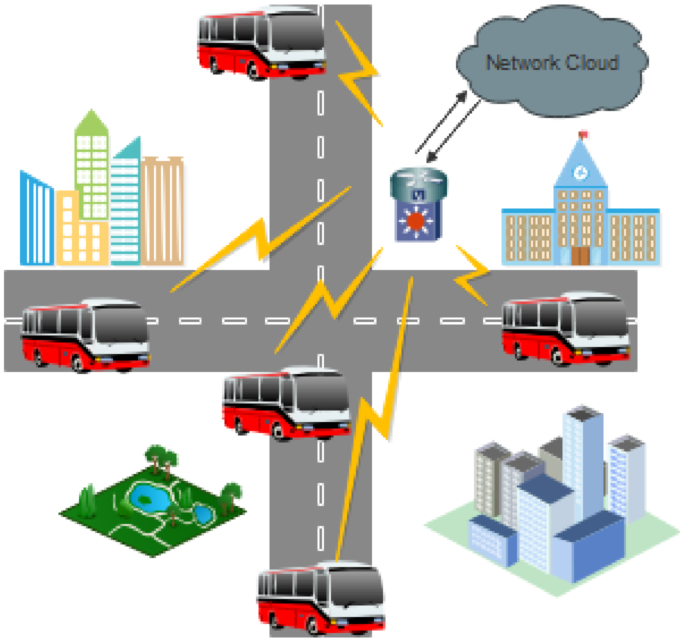

Figure 4. *Architecture of a Vehicular Sensor Network*

Your mobile phone is also constantly measuring your driving style and based on the collected data, information on how to optimize your fuel consumption are provided. You can study profiles of other drivers based on the data that are stored and processed on the internet.
During the lunch break, a heart monitor located in your wrist band and a pedometer in the training shoes track your run and offer results and statistics. These are displayed on the wrist band display in the form of distance, time and burnt calories. The wrist band comes with an on-line tracking site which integrates with your supermarket shopping account so that you may know how many calories you can still eat during the day.

Figure 5. *Smart monitoring*

14.3 Components of an IoT system

So far we have seen a spectrum of examples of Internet of Things; but which is the common thread present to all these applications? And why such a name? Well, analyzing the Internet of Things name and all these products, we can see that all these cases used the internet to send and receive different information. More than that, the particular gadget involved in each application was not a desktop PC, a laptop or even a mobile phone, but an object; it was a thing! Such a thing is designed for a certain purpose, being present physically in the real world,

in our homes, in the car or even worn on the body. Such an object can receive different inputs from the real world, our daily world, and then transform that into data which will be sent to the internet in order to be processed. Getting information into the object (let's call it a device) and also finding out different parameters from the surrounding can be done with sensors. The wrist band can monitor your heart beat based on a specialized sensor or the level pollution is measured by an entire spectrum of pollution sensors, ranging from ozone to particle matter.
The device can also produce different outputs to the exterior world with some special equipment called actuators. The outputs can be triggered based on the results obtained after processing on the internet the data that was collected from the sensors. So your wrist band might vibrate to tell you that you have reached the target of your daily calories or a pollution monitor system might trigger an alarm when the air reaches a certain level of pollution.
There are several definitions used for Internet of Things, also called The Internet of Objects.
Wikipedia says: *"The Internet of Things refers to a wireless network between objects, usually the network will be wireless and self-configuring, such as household appliances."* This is still a very limited definition, based on a specific application that stayed at the beginning of IoT development.
In 2008, the research community stated that *"The term "Internet of Things" has come to describe a number of technologies and research disciplines that enable the Internet to reach out into the real world of physical objects."*
Finally, at this moment it is stated that for 2020: *"Things having identities and virtual personalities operating in smart spaces using intelligent interfaces to connect and communicate within social, environmental, and user contexts"* [3].
So, the Internet of Things (also called "The Internet of Everything" by Cisco) is a network of connected devices (some physical objects) which communicate over the Internet (Figure 6).

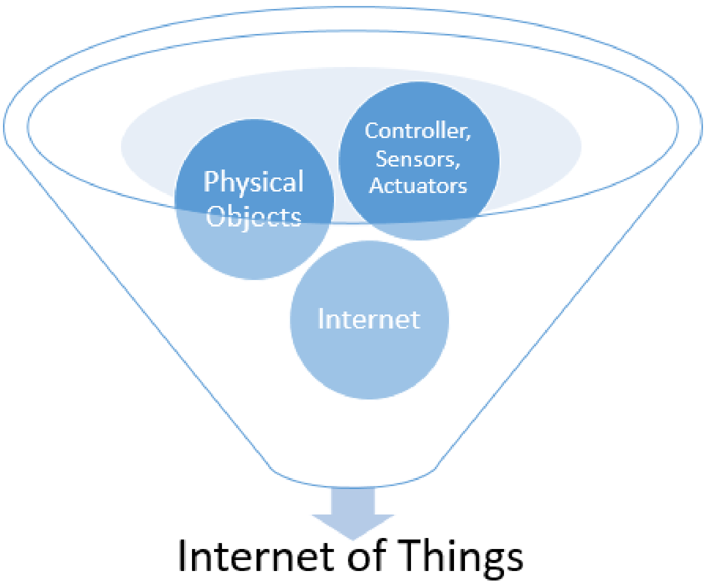

Figure 6. *Internet of Things components*

Based on some sensors, such objects gather data from our surrounding, the data is being processed in a controlled way and the results of such processing can be observed in the exterior world by means of different actuators.

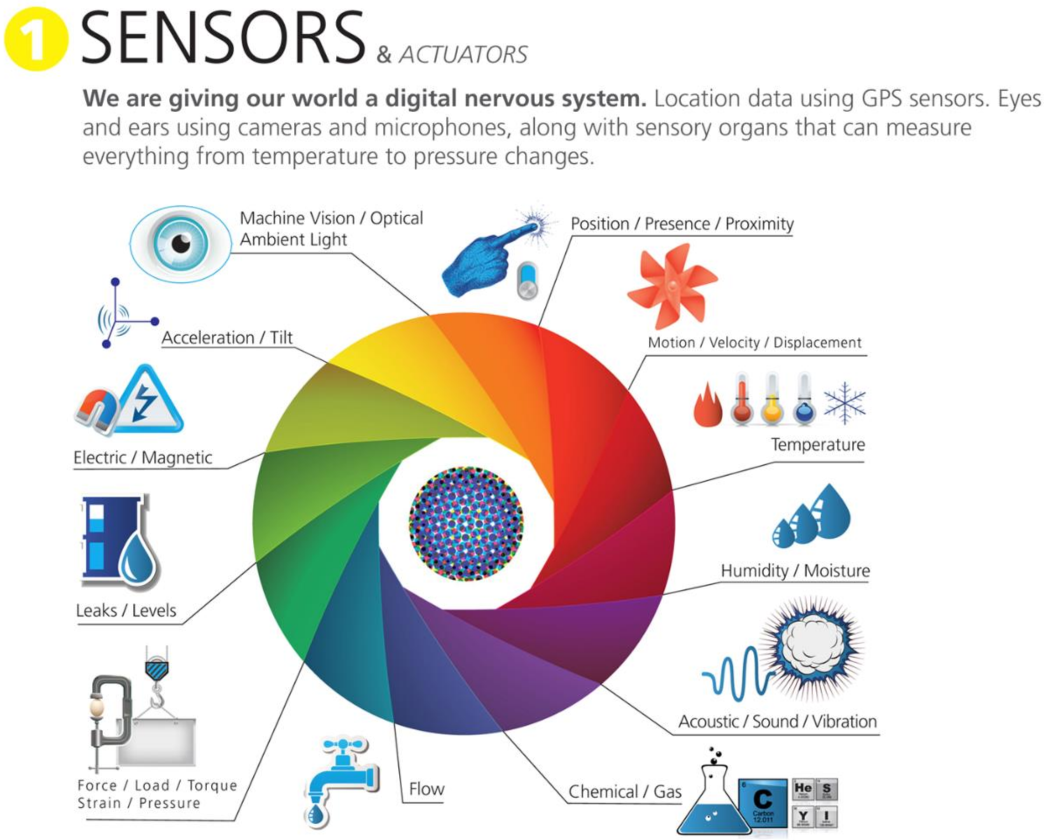

Figure 7. *Examples of sensors and actuators for IoT*

Sensors are input components that measure physical variables and convert them to electrical signals. Sensing refers to the acquisition of heterogeneous streams of data from a set of sensors integrated within the networked things. Multiple kinds of sensing elements are embedded in everyday objects, in wearable devices or positioned in the environment so they can adequately measure the physical phenomena of interest. Common sensors include: environmental sensors (temperature, humidity, light, air quality), motion sensing (accelerometers, gyroscopes, vibrations, pressure), biometric (heart rate, respiration, ECG/EMG/EEG, GSR), audio and imaging.

While sensors convert a physical variable like temperature to an electrical signal, output devices are the inverse: they convert an electrical signal to a physical outcome. Output devices include LEDs, speakers and screens, and actuators like motors or solenoids that move or control things in the physical world. Actuators are commonly deployed within industrial IoT applications; for example, pneumatic linear actuators are widely adopted in manufacturing to move and grip products during the assembly process.

Communication is central to the Internet of Things. Networking technologies enable IoT devices to communicate with other devices as well as with applications and services that are running in the cloud. The internet relies on standardized protocols to ensure that communication between heterogeneous devices can occur securely and reliably. Standard protocols specify the rules and formats that devices use for establishing and managing networks, as well as for transmission of data across those networks.

Networks are often described as being built up from a stack of technologies, with technologies at the bottom of the stack, such as Bluetooth LE, relating to physically connecting devices, while technologies further up the stack, such as IPv6, relating to logical device addressing and routing of network traffic. Technologies at the top of the stack are used by the applications that are running on top of those layers, for example, message queuing technologies.

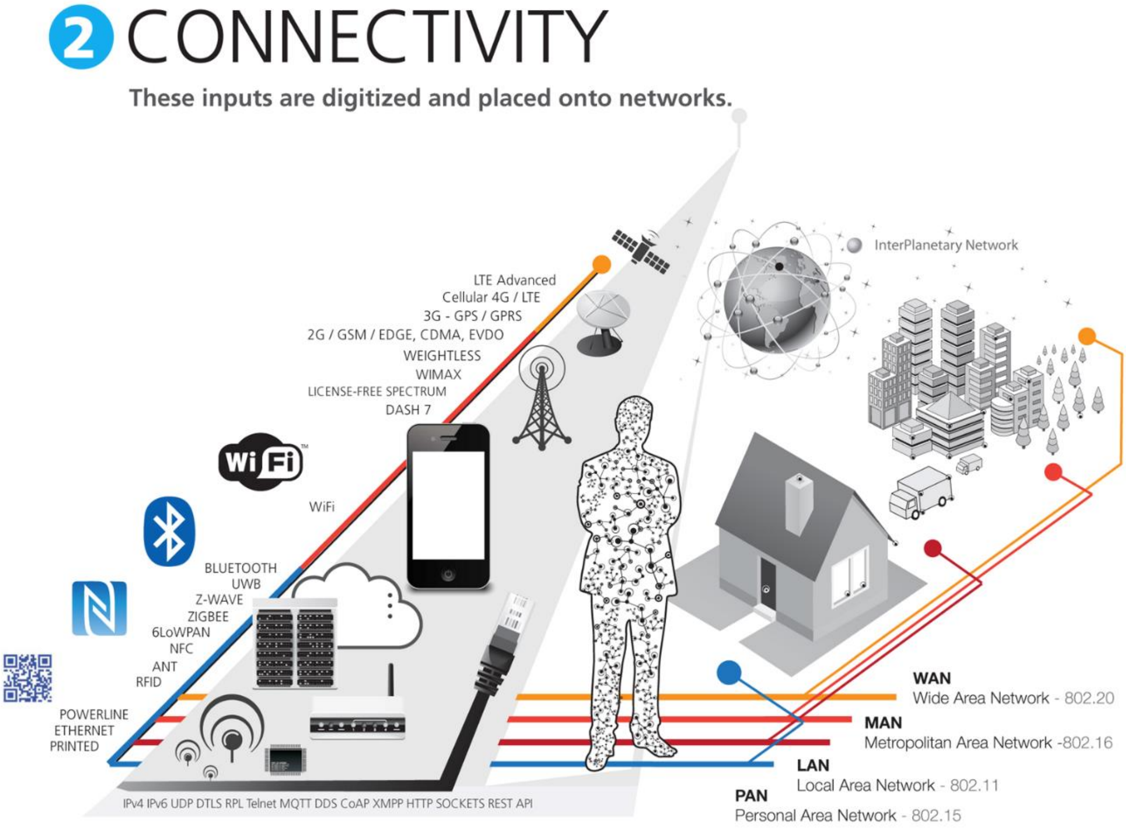

Figure 8. *IoT connectivity*

As seen in our previous examples, an Internet of Things device gives the possibility to control a certain object through the internet. It has a certain controller part which is used to read some data coming from sensors, send the data for storing, processing, analyzing to the internet, and based on the results, control some actuators, some other devices. The controller is directly interfacing with the real world through these sensors and actuators, but also exchanging data with servers connected by the internet.

In order to build such an embedded system IoT device, the controller can be any type of processing board like Arduino, Raspberry Pi, DragonBoard™ 410c and so on. The vision of Even Upton, the cofounder of Raspberry Pi, was to offer a very cheap education computer which can run an operating system (like Raspbian), talk to the Internet and even drive a monitor. During the years, different versions of Raspberry Pi appeared on the market, as it can be seen in this table, which have different levels of equipping.

The development of IoT applications become easier and easier due to the increasing number of devices and software libraries that are helping developers with coding the devices. IoT already become a mass application, used by more and more people to control and monitor different processes, as suggested in Figure 9.

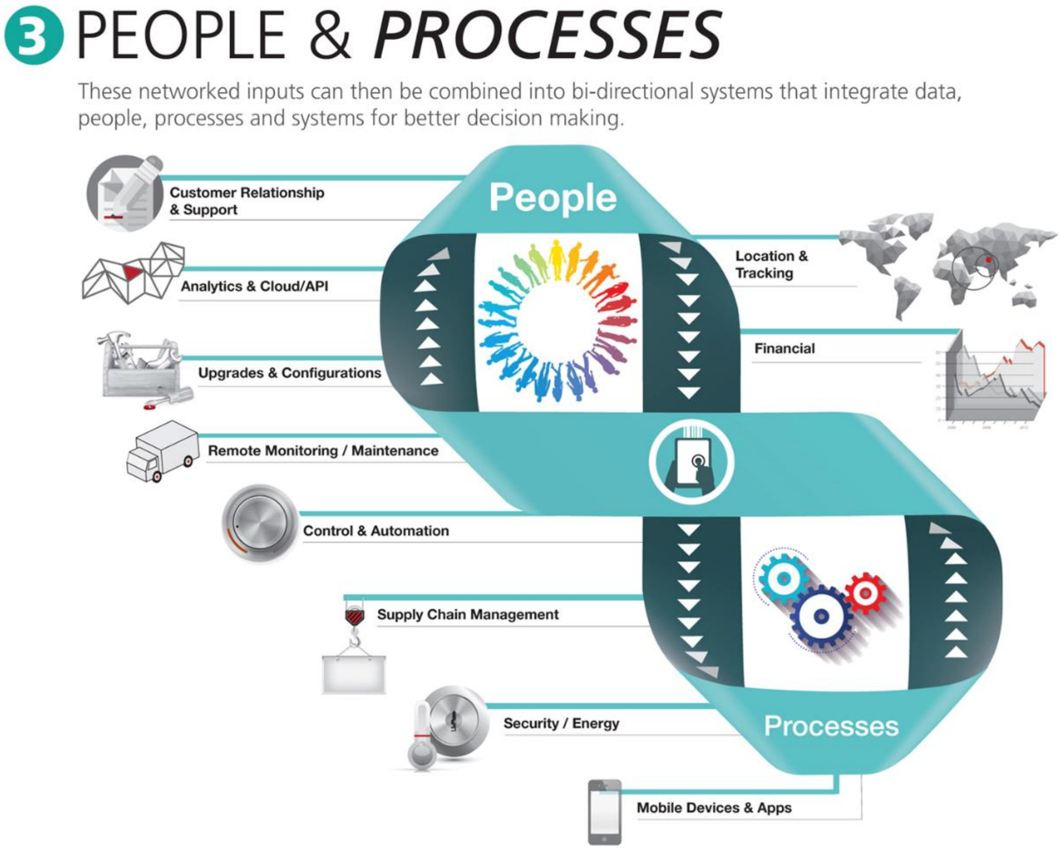

Figure 9. *IoT processes*

14.4 Future and impact of IoT

The evolution of IoT is tremendous. Until the years 2010s we used the term Internet of People, while after that the number of connected devices increased so much that we switch to the term Internet of Things (see Figure 10).

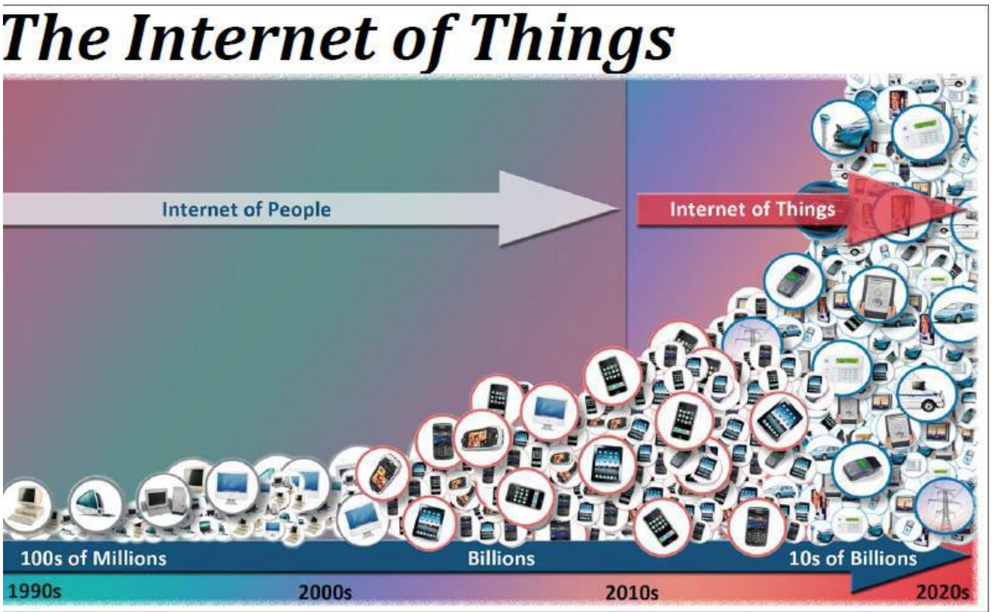

Figure 10. *From Internet of People to Internet of Things*

The number of application, devices and data collected increased so much that it is difficult at this moment to image any domain of life that is not affected by the revolution in IoT. Figure 11 illustrates the spread of IoT. We practically switched from *connectivity* to **everyone**, in **any place** and **any moment**, to *connectivity* to **everything**.

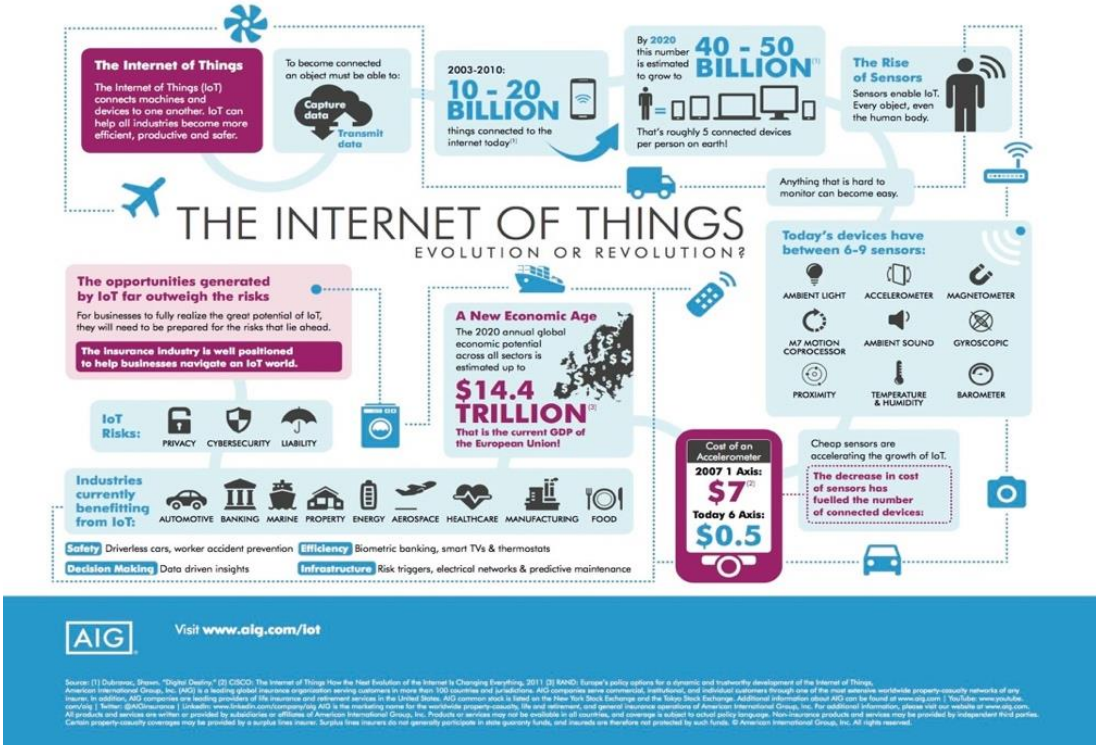

Figure 11. *Evolution of IoT*

The revolutionary development of IoT also comes with an increase of concerns regarding our future as humanity. This concerns are mainly having to do with the way data is collected, stored and used, and mainly by whom. It is recognized that information means power: economic, political, social, etc [4]. The way we are using the power of information can not only revolutionary change our life by making it easier, but can also affect our freedom and rights to privacy.

Peter-Paul Verbeek, a professor of philosophy of technology from Netherlands, writes that technology already influences our moral decision making, which in turns **affects human agency, privacy and autonomy**. He cautions against viewing technology merely as a human tool and advocates instead to consider it as an active agent.

Justin Brookman, of the Center for Democracy and Technology, expressed concern regarding the impact of IoT on consumer privacy, saying that "There are some people in the commercial space who say, ‘Oh, big data — well, let’s collect everything, keep it around forever, we’ll pay for somebody to **think about security later.**’ The question is whether we want to have some sort of policy framework in place to limit that.

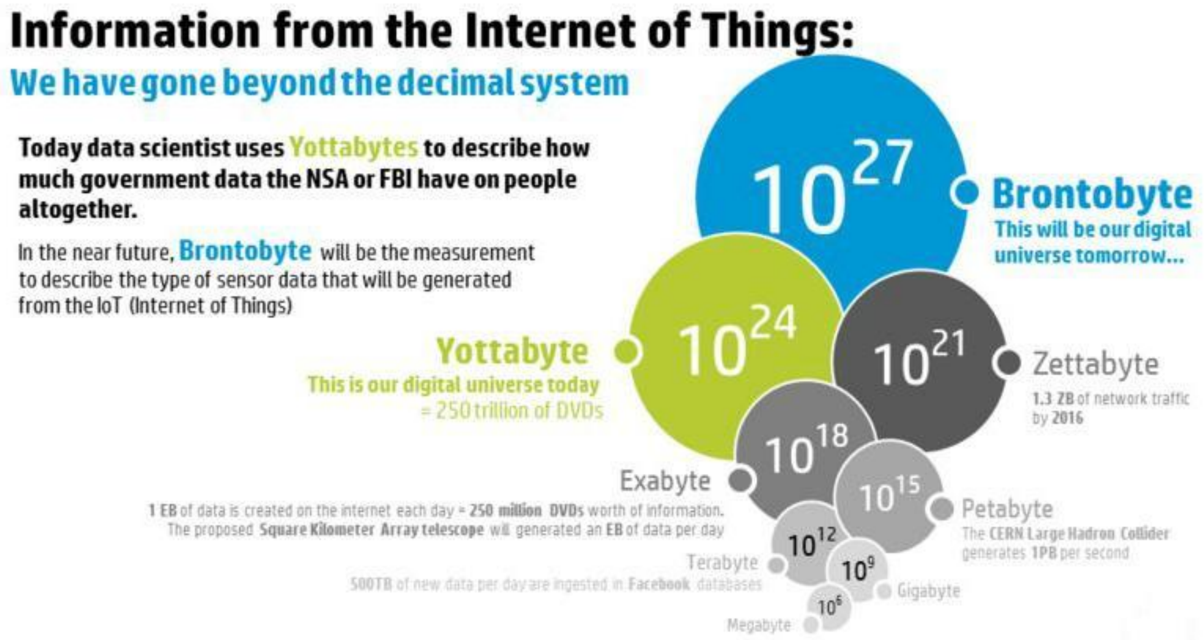

Figure 12. *New unit measures for collected data*

Just in order to have an idea about the quantity of data that is collected, we should say that new unit measures have been introduced, such as *Yottabytes* and *Brontobytes*. See Figure 12 for details.

14.5 IoT ProtoLabs Project

IoT Rapid-ProtoLabs is a European transnational project, co-funded by the European Union Erasmus+ Knowledge Alliance Programme, bringing higher education institutions and businesses together to accelerate Internet of Things (IoT) product development. The partners in the project are: Haaga-Helia University of Applied Sciences, Finland (project coordinator), University of Leiden, the Netherlands, Politehnica University of Timisoara, Romania, Technical University Delft, the Netherlands, Bruno Kessler Foundation, Italy, 247GRAD, Germany and Houston inc. Consulting, Finland. The project implementation timing is for three years, until 31st December 2020.

The project will create and implement a multidisciplinary (ICT, Design and Electronical Engineering) course curriculum which is focused on real problem-based activities (innovative IoT product development for SME's/Start-ups). Cross-border teams of students, teachers (coaches) and practitioners will jointly develop solutions to challenging IoT applications (Internet-connected objects), add value for enterprises and strengthen the employability, creativity and career prospects of students. IoT Rapid-Proto Labs represents an innovative, multidisciplinary, and low-risk enabler of SME/Start-up IoT innovation.

Distributed teams of multidisciplinary students (from three European countries – Finland, Netherlands and Romania) will be supported by a Project Arena (web-platform) which enables them to effectively collaborate on rapid-prototyping of IoT products/services. The Project Arena also stimulates the flow of knowledge and innovation between Higher Education, enterprises and other stakeholders. Each IoT Proto-Lab student-centred team will rapidly set-up, trial and test an innovative IoT solution for their SME/Start-up client (18 clients in the complete project cycle). Throughout the discovery, design, develop and test process, student teams are continually supported by teachers, external coaches (Research Centre and ICT Process Development House) and client staff. The fields of study embedded in the project curriculum (e-Competences, design thinking, lean/agile processes etc.) are highly relevant for every business today.

This project contributes to the modernisation of Europe's Higher Education system (relevance/quality) and reinforces the European Knowledge Triangle (more effective links between education, research, and enterprise innovation).

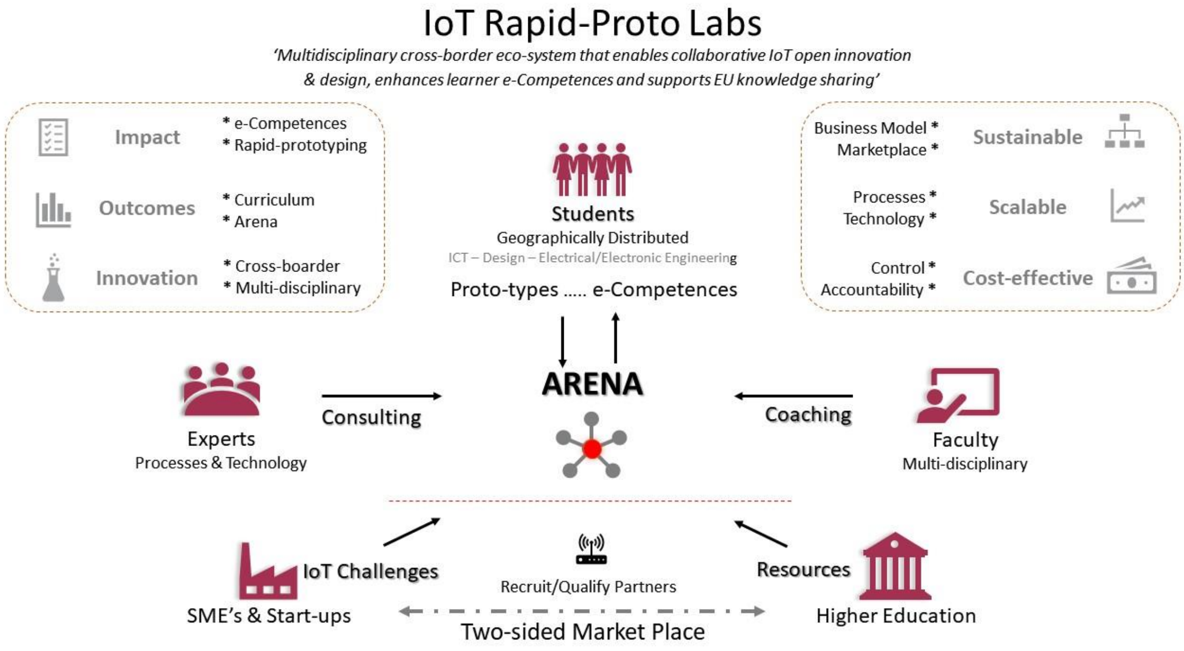

Figure 13. *IoT ProtoLabs project structure*

The main target groups of the project are VET students, girls in secondary school, professors and teachers, VET sector, employees. The expected significant public results are: IoT Rapid-Proto Labs Web-Arena (scalable) for project management (tools), marketplace activities (projects), and dissemination of knowledge.
More information can be found on the project's web site: www.iotprotolabs.eu.

14.6 Conclusions

Internet of Things is a very important topic those days and has a tremendous influence on our day to day life. More and more "objects" are connected and can directly communicate through the Internet, thus helping to make our life easier and safer, making economy and commerce more effective, allowing new ways of enjoying our free time, etc.
On the other hand, the immense number of data that are collected and stored by the developed applications are increasingly raising the potential of intrusion into our private life and private data, so the impact on our social life is higher and higher. All those concerns are addressed both by scientist and philosophers, but are not yet fully addressed by the educational system. At the moment, the need of changes in the educational paradigm is just perceived and more still has to be done in order to find the correct technical developments and technologies that might help in balancing the need of privacy and security while offering at large scale different open applications for the benefit of large communities.

14.7 References

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