

How Digital Identity on Blockchain can contribute in a smart city environment

Rogelio Rivera
IBM de Mexico
Guadalajara, México
rriverag@mx1.ibm.com

José G. Robledo
Smart Cities Innovation Center,
CUCEA
Universidad de Guadalajara
Guadalajara, México
joseg.robledo@gmail.com

Víctor M. Larios
Smart Cities Innovation Center,
CUCEA
Universidad de Guadalajara
Guadalajara, México
Victor.m.lariosrosillo@ieee.org

Juan Manuel Avalos
IBM de Mexico
Guadalajara, México
jmavalos@mx1.ibm.com

Abstract—Nowadays, in this digital world, one of the biggest concerns for business and many other public entities, is to know precisely the “identity” of the users that are behind of their systems. Since the data can define a person, there have been many tries to develop technology to determine accurately who the users are and certify their basics attributes like name, address, credit record, as well as other personal characteristics like health status, hobbies and others. That is why Digital Identity has taken a significantly important role in this area and becoming as a crucial security measure in this interconnected environment.

This research is a systematic mapping review with the goal of collecting all relevant existing research of Digital Identity on Blockchain technology implemented in a smart city environment. The objective of this paper is to understand the current research topics, challenges and future directions of these areas from the technical point of view. It is expected that this paper can stimulate interest in theory and practice to further discussions and research in these areas.

Keywords— *Smart city, Blockchain, Digital Identity*

I. INTRODUCTION

Governments around the globe are some of the entities that are leading the digital transformation through digital identity. The adoption of Blockchain technology for digital identity solutions helps to empower citizens and build a more connected digital society. These match with one of the primary objectives of a Smart City which is to improve their citizens' quality of life through the application of technology.

The reason for the importance of the use Blockchain in Digital Identity is its primary features that provide security, data integrity and anonymity without the need of a third-party organization in the middle or in charge of the transactions [1]. Consequently, it creates exciting research fields, particularly from the viewpoint of technical challenges and limitations.

By design, Blockchain is a distributed database and decentralized transaction data technology, applied for the first time for Bitcoin cryptocurrency in 2008 since the idea was coined [1]. Since then, the enthusiasm to implement Blockchain technology in different domains with similar transactions scenarios has been spreader.

The concept of a Smart City is to improve the citizen living conditions and respond with technology to develop a “Smart City” [15]. Some examples are issues such as carbon dioxide, traffic jam, waste disposal and others [2]. Nevertheless, due to the globalization and because the population is growing faster, the pressure to find cost-effective solutions to prove the citizen's identities have gained more and more attention lately and it is becoming an issue for governments and many other entities that need to be resolved.

Therefore, to understand the impacts of emerging Digital Identity on blockchain technology, on the application in a smart city environment, is necessary the study, the current use and the research perspective to identify their primary elements. To approach this problem, this paper proposes to use a systematic mapping study process [6] to determine relevant articles related to the use of Digital Identity on Blockchain-based in smart cities. The produced map of current research in these fields will help other researchers in identifying possible research areas and questions for future studies.

The objective is to find and map the current research papers with technical perspective on Digital Identity and Blockchain. The interest is to determine what services of Digital Identity have been implemented in the different dimensions of smart cities and how they are currently applied. The rest of the paper is distributed as follow: In Section II investigates the relationship between Blockchain and Digital Identity, this article investigates the relationship between the applications on both, Blockchain and Digital Identity in a smart city environment. In Section 3, this paper described the applied research methodology and presented the research questions. Section 4 presents the results of the collected papers and extracted data, and finally, in the last part, the conclusion of this study is presented.

II. SMART CITIES, BLOCKCHAIN, AND DIGITAL IDENTITY

A. Smart Cities

In the current research, a smart city is a full concept that incorporates many aspects of urban life [4] and embraces several different dimensions. Since there is ambiguity on the concept, it is hard to understand how the implementation of

technology precisely impacts in the development of a Smart City [5]. There is one concept accepted mostly by all literature; Smart City is the use of IT to improve the quality of life of their citizens [15]. However, despite these different dimensions, if a city wants to call themselves “smart,” they must improve with technology some horizontally cumulative elements, such as government, mobility, healthcare, resources, economy and take all of these areas together [8].

B. Digital Identity and Blockchain

In the past few years, digital services are rising continuously, allowing to build an interconnected digital society both in developing and developed countries [9]. These are causing new issues to be faced, such as the need to provide digital identity methods for the citizens that are interacting in this digital environment. Nowadays, many of the identity existing methods are fragmented and fail to address core citizen’s needs [9]. Digital Identity is becoming a priority to drive transformational change for citizens, businesses, and public administrations since the users/citizen’s expectations are to get control over their data when acceded to the many of the existing digital services [9]. Digital identity may be the primary source of authentication for digital services and other trust systems in the future [9].

About 2.4 billion people worldwide who live in a poverty condition, cannot answer the simple question “Who are you?” to a particular government entity. And this is not because they certainly do not know who they are, but simply because they are not able to prove with tangible evidence their identity [10].

It is well known that exists methods for authenticating personal identity in the physical world in the manner of ID documents such as passports, drivers’ licenses, national identification cards and others [11], but all of them are imperfect methods that can be altered, stolen or falsified. Concerning the digital world, nowadays exist numerous digital authentications methods to corroborate electronically the user’s identity, not only for humans but also for companies, government entities, even digital devices. The adoption of mobile technology for digital identity is one of these methods used to authenticate, digital tokens, communication chips and biometrics-based recognition are also playing an important role in this area. Nevertheless, one of the lastly key players in this field is the use and application of Blockchain technology to prove your identity. This needs for the use of blockchain based identity authentication is particularly remarkable in the era of the internet [11].

III. RESEARCH METHOD

The research methodology selected for this paper was a Systematic mapping study. The objective of a systematic mapping study is to present a summary of a research area, to establish if research evidence exists [6]. This study was guided in part of the systematic mapping process described by Petersen et al. [7]. This process consists of a total of five stages that begins with the definition of the research questions as the first of them, then the search for relevant articles must be done later to proceed to a screening of the articles found, proceeding subsequently to obtain of keywords obtained from the abstracts

to finish with the stage of extraction of data and creation of the map. A more comprehensive description of this process is detailed below.

The definition of research questions is intended to help determine the direction in which the main goal of the systematic mapping study should be directed. This goal stands to identify the quantity, type of research and results obtained through the study.

The search for primary sources can be done by conducting a search for terms either in scientific databases or by performing a manual search in conference reports. It is also recommended that the search terms be structured based on terms of population, intervention, comparison and results [6].

On the other hand, the screening of articles by inclusion and exclusion criteria related to research questions is the third stage of the systematic mapping process. The inclusion and exclusion criteria can handle the type of documents that will be taken into account for the search as well as the context of the terms that appear mainly in the abstracts of the works.

The fourth stage of the systematic mapping process consists in the use of a classification scheme based on the obtaining of keywords from the abstracts of the papers considered after the screening. This classification scheme tries to ensure that existing studies are taken into account. In case the abstract does not contain relevant keywords then the search for them is done in the introductory sections and conclusions. Once you have all the keywords, these are used to make groups of research works and thus to form the classes of the map.

The last stage of the process of systematic mapping consists of extracting data from the relevant articles in order to sort and classify them based on the scheme developed in the previous stage. Once this stage is completed, the results obtained from the frequencies obtained for each classification are presented. This last part allows to visualize in which categories has been emphasized in research already made, as well as research gaps and therefore to find opportunities in this respect.

The systematic mapping process was selected as the research methodology of this paper because its primary objective is to explore the existing studies related of Digital Identity on Blockchain technology and its applications in the digital services that currently exist in a smart city environment. Since the definition of the research questions is the initial step of the systematic mapping method, the following research questions of this paper are presented as follow.

A. What are the current research topics on Digital Identity on Blockchain-based?

The primary research question of this study is to understand the current fields where Blockchain is used as Digital Identity method, helping other researchers to stimulate their interest in further discussions and research on these topics.

B. What applications have been implemented in smart city projects to authenticate citizens with the use of Blockchain technology?

Although Bitcoin is the predominant application of Blockchain technology nowadays, this is not the only solution. Many other applications have been benefited with the use of Blockchain. Digital Identity on Blockchain-based validates and authenticate users in a secure, private and efficient way. Identifying the applications that currently exist, can help to understand the potential of this implementation.

C. What are the next research areas for Digital Identity on Blockchain to be used as one of the primary authentication methods in the digital services of a smart city?

The answer to this research question will help to decide where Digital Identity on Blockchain should be addressed and what problems need to be focused in future studies, as well as find the research gaps to focus future researchers in these areas.

To answer these questions, high-quality articles published in conferences, symposiums, workshops, books, and journals related to the research topic were used. Since the subject of Blockchain for Digital Identity implementations is just in its early days, for some cases, the gray literature such, industry white papers, opinion on industry news and subject matter experts of the related topic was needed to be used as a criterion of this review

IV. RESULTS

The results of this investigation revealed that the use of Blockchain for Digital Identity is mostly in its conception stage. The number of high-quality papers related to this merged technology is meager; however, it is very noticeable that the industry is quite interested in this topic. White papers, technical conversation papers from subject matter experts on the related topic and industry reports are the primary sources of information on this issue. Nowadays, the industry is one of the major entities that are betting and investing in the use of Blockchain technology to improve the Digital Identity services [3].

The current research of Digital Identity on Blockchain is focused on finding and identifying improvements to the current challenges and limitations [1]. A significant portion of the actual papers only describe the benefits of use Blockchain to authenticate users, and less portions of the research concentrated on security issues.

Regarding the applications that currently exist in a smart city environment, several startups are working on the use of blockchain for online identity [11]. The majority of the applications that could be implemented in a smart city environment are focused on protecting user's privacy information where ensure to the citizens that all identity data is encrypted, hashed and stored in the blockchain making impossible to be altered [11]. This will positively impact in different dimensions for a smart city. Some examples are; banking and payment methods that will allow anyone make bank operations across borders and almost in real time [12].

Population growth forecasting, helping to monitor the city expansion. Healthcare medical records that will share the patient data only to those that need to know [13]. Voting, making the elections more fair and democratic [14]. Transparency of governmental operations, reducing bureaucracy and increasing efficiency and many other industries and entities with similar scenarios.

The applications can help to government entities and industries to verify the citizen identities on every transaction in real time, avoiding fraud. Most of the current solutions help to the users to authenticate them using a simple app rather of using conventional methods, such as a username and password. These solutions stored and encrypting the citizen identity data, allowing them to share their information with different institutions and manage it on their own terms [16].

From the smart cities perspective, Estonia is the perfect example of the cities that are adopting emerging technologies to innovate their city services and one of this proof is use of its digital identity back-end system, powered by Blockchain [18]. Inside of each Estonia's ID cards, there is an electronic chip that, besides to hold the data about its citizen owner, it also has two certificates, one is to authenticate the identity and the other to render a digital signature [17]. Thanks to this electronic chip, this ID document can be used in many electronic web environments, such as, backing, buying tickets for public transportation, electronic elections and many other city services [17].

Besides, the healthcare service in Estonia it also uses Blockchain Digital Identity method to ensure data integrity. It uses an electronic prescription solution that is sent to a decentralized database where the patient can go to the pharmacy and the pharmacist receives the prescription with the electronic ID-card of the user, making the information accessible only to the authorized individuals [17].

The future research directions for the implementation of Blockchain for Digital Identity services in a smart city are not clear since there are only a few high-quality researchers in this particular field [3]. It is interesting to see where it is heading due that the industries are working hard in the exploration of this area.

Digital Identity on Blockchain has a high potential and opportunity to consider how governments and industries can adopt this mixed technology and apply it to their authentication services.

The future study will not only converge on smart city environments but other possible applications using Blockchain as a Digital Identity solution. There are already some researchers that studied the possibility of using smart contracts, licensing and IoT in the Blockchain environment [1]. It is expected that this type of research will have an impact in the future, and can be even more attractive.

There are a lot of discussions and concerns around digital identity implementation, especially in terms of data protection, privacy and other jurisdictions and legal issues. However, it will be inevitable stop the implementation of this digital service. Some industries and governments are inviting developers to build a platform to extend the digital identity

services in order to be used through the digital services of government entities and companies.

V. CONCLUSIONS

The Blockchain technology is an enabler that makes many processes and transactions services more transparent, decentralized, democratic and secure without the need of a third-party organization in the middle. There is no doubt that the role that Blockchain plays to be implemented as a Digital Identity method, is crucial in the near future to authenticate citizens and prove their identities for the bunch of digital services that currently exist in this interconnected world. Blockchain in this area could help to improve the way that society views identity privacy and security [10]. It will positively impact in different domains that a smart city environment interacts, such as; banking and payment, population growth forecasting, healthcare medical records, voting, digital services of governmental operations, financial services and many other scenarios.

In few words, we can say that Blockchain is a new system of trust and having this technology as an authentication method, which uses ledgers that never lose data, it would possibly change some behaviors of the society positively, bureaucracy and corruption can be corrected [10]. It is expected this paper will be a starting point for more research and discussions on the adoption and implementation of Blockchain for Digital Identity, applied in the environments of smart cities.

ACKNOWLEDGMENT

I gratefully acknowledge the support of, Universidad de Guadalajara and IBM Mexico, for their assistance and support to allowing me to collaborate in the Smart Cities Innovation Center, CUCEA, without which the present study could not have been completed.

REFERENCES

- [1] J. Yli-Huomo, D. Ko, S. Choi and Sooyong, "Where Is Current Research on Blockchain Technology? —A Systematic Review," 2016.
- [2] J. Sun, J. Yan1 and K. Z. K. Zhang, "Blockchain-based sharing services: What blockchain technology can contribute to smart cities," 2016.
- [3] J. S. Arun and A. Carmichael, "Trust me: Digital identity on blockchain," 2017.
- [4] Chourabi H, Nam T, Walker S, G. Garcia JR, Mellouli S, Nahon. K, P. TA and S. HJ, "Understanding smart cities: An integrative framework," System Science (HICSS), 2012 45th Hawaii International Conference, 2012
- [5] Komminos N, Pallot M y Schaffers. H, «Special Issue on Smart Cities and the Future Internet in Europe,» 2013.
- [6] Kitchenham B. y Charters S., «Guidelines for performing Systematic Literature Reviews in Software Engineering,» 2007.
- [7] Peterson K., Feldt R., Mujtaba S. and Mattsson M., "Systematic Mapping Studies in Software Engineering. In: Proceedings of the 12th International Conference on Evaluation and Assessment in Software Engineering," UK: British Computer Society, Swinton, UK, 2008.
- [8] Gori P., Parcu. PL and Stasi. ML , "Smart Cities and Sharing Economy," Robert Schuman Centre for Advanced Studies Research, 2015.
- [9] M. Ienco, "Digital identity as a key enabler for e-government services," GSMA, 2015.
- [10] M. Mainelli, "Blockchain Will Help Us Prove Our Identities in a Digital World," 2017.
- [11] D. Shrier, W. Wu y A. Pentland, «Blockchain & Infrastructure (Identity, Data Security) Part 3, Connection Science & Engineering,» Massachusetts Institute of Technology, Massachusetts, 2016.
- [12] F. Holotiu, F. Pisani y J. Moormann, «The Impact of Blockchain Technology on Business Models in the Payments Industry, Frankfurt School of Finance & Management,» Germany, 2017.
- [13] A. Ekblaw, A. Azaria, J. D. Halamka, MD y A. Lippman, «A Case Study for Blockchain in Healthcare: "MedRec" prototype for electronic health records and medical research data,» MIT Media Lab, Israel , Asaph Azaria, John D. Halamka, MD, Andrew Lippman, 2016.
- [14] Team Plymouth Pioneers, A. Barnes, C. Brake and T. Perry, "Digital Voting with the use of Blockchain Technology," Plymouth University.
- [15] O. Benedikt, «The Valuable Citizens of Smart Cities: The Case of Songdo City,» 2016.
- [16] O. Jacobovitz, "Blockchain for Identity Management," Israel, 2016.
- [17] Ministry of Foreign Affairs, Republic of Estonia, «e-Estonia,» Republic of Estonia, 2014.
- [18] J. Shen, «Thomson Reuters,» 20 December 2016. [En línea]. Available: <https://blogs.thomsonreuters.com/answeron/e-estonia-power-potential-digital-identity/>. [Último acceso: July 2017].