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Digital Transformation in Higher Education

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Abstract

Generally speaking the contemporary modern innovations in information and communication technologies (ICT) on the one hand foster the development of operation processes and marketing of products and services, and, on the other hand, provide a model of the use of information technology, which reduces the initial investment in IT and moderate the operational cost of ICT. Higher educations are organizations that offer services and are interested in the benefits of contemporary ICT. The new buzzword 'Digital transformation' refers to the business approach implementing the latest ICT technologies (cloud computing, Internet of Things-IoT, big data, blockchain, artificial intelligence-AI and machine learning-ML), adjusting these to the users in terms of their ability to use these novel ICT technologies. The paper includes a proposal of a possible and applicable ICT Ecosystem model for higher education, which can further enhance and accelerate the digital transformation in higher education.

Keywords: digital transformation, cloud computing, internet of things ;

1. Introduction

Since its origin ICT has continuously played a special role in organizations and recently this role has been extended to all spheres of life. ICT has always aimed to ease everyday tasks and to automatize routine, well-defined activities in organizations. With time the completion of these tasks have been performed improved and today ICT is inevitable in gathering and memorizing data, and also in finding, processing and presenting the stored and/or processed data. This continuous data availability and functionality of each process individually and also on an integral level, the high speed of transactions and other processes as well as the short term of investment return (ROI) have all resulted in the fact that today ICT is present in all spheres of life. The appearance of social networks and intelligent devices (Internet of Things –IoT) that can mutually communicate through the internet has led to a fast increase of newly-created data in the unit of time. That process has initiated new techniques for data memorizing and processing (big data, on line analytics), as well as storing data (cloud computing). Due to the fact that recently with the

application of artificial intelligence, knowledge management, statistical analysis and the application of data mining techniques which reveal hidden knowledge, new regularities, undiscovered connections, data patterns present in large data bases or anywhere on the internet, it is possible to obtain any information which qualitatively changes the significance and application of ICT in organizations and contributes to their efficient and successful operation.

This paper provides an analysis of the above-mentioned new technological tendencies and concepts already realized and available for application, from the aspect of their applicability in higher education. The basic cohesive technique for implementing the mentioned advanced technologies is certainly cloud computing, similarly to the role electrical energy played a hundred years ago. This similarity was described by Nicolas Carr, the main editor of Harvard Business Review in 2008: “A hundred years ago, companies stopped producing their own power with steam engines and generators and plugged into the newly built electric grid. The cheap power pumped out by electric utilities not only changed how businesses operated but also brought the modern world into existence. Today a similar revolution is under way. Companies are dismantling their private computer systems and tapping into rich services delivered over the Internet. This time it's computing that's turning into a utility. The shift is already remaking the computer industry, bringing new competitors like Google to the fore and threatening traditional stalwarts like Microsoft and Dell. But the effects will reach much further. Cheap computing will ultimately change society as profoundly as cheap electricity did.” (Carr, 2008).

Social networks function in cloud, and IoT devices deliver the data received from their sensors into big data also placed in a cloud, so the data can continually analyzed (on line) and based on the current results generate reactions to the occurred events. These reactions/functions are realized by actuators in intelligent devices. These innovative technologies provide the possibility to improve the development process of functioning and placement of company goods and services on one hand, and ensure a model of using information technologies that reduce initial investments into IT with modest cost of operation, on the other.

This paper describes a proposed ICT ecosystem composed of the earlier mentioned innovative technologies for supporting, advancing and accelerating the digital transformation in higher education.

2. Digital transformation

The concept of digital transformation is the reengineering of all manufacturing and sales processes, so that they would become more efficient, though this does not lead to the automatic modification of existing new services and products, or automatically creating new ones. Digital

transformation covers a lot more than the simple implementation of new ICT technologies (cloud computing, IoT, big data, blockchain, AI and ML). If the employees and/or users do not support the suggested approaches, then the ICT technologies recommended towards the goal of digitalization might even be counterproductive.

There are numerous definitions for digital transformation which summarize the facts listed above.

“Organizations must begin to look at digital holistically and transform by applying digital thinking across every-thing they do -- how they win, serve, and retain customers; how they operate internal processes; and how they source business services. In short, they must become a digital business” (Forrester) (McLellan, 2018).

“The goal of digital transformation isn’t better social or faster analytics... it’s to remake brands to be more adaptable, better at learning and above all, able to tie together the strands of product, sales marketing and service that make up the customer experience” (Adobe) (McLellan, 2018).

The main drivers of digital transformation are presented in Figure 1. (Altimeter), (McLellan, 2018).

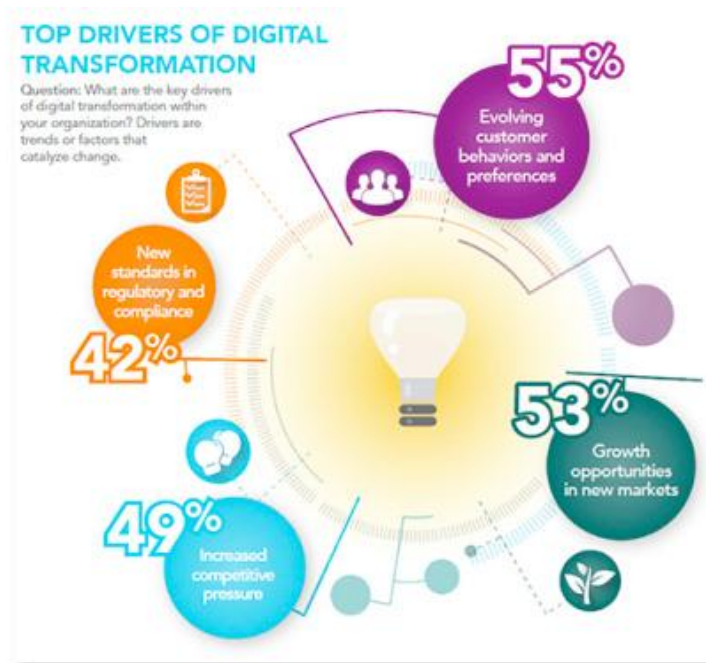


Figure 1. Top Drivers of Digital Transformation

2.1. Cloud Computing

Cloud computing (CC) designates a service of using an ICT resource (hardware, communication, software platforms, DBMS servers and application software) through the internet (public telephone or any other network) based on payable utility services as well as other public services that are paid according to how much the service is used. There is no universally

accepted definition despite the fact that the idea is more than fifty years old (formulated by John McCarthy in 1961). The appearance of cloud computing has been influenced by numerous factors such as the internet, the bandwidth of communication lines (speed of transfer), standardization and virtualization of computer hardware, service orientation of applicative software, the global economic crisis, etc.

Characteristics (advantages) of clouds providers frequently emphasize include:

1. “Multitenancy – a single instance of an application serves multiple consumers (tenants) with the possibility (for the tenants) to customize some details (GUI or business rules) of the software applications“,
2. Identity management and access control – application of advanced techniques in identity checks and access control in order to provide legitimate data use,
3. Security of services – implementation of the most stringent cutting-edge security measures for service provision” (Petkovics et al., 2014),
4. On-demand self-service with high flexibility and scalability (rapid elasticity),
5. Access to services from optional geographical locations (if internet connection is provided) at all times (ubiquitous network access),
6. Division of resources for services in server farms at different geographical locations (location-independent resource pooling),
7. Pay-per-use or pay-as-you-grow and
8. Low costs of use and reliability.

Apart from emphasizing the advantages of cloud computing providers of this service regularly point out the following savings when cloud is used:

1. there is no initial investment into hardware, communication network and premises for equipment,
2. there are no costs for software: purchase, licensing and update,
3. energy costs (and costs of cooling) can be saved and
4. there are no costs payable to experts/information experts (salaries and costs of further training).

Fears and drawbacks with regard to the application and use of cloud computing has been expressed even by renowned and famous experts including:

1. services with the same name have different content and conditions of delivery at various providers,
2. problem of service transferability between suppliers (danger that the user of cloud computing might become dependent of the provider),

3. limited number of services, poor offer of software solutions in cloud, lack and rigidity (offering unfavorable conditions for the user – user unfriendly) of existing contracts on providing services (SLA Service Level Agreement),
4. immature technology and its market,
5. availability of services and bottlenecks in transfer (power cuts and halting the use of the internet, problems occurring at the provider obstructing the service, limited ranges in transfer/communication and
6. the likelihood of troubles halting the service is great (the type of service is very complex).

2.1.1. Services, models and ecosystem

”The National Institute of Standards (NIST) differentiates three today well-known services (service model) with classic contents (from the standpoint of the user) for which all the previously cited essential characteristics:

1. Software as a Service (SaaS). Software rent (software on demand) via the Internet for using on thin client (web browser) on all computers and mobile devices,
2. Platform as a Service (PaaS). The rent of computation platform (platform on demand) with necessary software of special use (developmental environments, i.e. program languages, different libraries of programs for development purposes, tools and services) for applications development and
3. Infrastructures as a Service (IaaS). It is the rent of basic computer equipment in the form of virtual machines and networks.” (Petkovic, et al., 2013).

From the aspect of publicity of usage there are four models, the Community cloud is rarely used, so in practice only three models are used. The deployment models are (Petkovics et al., 2014):

1. Private cloud: The cloud services are dedicated for exclusive use to a single organization with a large number of end users. That model is physically often realized at the user itself,
2. Community cloud: This deployment model provides cloud services for a specific group of persons or organizations with common interest (hospitals, universities, etc.),
3. Public cloud: The public cloud provides offer to any consumer for open use over the public Internet and
4. Hybrid cloud: Represents a combination of two or three earlier described deployment models (private, community or public).

CC is an extremely complex service: one provider can provide only one type of service (IaaS, PaaS or SaaS), but also any combination of these services only in one form (public, private,

community or hybrid), but also in all possible forms. According to the latest opinion markets, hierarchies and ecosystems are the pillars of modern business thinking (Moore, 2006). In the ecosystem the principal objective is the perfect cooperation in innovation development among partners, which entirely describes the CC service itself. Due to its simplicity in this paper the e3-value methodology (Gordijn, 2002) is used for the illustration of CC ecosystem - the interconnection between the actors (roles). “A value model shows actors who are exchanging things of economic value with each other.” (Gordijn, Akkermans, 2003). The actor (in Figure 2 represented by a rectangle) is a legal or physical person, characterized by the name or role in the CC ecosystem. Composite actors (actor-partnerships) include two or more elementary actors, where actors mutually supply or demand products and/or services (but elementary actors of composite actors can appear alone with their own supply and demand). Actors exchange (presented by arrow) value objects (service, product, advice, money, etc.) through value ports (it is illustrated by a small shaded circle). The name of the value object reflects the essence of exchange, and it is indicated on or near value exchange. The value ports are in the value interfaces in pairs (illustrated by a rounded rectangle on the edge of the rectangle of the actor). Figure 2 shows how the services are created (appeared) and exchanged and how and in how many ways new, subtle, rich services in CC service ecosystem are composed (by adding new values or recombination of the current services) from the simple ones (Petkovic, et al., 2013).

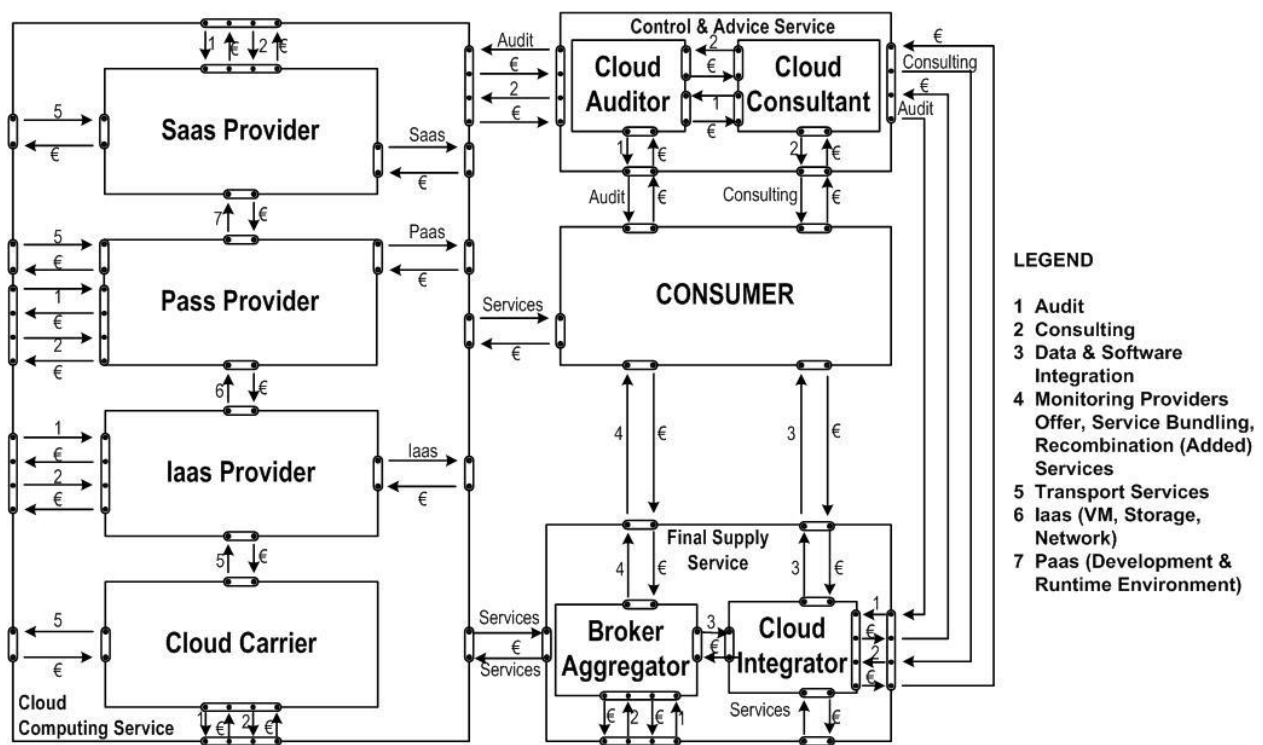


Figure 2. Cloud computing Value Network – Detailed Actor View

2.2. *Internet of Things*

IoT refers to Internet of Things, to fixed or mobile intelligent devices which can communicate and exchange data automatically via the internet without human intervention. Simply stated, IoT (sometimes machine-to-machine communications abbreviated as M2M is used for IoT) is a concept through which devices around us will receive their addresses on the internet and using sensors and actuators become intelligent. That will enable every one of us to control the technology we already use in a new way (Rodić, 2012).

The advantages listed below can serve as a motivation to apply the Internet of Things in organizations (Petkovics et al,2013):

- (a) gathering and storing (memorizing) data monitored by intelligent devices in real time,
- (b) more efficient control of devices connected into a network (and supplied with sensors),
- (c) processing and analyzing data from intelligent sensors located in the data bases or storages (data warehouse) in the computer center of the organization or computer cloud,
- (d) current data and their just in time processing or/and analysis for important reports create a basis for making good business decisions, and the appropriate decisions provide functional efficiency contributing to maintainable development of the organization and
- (e) such a realization of monitoring the operation of devices relevant for the functioning of the organization provides cost-cutting in business.

The motivation of implementing the Internet of Things:

- (a) a follow-up of the functions of organism, parameters of illnesses with the possibility of receiving information about them,
- (b) reducing and control of electric and heat energy consumption and
- (c) follow-up of the transportation of goods, materials (logistics), monitoring production processes, etc.

2.2.1. *Characteristics of Functioning and Models of IoT*

The Internet of Things was discovered by organizations in search for innovations, new business models under the pressure to achieve higher productivity and profit. Higher education worldwide lacks financial means. IoT is a great aid to them because the cheap gathering and sending of data through IoT and their integration into a system of data in higher education institutions enables to improve the current processes and services with significant reduction in operational costs. The intelligent devices represent nodes of the local network, but in some networks it is also necessary to use local servers or gateways in order to perform real-time analysis (autonomously or with the help of a server in a cloud).

There are two models represented for IoT: the service model and the building model. There is a great number of service models with the very different granulation (level of detail) but those models can generally be represented as three-level models similarly to CC with the following (sometime variously termed) level names: network (context-aware tier or physical layer), service (fundamental resource layer or M2M platform) and application (application layer or service platform access) level (Figure 3) (SPAN Systems Corporation, 2014). The building model illustrates mainly the method of the realization of IoT network level (Figure 4) (McLellan, 2013).

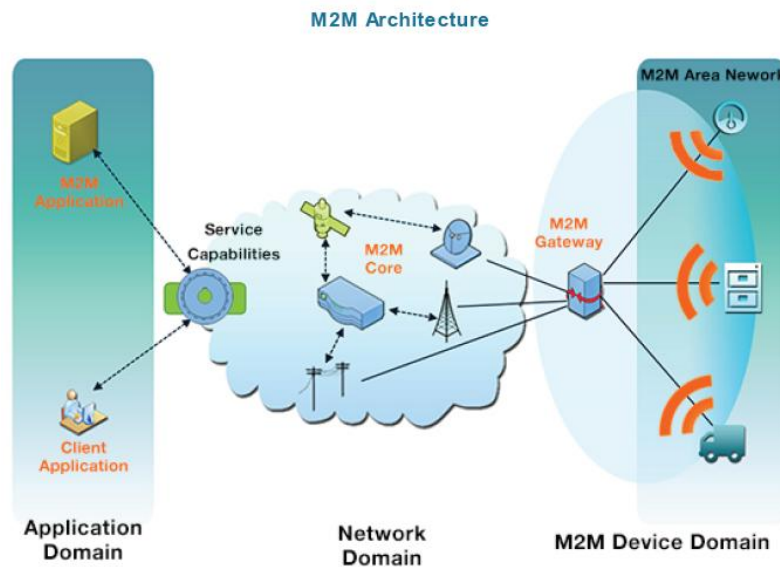


Figure 3. IoT –service model

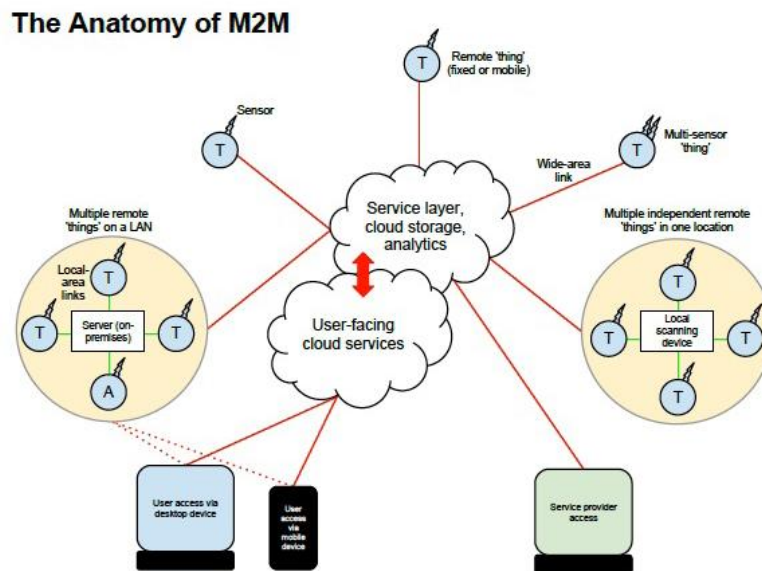


Figure 4. IoT – building model

3. Discussion

CC provides an ICT infrastructure which ensures a suitable quality and capacity for any type of user (physical, SME, big international companies), as well as higher education. The theoretical analyses describing the advantages of the model from the aspect of publicity of usage for higher education institutions generally prefer the application of hybrid clouds, having in mind the wide spectra of activities of the institutions (Petkovics et al., 2014), (McLellan, 2013). In practice the higher education institutions often opt for a private cloud because it functions safely and reliably, but under the condition that they have a loyal, safe and reliable private cloud provider (Petkovics, 2014).

The new procedures and techniques in data processing and communication, as well as the new applications (social networks, big data, on-line analytics, NoSQL data base systems) blend into the CC ecosystems entirely (practically they cannot exist without CC), that is why the CC ecosystem can be accepted for the ICT ecosystem. The appearance of IoT, however, strains the limits of ICT ecosystem because there is a new physical level which seeks its place in the ecosystem. That level is the level of intelligent devices and local networks which links them and connects them to the internet. That is the reason why some experts expand the CC (ICT) ecosystem with an additional level which includes them and is called things and communication networking. In my opinion the ICT (CC) ecosystem does not require the introduction of a new level, only a fine granulation of IaaS, PaaS and SaaS cloud provider (Figure 5).

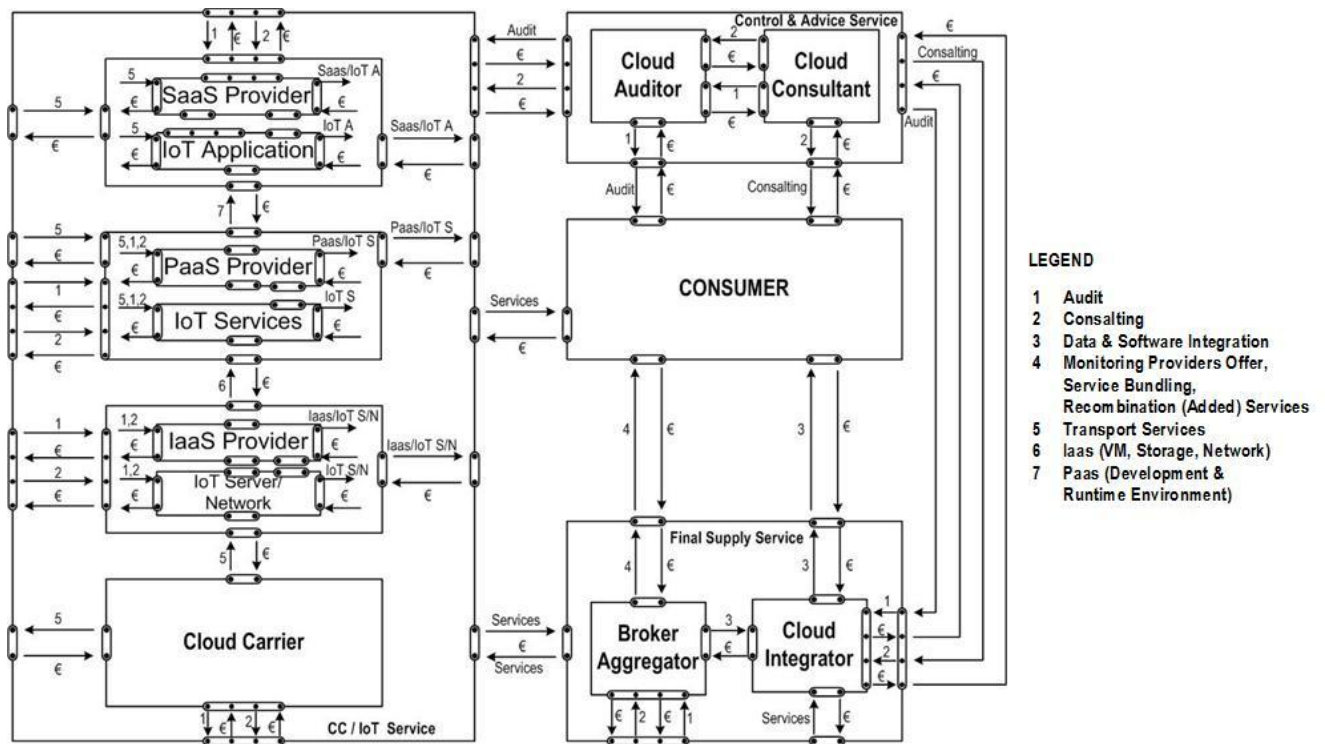


Figure 5. ICT value network – detailed actor view

A detailed description of the implementation of CC as one of the most important technologies in terms of the realization of digital transformation in higher education is given in (Petkovic et al., 2014). Though it must be pointed out that in that period the terms CC and digital transformation were much farther apart than they are today.

IoT in higher education can provide classic functions used in any field associated with surveillance and control of various devices ensuring work conditions and operation. These operations include surveillance and control of lights, electrical charges, temperature (i.e. heating and cooling), ventilation and locking and unlocking sealed spaces, as well as fire protection monitoring and building surveillance using cameras. The upgraded, modified fitness bands and wearable specific IoT devices can serve various purposes: apart from the well-known data collection (measuring blood pressure, pulse, body temperature and physical activity), they can also be used for monitoring individuals' movements, logging when borrowing books from the library, paying at the cafeteria, in bookstores and photocopy booths on campus. The class of IoT devices that contains all forms of personal mobile devices (cell phones, laptops, tablets, etc.) can also efficiently improve the students' academic advancement, if the students' academic activities are constantly monitored using AI on these mobile devices (monitoring knowledge acquisition and submission /uploading of obligatory tasks as well as the evaluation of the mentioned hand-in projects). There is even mention of measuring brain waves in order to monitor the students' cognitive activities during the classes. Another interesting class of IoT devices is that of virtual reality headsets, augmented reality headsets and adaptive learning systems. "The adaptive learning devices can track how well individual students understand course content and can provide new content or offer supplemental teaching in various forms including video, text, experiments, or even virtual field trips." (Asseo et al., 2016).

To improve the quality of learning and students' life on campus it is important to store and later study and analyze all the data collected by the IoT devices.

Depending on the skillfulness of the students, the huge amount of data usually stored in the cloud (Barbaschow, 2018) is likely to significantly improve the students' lives and academic advancement. By using predictive analysis of the IoT data combined with data from other sources, it is possible to predict the student's advancement, detect expected problems, and even offer an estimate of student dissipation with a great degree of accuracy.

Data analysis will offer students a way to track their campus movements and gain a deeper insight into how they spent time and resources.

The greatest amount of information stemming from IoT devices in higher education describe parameters of a highly private nature for individuals, people, or, in fact, students. Such data must

not be collected and stored (as well as analyzed) without their explicit prior consent, as that data is protected by law.

IoT networks as systems are distinct from other, traditional IT and information management systems. Five factors distinguish IoT systems from other technology systems: “(1) the large number of devices; (2) the high variability of types of devices; (3) the lack of language and conceptual frameworks to discuss and easily categorize and classify devices; (4) the fact that they span many organizations within an institution; and (5) the fact that the hundreds or thousands of devices embedded in the physical infrastructure around us tend to be out of sight and out of mind.” (Benson, 2016).

The IoT network, and especially the specific devices are the weakest links at the moment in this entire infrastructure or ecosystem of higher education institutions. Thus it is absolutely vital to pay close attention to and spend considerable funds on the security of this network.

4. Conclusion

This paper describes two new ICT technologies that are being increasingly implemented in the process of digital transformation in higher education. These two technologies bring countless new services developed in the last decade, and are well applicable in higher education. Due to the development of ICT a new model of CC is being increasingly applied. The latest tendencies of development (IoT) force the modification/expansion of classical CC service model to cover IoT services too. The ecosystem illustrated in Figure 5 can serve as ICT model for contemporary Higher Education. The coming years will show how long it will be applicable and how that model will develop. The new types, new classes of IoT devices, including fitness bands, wearables, virtual and augmented reality headsets and adaptive learning systems, are also well-developed and readily available on the market to the public, awaiting a wider spectrum of implementation.

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