THE IMPACT OF INTERNET-OF-THINGS IN HIGHER EDUCATION

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Abstract: *The paper aims to present a new concept in IT&C (Information Technology and Communications, namely Internet-of-Things (IoT). Starting from a short introduction on the basics of this concept, a study is conducted to demonstrate the importance of introducing IoT in higher education. Also, there are identified several practical methods identified for integrating IoT features in academia, especially in the areas of teaching and learning enhancements. Even if important IT&C companies launched and implemented projects in this area, a model for "smart universities" is no well-defined. In our study, we demonstrate that the optimal technical solution for academia are IoT Platforms with real-time, limited-area service provision using Cloud Computing services.*

Keywords: Internet-of-Things, Academia, Smart universities

JEL Classification Codes: **C88, I23, D83.**

1. INTRODUCTION

The Internet and all its associated services and applications have strongly influenced communication, information and marketing across the world via websites, blogs, e-mail and social networks. In this context, the educational environment has also registered major changes, especially since 2000, towards a new orientation of teenagers' education, reflected through online documentation, implementation of projects in virtual teams, online tutorials and much more. In 1999, there emerged a new term in the field, *Internet of Things (IoT)*, coined by the Britain Kevin Ashton, who was working in supply chain optimization, but the phrase was really used 10 years later.

There are several viewpoints regarding the definition of IoT, but we consider the definition from Gartner Inc., the market research company, to be the most accurate and complete:
"The Internet of Things (IoT) is the network of physical objects that contains embedded technology to communicate and sense or interact with their internal states or the external environment." (Gartner, 2017).

In this paper, starting from the definition and IoT components, we will approach its effects in academic field, presenting the advantages and the drawbacks in students' education.
Our work contains four sections and a Conclusions part. In section 2, Literature Review, the background information on IoT is presented and also, its influence on economic, social and educational fields. Also, there is a brief description of four communication models for IoT architecture.

Section 3 - Methodology, specifies the project aim and practical methods for integrating IoT features in higher education, especially in the areas of teaching and learning enhancements.
In Section 4, Discussions and Results, we will analyze and present our points of views regarding the influence of introducing IoT technologies in the academia in the areas of teaching and learning enhancements. Finally, the main concluding remarks close the paper, and suggest ways of improving our future research activity in this domain.

2. LITERATURE REVIEW

Gartner added *Internet of Things* to the 2011 Hype Cycle for emerging technologies, in the *Technology Trigger* stage (Gartner' s 2011 Hype Cycle Special Report).
In 2014, the IoT led up to the "*Peak of Inflated Expectations"* (Figure 1), showing the expectations and the importance of this technology (Gartner's 2014 Hype Cycle for Emerging Technologies).

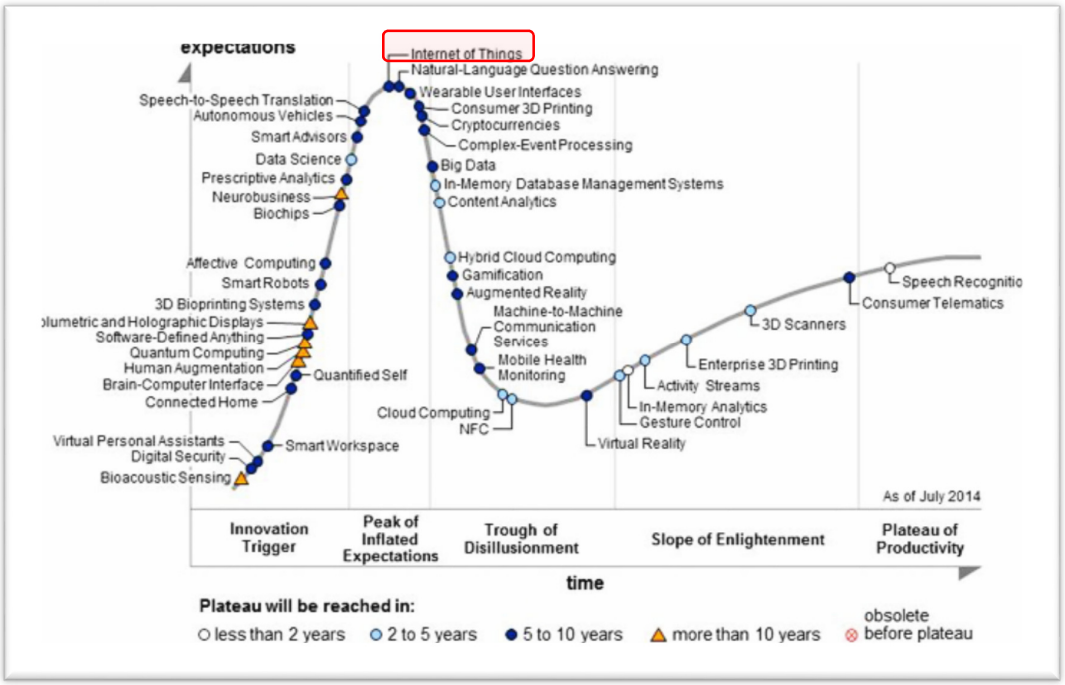

Figure 1. Gartner Hype Cycle for Emerging Technologies, 2014

(Source: Gartner's 2014 Hype Cycle for Emerging Technologies, http://www.gartner.com/newsroom/id/2819918)

The advances in the fields of sensing technology, in Information technology and Communication (IT&C) lead to a "world of interconnected devices", referred as the Internet of Things (Zicari, 2015).

This new technology has a major influence on the economic and social fields, and also on education, healthcare systems, energy management, environment monitoring, and smart cities by associating everyday objects with Internet capabilities and Big Data analytics.
IoT is developing in two directions: increasingly smarter physical devices and environments and ubiquitous interconnection. IoT does not imply only positive effects, but also many security and confidentiality issues caused by a huge number of Internet-connected devices that make impossible the surveillance of the whole network.
This overview section is designed to position the theoretical framework of the paper in light of current world research and studies.

Many IoT objects have appeared a long time before the concept itself, but they did not have a global dimension, they were not included in the so-called "hyperconnected world". In this category, we mention: connecting IP-based networks, Cloud Computing and Data Analytics (Rose et al., 2015). Another IoT characteristic refers to the communications models described by the Internet Architecture Board:

- The *Device-to-Device* communication model represents two or more devices that directly connect and communicate between one another, or through an intermediary application server, over many types of networks, including IP networks or the Internet.
- The *Device-to-Cloud* communication model starts from the idea that the devices connect directly to an Internet Cloud service.
- The *Device-to-Gateway* model means that an intermediary between the Internet device and the Cloud Computing services, consisting of a software application operating on a local gateway device and providing several functionalities (such as data and protocol translation) and security.
- The *Back-end-Data-sharing* model presents a communication architecture that enables users to analyse and export data objects from a Cloud service in combination with data from other sources.

This paper focuses on introducing the IoT in higher education, in order to demonstrate the new way of interaction among students and teachers and the movements produced in academic environment.

According to Bagheri (Bagheri & Movahed, 2016), the applications of IoT in education are categorized into four groups: "energy management and real-time ecosystem monitoring, monitoring student's healthcare, classroom access control and improving teaching and learning". Our study will be carried out only on the fourth group, meaning the influence of IoT on teaching and learning.

3. INTERNET OF THINGS - A NEW EDUCATIONAL TOOL FOR STUDENTS

The rigorous academic style of learning systems is necessary to be changed from the knowledge transfer to a collaborative model, in order to achieve a real student-centred learning.

As teachers, we cannot ignore the disruptive influence of technology in today's educational institutions and would like to be more flexible and open in our communication with students.

The influence of new Internet technologies is felt in many aspects of education, such as personalized content, course presentations, learning activities, sharing knowledge and ideas (Bagheri & Movahed, 2016).

Johnson et al. identifies seven categories of technologies that drive innovation in education: Consumer Technologies, Digital Strategies**,** Enabling Technologies, Internet Technologies, Learning Technologies, Social Media and Visualisation Technologies (Johnson et al., 2015).
The *Internet Technologies* category includes, in turn, several classes, the most significant for education being, in our opinion, Internet-of-Things, that offers the following ways to improve learning and teaching:

- the access of students to the learning materials from any computer or other device connected to the Internet (Xie et al., 2001);
- the use of intelligent devices (equipped with hardware and software applications) in so-called smart classrooms (Xie et al., 2001);
- the collection and analysis of an important volume of data from sensors and wearable devices more easily and monitoring students' capabilities and achievement (Xie et al., 2001);
- the development of *educational social software* within a context of IoT, referring to the *Social Networking Services* (SNS), *Wikis*, *Weblogs* as support for collaborative activities.

4. METHODOLOGY

In this paper, we aim to find some answers to the legitimate question about the influence of IoT in higher education. Also, we intend to exemplify our opinion through some of the best practices already used in universities.

For this purpose, an overview of Gartner's Top 10 IoT technologies for 2017 and 2018 is needed, because of their major impact on organizations and institutions.

In the following, we mention several significant technologies from Gartner's list, interesting for educational environment: (Gartner, 2016):

a) *IoT Security* – is required "to protect IoT devices and platforms from both information attacks and physical tampering, to encrypt their communications"; the researchers of the company warn that it will be complicated to use sophisticated security approaches considering that many existing IoT objects become obsolete and don't support these changes;
b) *IoT Analytics* – this technology allows to process the huge amount of information collected by IoT objects and stored in Big Data; IoT needs new and specific analytic approaches.
c) *IoT Device (Thing) Management* – refers to the tools capable of high-management of "things", including device monitoring, software updates and security management.
d) *IoT Processors* - even in the multitude and variety of devices supported by IoT, there will be requirements concerning the technical characteristics of processors and architectures, such as their capabilities of security and encryption, low-power consumption, adapting to a certain range of operating systems;
e) *IoT Operating Systems* – refer to a wide range of IoT-specific operating systems, corresponding to IoT Processors and IoT security; the Gartner document specifies that traditional operating systems, such as Windows and iOS were not designed for IoT applications because "they consume too much power, need fast processors, and in some cases, lack features such as guaranteed real-time response".
f) *IoT Platforms* – is a concept integrating IoT infrastructure components and services into a single product, having a well-defined purpose; such a platform is able to offer three categories of services: a) at the first level: device control and monitoring and communications; b) second level: data acquisition, transformation and data management; and third level: c) development of IoT applications, including event-based logic, analysis and adapters for connecting to enterprise systems.

Things are "smart objects", meaning they are capable to collect data from the environment and communicate with the entire system. At the first level there are sensors, microprocessors and communication equipment followed by the level containing the operating system (OS) for these objects.

An important number of IT companies already have accomplishments in implementing the above-mentioned solutions. For example, Microsoft has released a special, free version of the Windows 10 IoT Core operating system, for smaller devices, that run on ARM and x86/x64 processor architectures (https://developer.microsoft.com/en-us/windows/iot)

Windows 10 IoT Core can be run in two ways: the headless mode (without a video display, requiring 256 MB RAM and 2 GB for storage) and headed mode (with a video display, requiring 512 MB RAM and 2 GB for storage).

The device integration into IoT platform is done by using the IP address, which is unique for each device. IoT also includes special devices for wider operations such as routing, switches, data processing and more.

Another open source operating system for IoT is *Contiki*, released under BSD license, which introduces a quick way to connect objects to the Internet. It can be run on low-memory, low-power

devices and low-communication bandwidth, but it is considered a powerful tool for building complex wireless systems (http://www.contiki-os.org/)

The next level intends to collect and process large volumes of data, analyze them with special applications in order to obtain new information, templates, forecasts. The top level provides an integrated secured environment of all these components, hardware and software, into IoT platforms.

For academia, we consider the optimal technical solution to be IoT Platforms with real-time, limited-area service provision using Cloud Computing services.

An overview of IoT architecture for academia is presented in Figure 2.

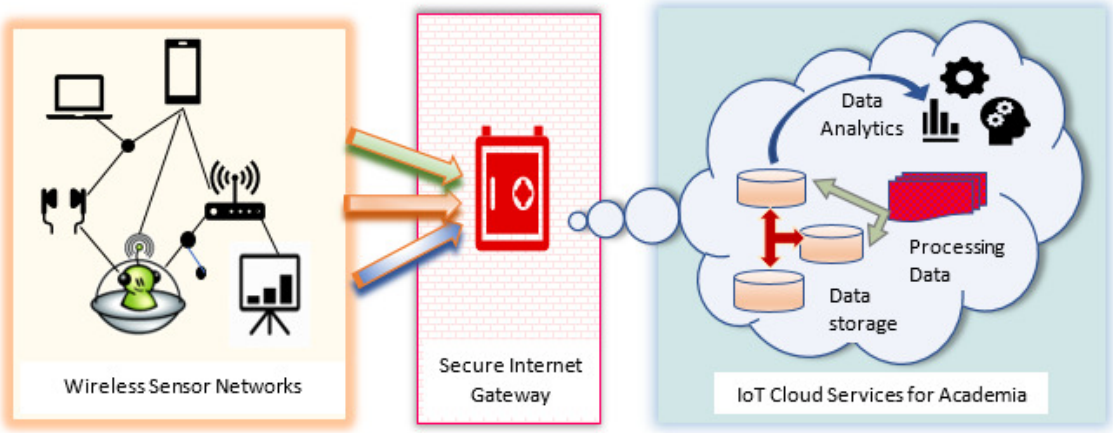

Figure 2. A model of IoT for Academia

In this open architecture for a Smart University, there are three directions for developing: IoT – representing the major concept operating with "things", Cloud Computing as provider of different services (infrastructure, software, security) and Big Data Analytics to process traditional databases and NoSQL Data and uncover hidden patterns, trends, correlations and student preferences.

We consider that a priority in achieving a project Smart University is the system of virtual classrooms, modern in terms of hardware and software, student-centred, and allowing the following facilities (Uskov et al., 2017):

a) Smart Learning;
b) Learning-by-doing (Virtual labs);
c) Adaptive Teaching;
d) Automatic translation Systems (from/to English Language);
e) Collaborative Learning;
f) Gamification in Learning.

In our study based on the recent IoT projects in education, we focused on analysing IoT platforms for classroom access control and improving teaching and learning by using a Cloud Computing-based model.

4. RESULTS AND DISCUSSIONS

Trying to keep a distance between the academic environment and the newest, modern technologies, implies a great loss for education, in communication and collaborative activities, but also in learning.

Students are increasingly moving away from paper documentation toward smartphones, tablets and laptops that offer them the necessary information at their fingertips, and also the possibility to learn at their own pace**.**

This trend provides convenience also for teachers, because the teaching activities become more efficient and student-centred. Professors can focus on the individual attention and care, and they can collaborate, using IoT connected devices, with each of the students, adapting their course and practical activities. (Meola, 2016)

Mobile Devices and Tablets Educational Apps changed the methods of teaching/learning and can be considered as powerful tools to create 3D graphics presentations and textbooks featuring videos. Also, mobile devices allow students the access to eBooks, quizzes, projects and to watch the labs and courses in video format, which are very attractive learning methods for students and new teaching opportunities for teachers (Mishra, 2017).

Even outside classrooms, in well-defined areas, universities can use Wi-fi connected devices to monitor their students and resources, and these capabilities lead to safer campuses.

The researchers from Capterra company demonstrated that "69% of students want to use their mobile devices more frequently in the classroom, and most of those students want to automate their tasks, such as note-taking, schedule checking, and research" (Morpus, 2016).

Another company, Greentech Media, "points out that investment in these smart schools usually pays off within two years" (Meola, 2016).

In recent years, several companies, such as SMART (https://education.smarttech.com/products/smart-learning- suite) and IBM (https://developer.ibm. com/academic/), have demonstrated their interest in introducing IoT into academia, developing "Smart University" projects. Google launched several applications that could be considered "things" supporting instructional objectives. Tools such as Google Apps allow the students and teachers to share the documents online and make changes in real time on a screen.

But there is no standard model with well-defined concepts and principles, and besides, there is a wide variety of smart devices, technologies and applications used in the educational environment that create even more difficulties in standardization.

Many researchers are trying to define a conceptual model for Smart University and identify its main features, components, technologies and systems, reducing the role of traditional teaching/ learning methods in universities (Uskov et al., 2017).

IoT is a generic term that includes a variety of smart devices, applications, services and also, a huge volume of media resources. Obviously, many aspects of IoT are positive for education and will continue to help the learning processes, but we also must to highlight aspects that negatively influence young people's education and their life principles.

Therefore, it is recommended that teachers conduct discussions and online activities with their students, but it is good to signal to them also the drawbacks, such as incorrect and incomplete information and plagiarism aspects.

5. CONCLUSIONS

The new concept of Internet-of-Things has a great potential to remove all barriers to education, such as physical location, geography, language and economic development. The combination of technology and education leads to faster and simpler learning and improves the level of knowledge and, implicitly, the quality of students. But, as any new concept emerged, it still has no widespread functional models and standards and, moreover, universities are not prepared to accept all the changes proposed by IoT in the educational sector.

From the students' point of view, self-governed and problem-solving activities, as well as the approach of a learning style based on video and gamification, and on interactive collaboration with teachers and colleagues, are considered the focal point of a learning process.

On the other hand, educators must get used to modern technologies and methods of communication and apply them in their current work, instead of marginalizing themselves.

In order to have a better impact on the students, the learning experience must be active, social, contextual, engaging and student-centred. To achieve this goal, teachers can encourage:

- The cooperation among students;
- The development of active learning;
- The communication between teacher and student;
- The expression of original ideas and the discussions;
- The possibility of choosing the ways of learning.

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