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Introduction of Emerging Technology into Higher Education Curriculum: The Case of Blockchain Technology as Part of Data Science Master Program

Stefka Toleva-Stoimenova[1], Dimitar Christozov[2], Katia Rasheva-Yordanova[3]
University of Library Studies and Information Technologies, Bulgaria[1,3]
American University of Bulgaria, Bulgaria[2]

Abstract

Since appearance of www protocol in 1991, the trend in different aspects of e-commerce is diminishing the role of mediators. "Disintermediation" become the keyword defining many e-commerce technologies. Bitcoin, the original application motivated development of Blockchain technology, aimed removing banks as the mediators and trusted third party in financial transactions. But the scope of this underlying technology is much broader than purely the word of cryptocurrency. Blockchain technology offers new paradigm of connectivity, information exchange and information use, exploring decentralized, distributed data processing, and encrypting via public and private keys.
Blockchain was launched as the underlying technology in introducing bitcoins. Research conducted on the dynamics of publications addressing Blockchain, shows that this technology deserted recently from purely bitcoin / crypto-currencies application domain. The intensity of publication addressing applications of this technology demonstrated its relevance to different business domains, mostly Internet of Things (IoT), but also sectors as Energy, Healthcare, and Finance, mostly related to retailed services.
Consideration of Blockchain technology from this broader perspective, justify the needs of introducing it to students in fields like Computer Science, Information Systems, and Information Technology, but it is especially valuable for programs training Data Science competences.
The paper shares experience of introducing Blockchain technology, which is still in its infantry stage according to maturity life cycle, in Data Science Master Program. Resolving problems like lack of sufficient well-developed training materials, lack of competent trainers, and lack of adequate equipment to experiment are among the overcome major barriers.
Dynamics of innovations in area of information technologies and shortening the life cycle from discovery to wide distribution forces education institutions, traditionally conservative in adopting innovation, to develop experience in fast adjustment of their curriculum to react to the emerging challenges. The case of incorporated Blockchain related content into curriculum is discussed as a possible practice.

Keywords: Blockchain, Data Science, Master Program, Curriculum

1. Introduction

Nowadays economies and governments are going digital and businesses recognize the opportunities to reach the consumers globally. New communication technologies open up new possibilities and benefits, but also create risks about privacy, security, fraud, identity theft, etc.

Blockchain, also called Distributed Ledger Technology (DLT), originated from financial services sector as the core mechanism for the cryptocurrency Bitcoin, recently begun to spread in other sectors. The rate of Blockchain spread depends on the industry's potential to benefit from it as well as its sensitivity to the challenges that Blockchain brings into play [1]. The intensity of publication addressing applications of this technology demonstrated its relevance to different business domains, mostly Internet of Things (IoT), but also sectors such as energy, healthcare, etc.

This study investigates the challenges of Blockchain technology (BT), justify the needs of introducing it to students in fields like Computer Science, Information Systems, or Information Technology, but it is especially valuable for programs training competences in the field of Data Science (DS).

The paper is organized as follows:

Section 2 describes key characteristics and important existing applications of Blockchain.

Section 3 shares our experience of introducing BT, which is still in its infantry stage according to maturity lifecycle, in DS Master Program.

2. Blockchain applications

Built on a purely distributed peer-to-peer network (P2P), Blockchain entails a large decentralized digital ledger, composed by diverse sequences of data blocks, integrity of which is ensured by cryptography and a consensus mechanism [2, 5].

Simply, Blockchain is a distributed ledger that provides a way to record and share information by a community. In this community, each member maintains his or her own copy of the information and all members must validate any updates collectively. The information could represent transactions, contracts, assets, identities, or practically anything else that can be described in digital form. Entries are permanent, transparent, and searchable, which makes it possible for community members to view transaction histories in their entirety. Each update is a new "block" added to the end of the "chain."

A protocol manages how new edits or entries are initiated, validated, recorded, and distributed. With blockchain, cryptology replaces third-party intermediaries as the keeper of trust, with all Blockchain participants running complex algorithms to certify the integrity of the whole [10].

To added to the Blockchain blocks must be validated. To prevent fraud and ensure trust within the network, Blockchain applies a consensus mechanism, which requires the nodes in the network to agree upon the validity of information stored in a block [6].

The security of information stored in each block is provided through an asymmetric-key encryption - every user has one pair of public and private keys. Users can transact anonymously and securely within the Blockchain using their private keys while only being known within community by their public keys.

In summary, BT offers significant possibilities [7]:

- **Decentralization (disintermediation**). The ability of nodes to transact directly with each other without the need for a central controlling authority.
- **Persistency**. The immutability of BT makes it nearly impossible to delete or

rollback transactions once they are included in the Blockchain. It increases confidence in data integrity and reduces fraud probabilities.

- **Anonymity**. Each user can interact with the Blockchain with a generated address, which does not reveal the real identity of the user. There is no longer any central party keeping users' private information.
- **Auditability**. Since the Blockchain is an open file and every transaction has a timestamp, any party can access it and audit transactions. This improves the traceability and the transparency of the data stored in the Blockchain.

The first major application of BT was decentralized electronic payment system using cryptocurrency Bitcoin. In fact, the main driver to the creation of BT was the ability to solve the double spending problem in which a user of a digital currency can spend several times the same amount of money [9]. The financial sector is continuously growing and adopting DLT for smart contracts [3], inventory control, insurance, corporate finance, corporate governance, cash management and treasury applications, etc. [4].

Theuse of BT for decentralized data management holds potential for applications beyond financial services. Blockchain along with IoT is used to improve the agriculture sector by optimizing farming resources including water, labour, and fertilizer to produce sufficient food with minimum resources and enabling transparency across the supply chain [8]. Zhang presented the use of blockchain in the healthcare is a prominent area where blockchain could found many use cases that help establish an infrastructure to ensure transparency of medical data, analytical methods, reproducibility of results and improved trust in translational medical value chain [12]. Many other Blockchain use cases are studied by the research community in the sectors such as education, culture, science and innovation, transportation, energy related applications, etc. [5, 10, 11]

3. Blockchain in Data Science Master Program

It is expected that a program, covering recent achievements in highly dynamic developing fields as DS, will include the last updates in the field and state-of-arts technologies, such as BT. BT has a great potential to play a key role in many fields directly contributing to accumulation of Big Data, and therefore directly related to the field of DS. From other side, designing DS curriculum faces challenges typical for developing training in a new field – lack of experience, lack of training materials, not established content, not any textbooks or other training materials, even not well-defined rubrics, indicators and criteria to test and justify that a student acquire the necessary competences.

Designing curriculum including BT requires research and creativity to address all those aspects. There are two general approaches to follow:

- Building curriculum around particular domain of application of given technology. From application toward the tool.
- Building curriculum based on pure technical aspects of given technology and it's potential. From tool toward the application.

We have chosen the first approach. We deserted from using cryptocurrency as background area of applying BT and selected IoT as the leading domain. Main reason to do this is the importance and potential of IoT in the Big Data area, the wider applicability, and closer relationship with other concepts of DS. Important aspect of this decision was our understanding regarding the role IoT is expected to play in years to come, and in both private and public domains.

The BT has been incorporated into DS curriculum on two levels:

a) First level is inclusion of a single topic in several courses addressing different application, especially IoT, exploring publicly available data, privacy, and cryptography, mostly as discussing BT as option for building application accumulated data without using trusted third parties.
b) Second level is a special elective course addressing technical aspects of BT. Public nature of spreading data by using BT makes possible to analyze data flows by classify transactions, and in general to explore and learn from data, without breaking users' privacy and access the content of distributed messages. In light of newly adopted regulations, known as GDPR, this aspect of DS is becoming critically important, and BT is a perfect area to train students to obtain knowledge about the processes without breaking privacy rules.

We expect that the selected approach will work well in attracting students' interest and as follow-up providing deeper training. The entire training materials are under development and during the next academic year the BT will be introduced in DS.

Students' outcome assessments, obtained by this first cohort, will justify whether our decision was correct.

4. Conclusion

Together with other emerging technologies like Artificial Intelligence, IoT, DS, Cloud Computing, BT is expected to have a huge impact on different sectors and industries.

The BT looks particularly promising in the area of Data Analytics due to the possibility to provide decentralised trust across a network of untrusted parties. That being said, the opportunity to make verified, immutable, distributed ledger of transactions is a challenge for the future Data Scientists and this require introducing BT to the students in Data Science Master Program.

The paper shares experience in making and justifying a decision to incorporate a new technology in a curriculum as a pioneering project. This decision follows recognition of potential technology is expected to play. BT is excellent example of the main-stream of changes made by CCT to the society.

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