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Tecnologia Blockchain em Smart Cities: uma proposta para cidades inteligentes autopoieticas

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ABSTRACT

This paper aims to show that smart cities are an alternative for the process of sustainable political, economic, social and environmental transformation. Surveys of smart city rankings and indexes were carried out to verify which cities are standing out in certain dimensions. It was found that blockchain technology enables very good results in the articulation of the autopoietic, self-regulating and sustainable smart city. In collecting data on the degree of applicability of the blockchain, carried out with market experts in the use of this technology, it was identified that the application of the blockchain has greater emphasis on the brain and less emphasis on the Locomotor System of cities.

K**eywords:** Blockchain; Smart City; Urban Autopoiesis; Urban Systems; Governance**.**

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RESUMO

Este artigo tem como objetivo mostrar que as cidades inteligentes são uma alternativa para o processo de transformação política, econômica, social e ambiental sustentável. Levantamentos de rankings e índices de cidades inteligentes foram realizados para verificar quais cidades estão se destacando em determinadas dimensões. Verificou-se que a tecnologia blockchain possibilita resultados muito bons na articulação da cidade inteligente autopoiética, autorregulada e sustentável. Na coleta de dados sobre o grau de aplicabilidade do blockchain, realizada com especialistas do mercado no uso desta tecnologia, foi identificado que a aplicação do blockchain tem maior ênfase no cérebro e menor ênfase no Sistema Locomotor das cidades.
Palavras-chave: Blockchain; Cidade inteligente; Autopoiese Urbana; Sistemas Urbanos; Governança.

INTRODUCTION

The popularization of the use of information and communication technologies (ICT) provides instruments for citizens to abandon their traditional, passive role, in which they wait for the government and authorities to solve the problems of cities, beginning to act actively in prevention, reduction and resolution. of urban problems. The central axis of the research discussion is urban systems as a means of connectivity and interaction between the city, citizens and the environment, in a continuous and transparent way, enabling progress in governance and sustainability. According to Duarte (2018), the way in which blockchain technology controls, records and secures transactions shows the potential that this technology has to bring advances in the urban context. The research seeks to show that the systemic process of autopoiesis in cities requires intelligence, independence and self-regulation that blockchain technology can help to manifest.

Blockchain is considered one of the most disruptive technologies today; and although still more present regarding the Finance area many cities around the world are launching blockchain initiatives as part of general efforts to shape Urban futures. However, the early stage of the blockchain industry presents a large gap between the knowledge we have and the actions that urban policy makers are taking. The experiences on sustainable cities, the theory of autopoiesis and innovative technologies such as blockchain are important in the process of generating smart cities and overcoming the difficulties to offer quality of life to the population.

1 THEORETICAL REFERENCE

A Smart City may be defined as a high-tech city with various problem-solving capabilities (Sharma, Rajput, 2017). The “Smart Cities Wheel” model developed by Cohen (2015) presents six characteristics of a smart city:

> **Smart Economy**: Innovative Spirit; Entrepreneurship; City image; Productivity; Job market; International integration. Smart People: Education; Lifelong learning; Ethnic plurality; Open mind. **Smart Governance**: Political Awareness; Public and social services; Efficient administration. **Smart Mobility**: National and international and local transport system; (inter-)national accessibility; Infrastructure – ICT; Sustainability of the transport system. **Smart Environment**: Air quality; Ecological awareness; Sustainable resource management. Intelligent Coexistence: Cultural and leisure facilities; Health conditions; Individual security; Housing quality; Education facilities; Tourist attractions; Social cohesion.

Smart city is an "Internet of things" application in a specific environment. For Lohachab (2020), this specific scenario is a vital (not only physical) and complex scenario, such as what constitutes the city. ICT, according to Pérez et al (2019), enter the concept of smart city in several initiatives and applications that allow monitoring the provision of services and measuring the measures taken by the municipal administration.

Collaborative governance depends on bringing local governments and civil society together to develop smart and sustainable cities. For Conti et al (2019), collaborative governance refers to how power relations and the different actors are articulated, using a series of tools and mechanisms to build long-term solutions in a balanced, complete and transparent way. According to Conti and Vieira (2020), digital platforms represents a governance mechanism in real time, which allows the structuring of collaborative governance models in networks, the exchange of experiences and the construction of knowledge between different social actors.

2 ICT IN THE CONSOLIDATION OF AUTOPOIETIC SMART CITIES

2.1 Urban autopoiesis and aspects of biomimetics

Griffith and Berdague (2006) present a systemic vision and a biological explanation of the problems of the city, based on the concepts of semiosis, ontogeny and autopoiesis. Griffith and Berdague (2006) propose a semi-permeable border, which allows exchanges between the internal organization and its environment, in order to constitute a system of "Autopoietic City". Thus, the city is able to monitor its own operation and make necessary adjustments at the border to control the entry and exit of flows. The city presents, according to Griffith and Berdague (2006), sufficient autonomy to self-organize, contributing with synergistic returns in its exterior, external environment, field or rural region.

Cunha (2019) adapted Maturana and Varela's theory in their study, presenting the smart city as a living organism, allowing to visualize the city with different characteristics, as well as the elements of a human body. Chart 1 shows the relationship of these elements.

Table1 Relationship of the Elements of the Human Body with Smart Cities

Body Elements	**Cities Relationship**	**Dimensions reached**
Heart	Heart The heart of a Smart City is the city center. It is the space that brings the soul of the city, its values, its history and especially its visual and cultural identity. Smart Cities that stand out the most in the world are those that manage to capture their essential characteristics very well, strengthen and preserve them.	People, Quality of Life, Education, Entrepreneurship, Human Capital and Social Cohesion.
Brain and Nervous System	System Public bodies, service providers and concessionaires, the City Council and the city hall/government are the brains of the Intelligent City. The nervous system, according to current technology, uses all the data from sensors, Internet of Things and applications to provide the brain with information so that it is possible to make a much more effective and efficient management of all these resources in the city.	Governance, Government and Technology.
Circulatory system (Veins and Arteries)	The streets, roads and highways are the veins and arteries that transport various resources (human resources, water, sewage, electricity, garbage collection, communication) necessary for this organism to function. Arteries are the routes that depart from the city center (heart) to the periphery and other cities. Veins are the result of the junction of smaller pathways and promote the circulation of resources (vehicles, people, consumer goods, food, information, energy and water).	Infrastructure and Mobility.
Locomotor System (Skeleton and Muscles)	These are the physical and spatial characteristics of smart cities. The city can be characterized simply by its geographic area, climate, natural resources and its location in a given territory. On the other hand, muscles are socioeconomic characteristics, such as: number of	Environment, Quality of Life, Economy, Energy, Health and Urban Planning.

	inhabitants, Gross Domestic Product, number of public facilities (squares, schools and hospitals).	

Source: adapted from Cunha (2019)

For Cunha (2019), highly connected intelligent systems intensify the idea of autopoiesis, since they heterogeneously and universally recognize the diversity inherent in the environment of cities and promote their actions in a self-sustainable way. In the vision of Dalbelo (2019), autopoiesis is a holistic phenomenon that integrates the complexity of the urban ecosystem in its metabolism, and that guarantees its identity in a continuous process of maintenance, so urban autopoiesis must have its role recognized for urban sustainability at the ideal level. stage.

2.2 ICT in the consolidation of smart cities

For Weiss et al (2013), ICT platforms may be configured to allow their use as channels of knowledge transmission, access bridges to economic transactions and generation of wealth and creation of value that are developed through public scientific institutions and business architectures. conducive to fostering innovation, inclusion. and sustainable solutions. Castells (2012) relates the vision of the intelligence of cities with the convergence between the knowledge society and the digital city, which makes extensive use of telecommunications systems and internet resources as a means to significantly transform the forms of relationship and life within a region. From this perspective, the digital city is not necessarily smart, but the smart city necessarily has digital components (Nam; Pardo, 2011).

In addition, investment expectations for the acquisition of technologies by the government, especially at the local level, represent an additional motivation for this industry. ICT innovations applicable to city management are multiplying and are available to be implemented, allowing the creation and transformation of interactions between different social actors - government, companies, academia, non-governmental organizations and citizens (Weiss, 2019, p. 169).

Weiss et al (2013) further reinforce the importance of ICT and its transformative implications in the management pattern of cities, which produce benefits in terms of efficiency and performance, although there may be divergent opinions based on arguments based on consequences. social. even privacy (Dogdson; Gann, 2011).

ICTs provide the appropriate interfaces so that citizens can interact with their city, through digital services and so that public authorities can act preventively - or ideally predictively - through the use of monitoring, management and analysis systems (Hall, 2000; Kanter; Litow, 2009; Cromer, 2010; Toppeta, 2010; Harrison; Donnelly, 2011; Chourabi et al, 2012).

The ICTs are increasingly present in decision-making processes on the composition of factors that classify cities as smart. Numerous studies around the world mention the indexes and rankings elaborated to qualify the smartest cities, and that present innovative solutions for these urban spaces, creating a space for the decentralization of data, pulverization of its domain and transfer with responsibility, without the need for control or manipulation of data by a central actor.

2.3 Blockchain technology *plus* autopoietic smart city

Blockchain is a chain of blocks stored in a fully decentralized database, capable of storing permanent, inviolable and sequential records. The blockchain allows any transaction to be carried out, the verification is carried out instantly through any computer with transparency, speed and agility in operations, and eliminating intermediaries (Duran, 2017). Blockchain technology is a broad and flexible type of data structure that operates under the principles of Distributed Ledger Technology (Natarajan et al, 2017), which can seem complex and difficult to understand with respect to its basic components. According to the World Bank (2017), being a distributed system, blockchain data transactions are shared, validated and archived by different members of a network in a complementary way.

In terms of the breadth of technology use, although blockchain is often associated with digital or virtual currency schemes, payments, and financial services, its scope is much broader. According to Natarajan et al (2017, p. 22), "Theoretically, blockchain can be applied in a wide variety of sectors (for example: commerce, industry, health, governance...) and in many other potential applications: it may affect the provision of guarantees, the registration of shares, bonds and other assets, the transfer of property titles, the operation of the registries, among others".

The idea of using blockchain for a long time was limited to the financial sector. Although blockchain is a fairly new technology, it can be used widely across industries in new solutions. A survey conducted by the World Economic Forum in 2015 predicts that 10% of the world's GDP will be stored in blockchain technology by 2027.

Smart Contracts or Smart Contracts for cities are another innovative application within the blockchain, which has not yet been tested in practice to understand its impacts. Smart contracts are effectively small computer programs stored on a blockchain that will carry out a transaction under specific conditions. Therefore, a smart contract is typically a statement such as "transfer X to Y if Z occurs" (Grech; Camillieri, 2017). Blockchain provides several advantages for cities: flexibility, agility, no capital expenditure, compliance and scalability (Salha et al, 2020). Blockchain benefits include: reduced transaction costs, fast processes, privacy, and reliability. In the opinion of Witzig and Salomon (2018) blockchain technology operates in a multidimensional way. Other authors also comment on the characteristics of blockchain often using different terms. However, there is consensus around four core properties of blockchain technology, which drive data transparency, security, and privacy.

According to Tapscott and Tapscott (2017) it is also important to comment on the need to use blockchain in institutional innovations with systems open to transparency and information governance. Governance favors the consensus mechanism to validate the information that comes directly from the source, helping to work against the misuse of information.

3 RESEARCH METHODOLOGY

This work considered a data collection or survey applied to professionals with in-depth understanding of the blockchain structure in Brazil was carried out, in the period between October and November 2020. The data sample in the research comprised twenty-one experts in blockchain technology in the areas - financial and tokenization, educational, industrial. The survey data was merged into the Google form.

The questionnaire consisted on twenty-two closed and semi-structured questions to survey the use of the blockchain in smart cities and possible effects in the regional context. It was developed based on the existing literature to verify the applicability of blockchain technology in transforming cities into smart cities.

4 SURVEY RESULTS ON THE APPLICATION OF BLOCKCHAIN IN SMART CITIES

The survey carried out on the applicability of blockchain in the governance process in autopoietic smart cities showed that the technology has been applied more in the Brain dimension, and less in the Locomotor dimension, and that even the smartest cities are fragile in some dimensions. It seems that autopoiesis, the smart city and blockchain technology are connected through the dimensions in which they can be worked. Therefore, for each dimension of autopoietic smart cities the following meanings and levels are observed:

• At the heart of smart cities are people, quality of life, education, entrepreneurship, human capital and social cohesion: governance and technology. In addition, there is the impact on formal employment, education and P&D. Through the responses obtained, it was found that the blockchain is possible to apply, achieving an impact on people - Connected Smart Cities allowing to advance in this ranking, reaching intelligent coexistence and intelligent people;

• The brain and nervous system of smart cities address governance, technologies for cities and the perceived impact on government services. It means that smart governance is possible in sustainable governance,

considering laws and regulations. The Smart Connected Cities Ranking allows advances in the integration of blockchain with broadband connections;

• The Smart Cities Circulatory System covers infrastructure and mobility and the environment, which means reaching the dimension of smart mobility and the smart environment, that is, a technological, sustainable and safe city;

• Regarding the Locomotive System of smart cities, the quality of life, the economy, energy, health and urban planning are part of it. However, for this dimension the lowest average was obtained, resulting in a lower applicability of blockchain technology according to the research. The financial sector responsible for the transactions is the basis of this technology and the forerunner of its use.

Technologies such as sensors, IoT, Big Data, Broadband and, above all, artificial intelligence enable solutions to current urban problems and the planning of solutions for challenges in future scenarios. Once the challenges are overcome, it will only be necessary to wait for the city management systems to be adequate, linking the devices of the cities, such as sensors in the streets, parks and local buildings, to collect information for public use, and then use the data collected to provide better and more efficient services.

The sampling restricted to a select number of experts impacted the limitation of the research, also influenced by the fact that the blockchain is a new and still little explored technology.

Future research proposes to apply a sample with a greater number of blockchain specialists who, although acting mainly in the financial market, can collaborate in the development of online platforms, as recently suggested by Ursula Huws (Huws, 2020): a participatory governance system from the city.

CONCLUSION

This article seeks to investigate the applicability of blockchain in the governance process in autopoietic smart cities, gathering and comparing information by applying a questionnaire to market specialists who work with this technology. Based on the data collected, it is possible to affirm that the blockchain has applicability, within smart cities, generating self-regulation and self-sufficiency in the city's governance system.

The survey conducted on the applicability of blockchain in the governance process in autopoietic smart cities showed that the technology has been applied more in the Brain dimension and less in the Locomotive Device dimension, and that even the smartest cities are fragile in some dimensions. It seems that autopoiesis, the smart city and blockchain technology are connected through the dimensions in which you can work.

Similarly, is the people's relationship with blockchain technology, in the qualifying sense, directly interferes with the use of the Internet of Things (IoT - Internet of Things) - cars, houses, buildings, public places - by integrating with devices specific virtually connected by ICT.

Regarding the biggest obstacle to the adoption of blockchain technology in government services, the smart contract variables for the management of origin, transportation and consumption of resources, health and financial services (for example, storage and security of data, increased transaction volume, interruption of several intermediate layers), to the possibility of blockchain integration with higher speed broadband connections, are directly related. This fact is explained by the lack of awareness and education derived from the public sector, on the contrary, the private sector invests much more in technology and information for the use of the blockchain.

The autopoietic smart city proposal, using for example blockchain, has the potential to be elaborated and developed and to conceive cities as living and adaptable organisms. The proposed indicators and the suggested dimensions allow the integration of different areas of knowledge. The development of this proposal, however, depends on establishing the necessary considerations, as well as evaluating the dependencies and impacts of each dimension and indicator on the others. Technologies such as sensors, IoT, Big Data, Broadband and, above all, artificial intelligence enable solutions to current urban problems and the planning of solutions for challenges in future scenarios.

In the last 5 to 10 years, we have seen an increase in the flow of immigrants from Latin America to the United States and Europe, an unprecedented level of intra-regional migration, which has led to an increase in the need to send money to relatives and friends. Money remittances reach regions like the United States, Europe, and

within the region, and represent a $ 100 billion industry in Latin America. Migrants need fast, cheap and secure transactions, which can be made available through the use of cryptocurrencies and blockchain technology.

Subsequently, governments and legislators need to move. As this is something relatively new and unknown - changes in legislation are needed to ensure flexibility and confidence in the use of the blockchain. For the initiative to expand, a gradual movement is also necessary, starting from the professionals themselves, since according to the data collected, the level of knowledge about blockchain is low.

Recently, these types of initiatives could have helped to control the COVID-19 pandemic and would have been very useful for the socioeconomic balance, the preservation of Biodiversity and the Control of Climate Change. Once the challenges are overcome, it will only be necessary to wait for the city management systems to be adequate, linking the devices of the cities, such as sensors in the streets, parks and local buildings, to collect information for public use, and then use the collected data to provide better, fairer and more efficient services.

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