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UNDERSTANDING BLOCKCHAIN TECHNOLOGY AND HOW TO GET INVOLVED

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***Abstract**: Introduced in 2009 as the core mechanism for the Bitcoin, Blockchain technology enables the creation of a decentralized environment, where transactions and data are not under the control of any third party organization. Any transaction ever completed is recorded in a public ledger in a verifiable, secure, transparent and permanent way, with a timestamp and other details.*
In the first part of the paper, we explore the blockchain technology and platforms. Next, there are presented existing global and governmental initiatives, together with potential applications of blockchain in different domains, with focus on education. The need to learn about this emerging technology is discussed, together with pioneering cases in formal and informal learning settings.
There are also introduces the educational projects developed by the author, such as OpenEduChain, a permissioned blockchain designed as a repository for open educational assets, but also for issuing digital certificates.
Offering a fresh perspective over blockchain technology and educational initiatives, the paper could be useful for educational actors and policy makers wanting to explore and to integrate blockchain in institutional projects and curricula.

***Keywords:** Blockchain; Ethereum; decentralized applications; education; digital certificates.*

I. BLOCKCHAIN TECHNOLOGY OVERVIEW

1.1 Definition

Blockchain technology enables the creation of a decentralized environment, where the cryptographically validated transactions and data are not under the control of any third party organization. Any transaction ever completed is recorded in an immutable ledger in a verifiable, secure, transparent and permanent way, with a timestamp and other details.

The blockchain term, originally block chain, was first coined in 2009, by (the still unknown) Satoshi Nakamoto, in the original source code for the virtual currency Bitcoin: "Nodes collect new transactions into a block, hash them into a hash tree"; "when they solve the proof-of-work, they broadcast the block to everyone and the block is added to the block chain" (Nakamoto, 2009).

The interrelated terms Blockchain, Cryptocurrency (currency that only exists digitally, using a decentralized system to record transactions) and Initial Coin Offering – ICO (the first sale of a cryptocurrency to the public, conducted raising funds to support a start-up) were added to the Merriam Webster Dictionary in March 2018 (http://twitter.com/MerriamWebster/status/970667988964831232).

1.2 Characteristics

A blockchain is characterized by censorship resistance, immutability and global usability, and has a global network of validators called miners, who maintain it through block rewards, named cryptotokens (Jeremy Gartner, in Shulman, 2018).

Vitalik Buterin (2017), the creator of Ethereum, states that decentralization assures fault tolerance, attack resistance and collusion resistance. Also, that blockchain is decentralized on two of the three possible axes in software decentralization:

- politically decentralized - meaning that no one controls it;
- architecturally decentralized - no infrastructural central point of failure exists;
- logically centralized - there is one commonly agreed state and the system behaves like a single computer.

Anyone has the autonomy to access a blockchain, to download a copy and play a role in maintaining the blockchain, thus that computer becoming a node. The copy will be actively updated along with every copy on every other node, edits can only be made to the blockchain with general consensus among the individuals running a node (ConsenSys, 2018).

The process of adding a new block (containing thousands of transactions) to a blockchain, by hash verification procedures, is named mining. The new block is linked to the last one in blockchain. Each blockchain starts with the genesis block, containing its settings (Dhillon et al., 2017).

The advantages of the blockchain technology are the following (Grech and Camilleri, 2017):

- self-sovereignty - users identify themselves and maintain control over the storage and management of personal data;
- trust - the technical infrastructure offers secure operations (payments or issue of certificates);
- transparency and provenance - to perform transactions in knowledge that each party has the capacity to enter into that transaction;
- immutability - records are written and stored permanently, without the possibility of modification;
- disintermediation - no need for a central controlling authority to manage transactions or keep records;
- collaboration - ability of parties to transact directly with each other without the need for third-parties.

The main drawbacks are the high consume of hardware, energy and time needed for the mining process, also the fact that the technology is complex and difficult to understand. Moreover, the plethora of development platforms in continuous release and the novelty of associated languages still keep the blockchain implementations as appanage of geeks, similar with sending e-mails using line commands at the beginning of web.

1.3 Platforms

There are many blockchain platforms, coin or smart contracts oriented, based on different consensus algorithms, and with different developing tools and programming languages (Body, 2018; Armasu, 2018), in this section a few of the most important are presented.

In October 2008, the Bitcoin (a compound of the words bit and coin) protocol, a fully peer-to-peer electronic cash system, and the corresponding white paper were announced by Nakamoto (2008) in the Cryptography mailing list (http://www.metzdowd.com/pipermail/cryptography/2008-October/014810.html). Launched in 2009, Bitcoin (http://bitcoin.org) is the first and best known blockchain network, mainly oriented on crypto-currency transactions. The network maintains consensus using a hash-based proof-of-work (PoW) distributed algorithm (Nakamoto, 2008). At the time of writing (March 2018), a new block is created on the Bitcoin network at each 10 minutes (https://blockchain.info/stats), and around 12 thousand nodes participate in the blockchain maintenance (mining process), almost 60% being located in the USA, China and Germany; in Romania there are 45 nodes (https://bitnodes.earn.com).

Ethereum (http://ethereum.org), described in a white paper by Buterin (2013) and launched as an open-source blockchain platform in 2015, defines smart contracts and is designed for a large variety of decentralized applications (DApps). A new block is added to Ethereum at each 10 seconds (https://ethstats.net), and the number of nodes is greater than 16 thousand, the USA, China and Russia running around 60% of them (http://ethernodes.org).

The Ethereum main network is a public network that is open to anyone, but it is possible to run a private Ethereum network, which allows for certain advantages, like faster processing and private transactions within a permissioned group of known participants. Developed by JP Morgan, Quorum (https://www.jpmorgan.com/global/Quorum) is such an enterprise-focused version of Ethereum.

Sidechain is a term that permits scaling and was recently defined as a custom 'rule-set' used to offload computations from another chain, while relying on the mainchain for issues requiring the highest levels of security (Konstantopoulos, 2017).

Hyperledger (https://www.hyperledger.org/projects) is a Linux Foundation Project and incubates and promotes a range of business blockchain technologies, including distributed ledger frameworks, smart contract engines, client libraries, graphical interfaces, utility libraries and sample applications. Hyperledger Fabric (https://developer.ibm.com/blockchain), developed by IBM and Digital Asset in 2017, is a fully integrated enterprise-ready blockchain platform designed for business. A Fabric network comprises peer nodes, which execute smart contracts, called chaincode, access ledger data, endorse transactions and interface with applications. Hyperledger Iroha was designed as a mobile-first blockchain, to be simple and easy to incorporate into infrastructural projects.

The Microsoft Azure ecosystem proposes a cryptographically secure, shared, distributed ledger, coming with scenarios as easy-to-deploy templates for the most popular ledgers (https://azure.microsoft.com/en-us/solutions/blockchain).

The IOTA blockchain (http://iota.org) was developed to enable fee-less micro-transactions for the Internet of Things, as a solution for the interoperability and sharing of resources. The main innovation of IOTA is the Tangle: the structure of blockchain is not any more linear, but peer-to-peer, and the consensus is an intrinsic part of the system. IOTA comes with a platform for developing decentralized applications for which value is transferred without any fees (http://www.tangleblog.com/what-is-iota-what-is-the-tangle). It opens the door to the next decentralized systems, which are not based on the blocks cryptographically connected in a linear fashion (Murphy, 2018).

Nebulas (https://nebulas.io) is a self-evolving blockchain system with "a decentralized platform which provides a search framework for all blockchains". Referred as the new "Google for Blockchain", Nebulas would search among decentralized applications (DApps), smart contracts and user's blockchain assets, thus turning of public data into private data (Gorsline, 2018).

A technology in development, called Hashgraph (https://hashgraph.com), is presented in its white paper as a decentralized public ledger based on a new consensus protocol, that aims to boast faster and cheaper transactions than the blockchain.

II. BLOCKCHAIN IMPACT

2.1 Global policies

In the last years, the distributed ledger technology constitutes an important topic of research and interest at institutional, national and global level, such initiatives are presented in this section.

The World Wide Web Consortium (W3C) has a Blockchain Community Group (https://www.w3.org/community/blockchain), with the scope to study and evaluate new technologies and use cases related to blockchain, showing the W3C's intention to become more involved with distributed ledger technology as a foundational element of tomorrow's web. In June 2016, the group and MIT Media Lab organized the exploratory W3C Workshop on Distributed Ledgers on the Web, to determine opportunities and timelines for blockchain standardization (Prisco, 2016).

The European Commission (EC) considers blockchain as a strategic technology and encourages governments, European industry and citizens to benefit from blockchain opportunities. The EC organized an information day on 19 December 2017 to explain the different topics related to blockchain and distributed ledger technologies in the Horizon 2020 Work Programme and Fintech cooperation actions (https://ec.europa.eu/digital-single-market/en/news/information-day-19-december-2017-horizon-2020-blockchain-distributed-ledger-technologies-topics). The EC aims to develop a common approach on blockchain technology for the EU in the international arena, thus in February 2018, the EU Blockchain Observatory and Forum (http://www.eublockchainforum.eu) was launched, in order to become a knowledge hub on blockchain, to map relevant blockchain initiatives, to share experiences and pool expertise on blockchain and its related challenges, to promote European actors, and to organise debates at the EU level. Also, the results of a study on the opportunity to pilot a EU Blockchain Infrastructure (EuroChain) for the advent of an open, innovative, trustworthy, transparent,

and EU law compliant data and transactional environment are expected in 2018 (https://ec.europa.eu/digital-single-market/en/blockchain-technologies).

2.2 Application domains

A lot of countries and governments are starting to fund projects and to place regulations on the blockchain technology; Estonia, USA, Denmark, Sweden, Finland, Australia, North Korea, Canada, UK, The Netherlands, Malta are among the countries that support digital currency (Smolenski, 2017; Levis, 2018; Nelson, 2018; DF, 2018).

The blockchain technology is deeply interlinked with the foundations of society, government, economy, education, culture, charity and even identity, reconsidering fundamental questions such as "what is the definition of value?" or "what does society look like when authority is decentralized?" (Obrist and Chu, 2018). Moreover, blochchain is categorized in the top ten strategic technology trends which will disrupt business in the next five years, constituting an intelligent digital mesh, which entwines people, devices, content and services (Panetta, 2017).

Initially predominant in the financial sector, taking advantage of its unique characteristics presented before - such as being able to replace trust-based systems, blockchain has the potential to become a significant source of disruption. Thus, innovative applications have been already implemented in a lot of domains, such as: humanitarian projects, business, management, finance, banking, cryptocurrency, Internet of Things, education, smart property, energy, healthcare, digital identity, Machine Learning, digital notary, food industry and agriculture, transport, carrier services, mobile parking, social media networks, distributed cloud storage, travel, sport or games (Holotiuk et al., 2017; White, 2017; Sumeet, 2017; Zambrano, 2017; Blechschmidt, 2018). An interesting insight into the blockchain impact in different domains is provided by an interactive map of global transformations, the key issued being considered: Decentralized Asset Management, Economic and Social Structures, Financial Products and Services, Identity and Persona Management, Governance and Law, Environmental Sustainability (WEF, 2018). In Romania, there is an important interest for cryptocurrency, exchange and ATM network operators exist, and startups, events, publications related to blockchain appeared lately, in spite of the lack of governmental regulations and initiatives.

III. BLOCKCHAIN IN EDUCATION

3.1 Educational applications

Education is another domain registering many national and institutional research and projects for integrating the blockchain technology in interesting and innovative applications, such as: proof of learning, management of credentials and transcripts, management of student records, management of reputation, and payments (Grech and Camilleri, 2017; Watters, 2016; Esposito, 2018).

Based on the blockchain property of serving as a decentralized permanent unalterable store of all types of information or assets, a group of pioneering universities started to experiment and issue cryptographically-signed, verifiable certificates on blockchain, which students can access or share with employers: the University of Nicosia in Cyprus (offering digital certificates since 2014 - https://digitalcurrency.unic.ac.cy), Massachusetts Institute of Technology - MIT (project developed by Media Lab Learning Initiative and Learning Machine - http://certificates.media.mit.edu, https://www.blockcerts.org) and Open University UK (http://blockchain.open.ac.uk). These projects are open source and could be adapted by interested universities and training institutions.

There are also other free or open source projects for digital certificates, such as: Open Certificates (http://opencertificates.co), BadgeChain (a research group on open badges and blockchain - https://medium.com/badge-chain), APPII (https://appii.io), uPort (https://www.uport.me), Educhain (https://educhain.io) or Smart Diploma (https://smartdiploma.io).

Following the agreement signed with Learning Machine (https://www.learningmachine.com) in September 2017, Malta has become the first nation-state to deploy blockchain technology in education, issuing digital diplomas, training certificates and equivalency statements, using the BlockCerts standard (http://connectedlearning.edu.mt/news). Many other universities worldwide offer digital certificates, among them there are: Central New Mexico Community College (https://www.cnm.edu), British University in Dubai (http://buid.ac.ae), also three Greek universities will use the Cardano platform (https://www.cardano.org).

In 2017, Sony Global Education implemented a project on the Hyperledger platform to maintain and manage transcripts and high security data, such as learning history (https://blockchain.sonyged.com).

Several universities, including the University of Nicosia, The King's College in New York, Simon Fraser University in British Columbia, or Varna in Bulgaria, accept the digital currency for tuition payments.

The management of reputation on blockchain-based ecosystems helps participants to access remuneration appropriate to their skill and service level. A project for ePortfolios and reputation was developed by Open University UK (Sharples and Domingue, 2016), while in the case of bitJob (https://bitjob.io), the peer-to-peer connections are between employers and students, and Vanywhere (https://vanywhere.com) connects people seeking and offering skills.

Blockchain (or distributed) universities and learning communities constitute a category of innovative educational applications, bringing a new model of learning, where there is an exchange of ideas and concepts coupled with a tracking system for learning results. The blockchain technology is used in the regulation of contracts and payments, to assess learning and to record academic progress, a kind of Uber for learning. Tuition payment could be done by peer-teaching other students. Such projects are:

- Woolf University (https://woolf.university) - set up by a team of Oxford academics,
- blockchainedu (https://www.blockchaineducation.school) – developed by blockchainedu Foundation on the NEM blockchain platform (https://nem.io);
- fathom (https://fathom.network) - a decentralized system on Ethereum, for creating and assessing meaningful credentials through the consensus of knowledge communities, aiming to build identities based on qualifications;
- BitDegree (https://www.bitdegree.org) – there are many online courses on different topics, including Solidity and game development on blockchain (Space Doggos); the platform is also a tool for businesses to recruit tech talent and shape global education to their needs;
- ODEM (https://odem.io) - a beta-phase platform aiming to revolutionize how educators and students plan, connect, and book educational programs; it uses artificial intelligence to seamlessly manage complex requests, organizing complete educational programs.

Blockchain for Science (https://www.blockchainforscience.com) is a project supported by an active community and has as aims to bring science towards reproducible results, autonomous and free data handling and incentivisation of true innovation, to support scientific communication and education, and also to free science from any kind of censorship or central point of failure.

Disciplina (https://disciplina.io) is a new blockchain platform for projects in the educational and recruiting spheres, aiming to provide the transparency of work and to maintain confidentiality and reliability of information added by system participants.

3.2 The need for instruction

If 2017 has brought new tokens and funds, and the largest increase in the global blockchain participation, this year demands the education of new participants in the blockchain ecosystem, the understanding of the opportunities as a matter of empowering human rights and the involvement of diverse communities in the creation of all blockchain products (Mehrain, 2017).

Considering the variety of the numerous current and projected blockchain applications, in the last months there are many evidences for a high demand of workforce specialized in the decentralized applications paradigm.

On LinkedIn, blockchain-related job adverts have tripled in the last year, in a single week around one thousand are published, while ten thousand people list blockchain as a skill (Arnold, 2017).

The ConsenSys company, one of the leaders in Ethereum development, states that there are currently 5,000 blockchain developers worldwide, while in 2020 500,000 will be needed (https://consensys.net/academy/developer).

Last year, blockchain and bitcoin-related skills (together with robotics) were the fastest growing in the labor market (http://www.upwork.com/press). The blockchain careers comprise specialty areas such as product design, data analysis, development, machine learning, legal and public service, ICO advisory services, consultancy or subject matter expertize (Stein, 2018). Job offers can be

found on dedicated portals such as UpWork, CryptoJobsList, CryptoJobs, BlockchainJobz, BlockchainJobs or HiredCrypto (Zhao, 2017).

Therefore, considering the continuous growing need of blockchain-related jobs in a variety of domains and for different specializations, there is a real need for courses on the blockchain technology. The following section will discuss some interesting initiatives of blockchain instruction in formal, informal and continuing education.

3.3 Teaching and learning initiatives

The involvement in research and the readiness in teaching blockchain technology are indicated by the fact that more and more scholars set up blockchain as an area of interest on their Google Scholars profiles: in March 2018 there are around 420 scholars, while three months before there were only 270 (https://scholar.google.ro/citations?view_op=search_authors &mauthors=label:blockchain).

As business schools are constantly updating their offers to meet employers' needs and market demands, already blockchain is one of the topic on the MBA curriculum in 2018, together with Big Data, Sustainability, Soft Skills and New Business Models (De Novellis, 2018).

The University of Nicosia (https://digitalcurrency.unic.ac.cy) offers an online Master program in Digital Currency since 2014, the first course being free. Recently, the university extended its programs with a broad range of blockchain professional certifications, such as business analyst, financial analyst and developer. Many other universities included blockchain in their curricula, courses: Stanford University, Cornell University, Massachusetts Institute of Technology (MIT), Johns Hopkins University, Duke University, Cambridge University, University College London, Frankfurt School of Finance and Management, IT University of Copenhagen and Moscow State University (Coinify, 2017; Trustnodes, 2017; Mearian, 2018).

Students initiatives related to blockchain education include the Blockchain Education Network (BEN) (https://www.blockchainedu.org), with over 3,000 students in 60 countries or clubs at Tufts University USA (Tufts Blockchain and Cryptocurrency Club) and Berkeley University (https://blockchain.berkeley.edu).

Blockchain Research Institute (https://www.blockchainresearchinstitute.org), Institute for Blockchain Studies (http://www.blockchainstudies.org) and European Blockchain Center (http://ebccenter.eu) are specialized research institutes with a large area of projects.

Blockchain is the topic of a few MOOCs offered by well-known platforms: Coursera - Bitcoin and Cryptocurrency Technologies, and IBM Blockchain Foundation for Developers, EdX - Blockchain for Business - An Introduction to Hyperledger Technologies, and FutureLearn - Blockchain in the Energy Sector.

Companies and organizations offer courses for blockchain development: Blockchain University, which organizes also hackathons (http://blockchainu.co) or ConsenSys Academy with the 2017 Developer Training Course including an 8-week online course, followed by a 3-day in-person coding event for more than 100 participants (https://consensys.net/academy/developer).

CryptoZombies (https://cryptozombies.io) is an ingenious online course for learning smart contracts in Solidity through building games on Ethereum. Another interesting project is Kauri (https://kauri.io), a decentralized technical support network to serve Ethereum developers at all levels and organizations.

Conferences (Blockchain in Education 2017 - https://www.bcined2017.nl, Blockchain, Credentials and Connected Learning, organized by Commonwealth Centre for Connected Learning, in May 2018, in Malta - https://3clevents.com) and hackathons (Global Blockchain Challenge in Dubai - http://smartdubai.ae/story0531.php, Blockchaingers Hackathon 2018 in Groningen - https://blockchaingers.org or Unlock The Block Blockchain Hackathon 2018 in South Africa - https://unlocktheblock.io) complete an ample blockchain learning ecosystem.

IV. ROMANIAN EDUCATIONAL INITIATIVES

A series of initiatives and projects have been initiated and implemented lately by the author in order to improve the awareness of scholars about the potential of blockchain in education, and to develop the students' knowledge about the decentralized applications programming (Table 1).

Action	Initiatives and Projects
Educational Blockchain projects	There is in implementation a permissioned blockchain called OpenEduChain (http://openeduchain.io), designed to store open educational assets (OERs, MOOCs, open pedagogies and scenarios), but also to issue certificates and open badges by universities and other educational and training institutions. At university level, OpenEduChain, implemented on Ethereum, is used to store data about the open educational items created by faculty members and students. Also digital certificates or open badges are provided to the participants in the trainings and workshops. In the summer of 2018, University "Ioan Slavici" of Timisoara will be the first Romanian university that will issue digital certificates for the students.
Educational Conferences and Workshops	In March 2018, the workshop "Open Education Week" (https://elearning.upt.ro/workshop-open-education-2018/n-32-70-233/d) organized by the eLearning Center of Politehnica University of Timisoara included the presentation "Blockchain and Open Education" delivered by the author (Holotescu, 2018). The workshop "Open Education", co-chaired by the author and co-located with the International Conference "eLearning and Software for Education" in April 2018, in Bucharest, has Blockchain in Education as one of the topics (http://elseconference.eu).
Academic Courses	The students in the last bachelor year at Faculty of Engineering of "Ioan Slavici" University of Timisoara learn about the potential of blockchain and how to develop decentralized applications on Ethereum and Hyperledger, in the Blockchain course taught by the author. This is the first such course in Romania; a few of other universities only have modules on financial aspects of blockchain and digital currencies.
Student Hackathon	A hackathon for blockchain development is planned to be organized in the autumn of 2018, for the students at universities in Timisoara.

Table 1. Romanian educational initiatives

V. CONCLUSIONS

In less than a decade, blockchain has surged from a technology with narrow applications related to digital currencies, to one with important applications in many domains, drawing attention to policy makers at different levels too. In spite of the evidences that blockchain could solve some of the most pressing problems in business and society today, there is a gap in turning many use cases into reality, particularly from a strategic viewpoint.

The evaluation of the educational projects implemented by the author will make possible conclusions for their extensions in other universities and for specific recommendations related to blockchain technology adoption for the Romanian Ministry of Education.

We believe that the fresh perspective over blockchain technology, policies and projects, brought by this article, will be useful for educational actors and policy makers in taking concrete steps to explore and to integrate blockchain in institutional projects and curricula.

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