Smart Contracts with Blockchain in the Public Sector

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Abstract

The appearance of so-called block chains or Blockchain with the promise of transforming trust and the way value is exchanged, joins the expansion of the technological capabilities of organizations to achieve higher levels of productivity and innovation. This is how Blockchain-based techniques are being applied to many fields, focusing in this article on the public sector, as a possible solution to the demands for transparency, participation and citizen cooperation that society demands; due to the possibility of disintermediation based on automated transactions and on the responsibility and security in the management of official blockchain records. This could obstruct corruption and make government services more transparent and efficient. Although, it investigates about applications in the public sector under the Blockchain system, such as transactions, agreements, property registries and innovations, developments and other assets; Special emphasis is placed on the possibility of implementing Smart Contracts (mechanisms that aim to eliminate intermediaries to simplify processes) in public procurement procedures, given that it is in this type of activity where high levels of corruption are generated. It is concluded then that Europe has the largest number of blockchain initiatives worldwide, while Latin America, except for the case of Peru, lacks this type of applications, being this continent exactly where there are the countries with the highest levels of corruption. It concludes with a recommendation to use blockchain along with smart contracts through platforms such as Ethereum or Lisk, mainly given its flexibility and current development on topics with similar functionalities.

Keywords

Blockchain, Smart Contract, Public Sector, Transparency, Corruption.

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I. Introduction

The last decade has been characterized by a significant development of the Internet of Things (IoT), defined as the interconnection of objects connected to the Internet with the ability to communicate [1] and which is becoming part of organizations' technological capabilities and enable them to achieve increasingly accelerated levels of productivity and innovation [2]. In addition to the above, it is the artificial intelligence that is driving data mining [3]; Model-Driven Engineering (MDE) that emerges as the answer to the industrialization of software development because it provides better productivity and quality [4]; as well as the appearance of the so-called Blockchain is added with the promise of radically transforming the way in which value is exchanged [5].

The Blockchain emerged in 2008, as a proposal made by Satoshi Nakamoto [5], at a time when the deterioration of the economy, credit mistrust and the mortgage crisis, consumed the US market, and which would later spread to other countries [6]. Nakamoto's proposal aims to replace the centralized model with a decentralized one, where the decision-making power over the system is delegated directly to the users of the blockchain.

Blockchain-based techniques have become independent and evolved from Bitcoin, being applicable to many fields that go beyond currency, finance and markets [7], it is seen as a technical and economic innovation [8] [9] [10] particularly in the areas of government, health, science, literacy, culture and art [11], becoming a key factor in solving scalability, privacy and reliability problems directly related to the IoT paradigm [12].

A smart contract has de ability of executing and enforcing itself, autonomously and automatically, without intermediaries and is valid, without depending on authorities or third parties [8] by consensus of network users [13] [14]; eliminating bureaucracy given the decentralized, immutable and transparent nature of Blockchain technology.

Returning to Blockchain technology, and taking it to the field of government / State, within the framework of the society that demands transparency, participation and citizen cooperation; it is found that this technology potentially allows individuals and communities to redesign their relations in politics and society in general, with a process of large-scale disintermediation, based on automated transactions and responsibility and security in the management of official records [15] [16], which could favor the system of their states and eventually obstruct corruption and make government services more transparent and efficient [17], given that the blockchain offers a wide range of potential solutions in different governmental areas and that mainly benefit the citizen [18].

Therefore, Blockchain in public management could constitute decentralized solutions and consensus-driven public repositories, which may have a series of applications to make citizens less dependent on governments, but within a society that is ultimately based on State authority. Thus, providing the same services offered by the state and the corresponding public authorities (maintaining their validity), in a

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decentralized and efficient manner through Blockchain, does not mean dismissing the State, but promoting good government; this is "making better governments when all power is not concentrated in the hands of a few people" [17][19].

According to Preukschat [20], the public administration is in crisis because the way of understanding it is changing, and in order to adapt to these changes, it is necessary to promote new measures that guarantee an active and intelligent model, given that citizens demand more transparent, fast and efficient administration.

For this reason, integrating Blockchain in public management would suppose the solution of many of the problems that society frequently claims, and directly influencing organizations [9], at the same time that infrastructure cost savings could be incurred, given the relative simplicity in transactions using smart contracts [13].

This article provides a review of the level of progress in blockchain applications in public administration to find out what the future challenges and developments in this area could be.

II. Methodology

This work corresponds to the literature review related to the terms in both Spanish and English, in the advanced search engines and relevant databases, of: blockchain, smart contracts, open government, public administration, transparency and citizen participation.

After the selection of the conclusive terms for the research, they have been used to make queries in verified sources of information, such as forums recognized by the member states of the European Union, bibliographic and legal (legislative) databases, institutional and thematic repositories, platforms and indices on the level of national transparency:

1. EU Blockchain Observatory and Forum.
2. Bibliographic databases and academic and scientific repositories.
3. Information sources and database corresponding to current regulations and their respective modifications.
4. Transparency Portal of the Government of Spain, Transparency International - The Global Anti-Corruption Coalition, Transparency International Spain (TI - Spain) and Transparency Portal of the Generalitat Valenciana.
5. Transparency Indexes, the work analyzes the Transparency Index of the Autonomous Communities (INCAU) and the Transparency Index of the Municipalities (ITA).

Subsequently, a review was made of what is known, who and how blockchain has been studied and its repercussions in the different areas that can be introduced, as well as the origin and contribution of Smart contracts.

Knowing the bases, an analysis has been made of the cases in which blockchain-based applications or projects have been developed, of interest mainly to the public sector, showing them through a list of tables that allow analyzing the degree of implementation and viability following a pattern of own elaboration. Finally, a discussion was held on the proposed application, concluding observations, and analysis of future research.

III. Technical Context

First of all, it is important to review the definitions that exist of blockchain and Smart contracts, as well as their functions and applications in different contexts.

A. Blockchain

The blockchain is considered as a more recent technological revolution that can change the way of working of many industries; however, the greatest recognition has been achieved in the financial sector, due to the rise of bitcoin.

This term, popular for a few years, was born in 2009 associated with the aforementioned bitcoin, by Satoshi Nakamoto and is conceived as a decentralized, autonomous, auditable and reliable registry or database of transactions [18]; popularity also of the success of other cryptocurrencies [21]. Its origin is related to cryptography, linked to wars and power struggles between states, whose use intensified in the 1990s with cryptoanarchism, framed in the movement "cypherpunks" or activists who oppose surveillance of computer networks by states and evade censorship, defend the generalization of cryptography and technologies that improve privacy [20].

Thus, the Blockchain is a distributed peer-to-peer data structure in which untrusted members can interact with each other, verifiably without a trusted intermediary [22], this structure is shared and replicated between members of a network and in bitcoin, becoming the public and validated registry of all the transactions that have been executed [5] [23] [24] having the blockchain complete information about the balances of the initial block.

The potential of the blockchain is approached in a way that is accessible to different industries and sectors, including the internet of value model, different from the information internet.

The information available at the internet, allows its free circulation of information creating an infinity of business models; for its part, the internet of value is a tool to manage and share the value of digital assets or assets without the need to depend on a trusted central entity.

Blockchain became popular as the technology behind the Bitcoin cryptocurrency and as previously stated, it has emerged in other ways among applications such as smart contracts, which are scripts in the blockchain that allow automating multi-step processes, allowing self-fulfillment of digital contracts that are based on a counterfeit-proof consensus on contingent results, and financing through initial coin offerings [8].

Likewise, as with all new fashions, both technical and legal discrepancies and limitations arise when it comes to their large-scale application and it is essential to present and analyze them in order to carry out the review.

With the purpose of establishing an approach to the developments, applications and trends that originate in the context of BlockChain, a bibliographic review related to the subject is done in the first instance. The search continued to be delimited, including the criteria of blockchain and smart contracts in the areas of services, industry, logistics and public sector. As a result, the analysis proceeded with 21 documents [12], [25]-[44]. As a result of the review and analysis, Table I was obtained.

For the development of this research, it is important to note that, of the total number of markings (137), 13% (18) respond to problems associated with security, transparency and trust, 12% (16) correspond to developments supported by Smart contracts and 9% (13) are applications oriented to the public sector.

B. Smart Contracts

A very practical use of the blockchain is precisely smart contracts, which are tools that allow the automatic and independent execution of those terms of a contract that are programmable in relation to their functions through mathematical logic (IF + Then) and that make its clauses binding, unstoppable and automatic, and can be executed by external conditions. In addition, they guarantee the execution of a contract (neutrality principle), the delivery of digital goods and make the delivery of real goods and services more efficient.

Therefore, an smart contract can be understood as any contract

TABLE I. Topics and Applications Addressed with Blockchain in Services, Industry and Logistics

BlockChain in services, industry and logistics		
Grouping by topic	**Topics**	**Number of matching keywords**
Management, validation and registration of information	Registry maintenance	3
	Registration and protection of Industrial and Intellectual property	4
	BlockChain as a mechanism to provide Security, Transparency and Trust	18
BlockChain payment network	Cars with connectivity to make micro payments	1
	Air delivery drones that allow micro payments	2
BlockChain developments and tools	Platforms for the development of BlockChain Applications	1
	Ethereum blockchain and platform	5
	Smart contracts	16
	Digital Identity	7
Applications with decentralized features	DAOs (Decentralized Autonomous Organizations), DACs (Decentralized Autonomous Corporations) and DASs (Decentralized Autonomous Societies)	2
	Dapps (Distributed / Decentralized Applications)	8
BlockChain categories	Public BlockChains	9
	Private BlockChains	10
	Semi-private BlockChains	4
Traceability	Product life cycle	2
	Traceability and Logistics Systems (Supply Chain)	5
	Traceability in the automotive sector	1
	Transparency and Traceability in the Food Sector	3
	RFID	4
Applications in the area of technology and computing	Artificial Intelligence supported in BlockChain	1
	Applications that incorporate Internet of Things (IoT) and BlockChain	8
	Electronic Commerce	2
	Machine to Machine Interactions (M2M)	3
	CMfg (Cloud Manufacturing)	4
Environmental applications	Blockchain and Climate Change	1
BlockChain for business and business sectors	BlockChain and Insurance Companies	2
	Exchange of electricity through agreements supported in BlockChain	5
	Construction projects	1
	Exchange and Transaction of knowledge between teams and organizations	1
	Collaborative and Shared Economy	2
	Blockchain and Business Processes (BPM)	2

that executes by itself automatically without the measurement of third parties, but does not involve the use of artificial intelligence, they are written as computer programs or codes in which rules and consequences are defined and described, instead of being written in legal language on printed documents as they are traditionally known [27], since they act as binding agreements between two or more parties, and reside on the blockchain.

The term predates the blockchain with Nick Szaboo, who in 1994 was the first to use the term smart contract, defining it as a protocol for systematized transactions that execute the terms of a contract, mitigating the intervention of trustworthy third parties and avoiding malicious exceptions. They also inherit all the power that blockchain confers in terms of anonymity, security and decentralization [5].

IV. Blockchain and Smart Contracts Applications in the Public Sector

Public administration is one of the most relevant economic sectors because it is responsible for ensuring economic growth of a nation, as well as for establishing public policies that favor the social and economic well-being of citizens.

However, the current public administration does not provide comprehensive responses to society's demands, is not efficient, and is perceived as slow and bureaucratic [20]. So it is necessary to incorporate new perspectives to regain trust with more transparent, faster, more efficient and integrated models in the daily life of citizens, which also allows their participation and incidence, and in this sense, the blockchain system not only serves for companies seeking benefits, but also for public entities, both in the field of government, education, health, and in energy networks [28] , transport systems and social services, among others [29].

Taking into account that transparency was mentioned as a problem in the current public administration [18], it is crucial to change the behavior of an institution, you cannot force yourself to choose certain behaviors, but you can limit your decisions and actions.

In this sense, transcending the economic plane, the term "smart contracts" can be used as a pact of conditions in any field, which does not require intermediaries to validate or monitor compliance, which does not give rise to misleading interpretations and that they are completely transparent [30], because they execute themselves and are stored on a blockchain, which no one can control and that everyone can trust. In this sense, the blockchain system will allow these processes to be automated and will guarantee the integrity of their transactions, administrative concessions, records and important decisions, so that officials could not hide payments or official records or other manipulations from inside or outside and will favor greater control, traceability and transparency in the processes.

Currently, public administrations are going through a period of credibility crisis in many fields caused, in part, by the lack of innovative processes and the way of involving citizens in their decision-making [29]. The search for innovative resources to rethink communication and relationship with citizens must therefore be a constant in the management of Organizations and cities. The appearance of new currents of land management, such as those associated with the termination of Smart cities or the Internet of Things, cannot ignore the relationship with the citizen and the way in which he relates to and takes part in the own management of the territory [30].

Although in recent years, terms such as open government, transparency and electronic administration have been invoked as if they were modernizing public administration, it continues to lack the capacity to satisfactorily incorporate those instruments that would allow the most effective and efficient public activity. Therefore, an

administration incorporated into technological change in which the blockchain would make possible the aforementioned demands should be considered, by enabling citizens, companies and civil society organizations to access relevant information, improve public services and participate in decision-making more actively.

Among the benefits of blockchain is electronic voting, which decentralizes responsibility and disperses it among the participating nodes[12], which are the ones that achieve consensus on the data housed in the database by being based on centralized systems and governed by a single source.

Another application of blockchain in the public sector, is proposed by the Republic of Estonia, which has designed an e-government strategy based on interconnectivity and decentralization, openness and cyber security [29], which is why it is considered a leading country in digital government. and second with better indicators of social progress in terms of civil and political rights, along with Australia and the United Kingdom [29].

Estonia has recently launched its e-Residency program, in which anyone in the world can request a "transnational digital identity" and authentication to access secure services, as well as encrypt, verify and sign documents digitally. Currently the country is deploying a Blockchain system to streamline the sharing of various types of data between the Public Administration (legal, etc.), as well as its protection and security, and transparency.

Sweden, for its part, plans to build a blockchain-based property registry in search of security, modernity and transparency, thereby reducing the delay between signing a contract and registering it [27], the model has been exported to Georgia and Honduras.

In another case, in 2018 the signing of a Declaration for the establishment of a "European Blockchain Partnership" was signed, to address the digital transformation process that is looming for both public employees as well as citizens through the blockchain [31].

Already in Spain, the development of blockchain projects for the Public Administration is still in a premature phase, the uses of blockchain in Public Administrations are scarce, two of them are developed in the field of public procurement, one of the areas that, rightly, as suitable to "benefit" from this technology. This is the use of blockchain in the register of contractors, which was tendered by Basque Government´s Information Society (EJIE) in January 2018, from the Government of Aragon, to create a decentralized registry of public contract offers that allows a valuation afterwards automated offerings through smart contracts [32].

These initiatives in the form of contracting originate because the estimated amount of the weight of public procurement over GDP ranges from 18 to 20%, of which, the National Market and Competition Commission (CNMC) estimates that at least 48,000 million euros (4.5% of GDP) of the amount of the contracts must be associated with extra costs caused by the lack of transparency and competition in public procurement [32], for which the Council of the European Union issued a warning-recommendation to Spain to adopt measures aimed at reducing the deficit, expressing in this regard that in our country there is a "lack of sufficient a priori and a posteriori control mechanisms that hinder the correct and uniform application of public procurement legislation" [33]; as well as an absence of effective transparency.

Apart from the contracting projects mentioned in the previous paragraph, there is also the Project developed by the Alcobendas City Council: "Blockchain technology-based citizen participation voting system", the results of which were presented at the IV Congress of Smart Cities in 2018 [32].

On the other hand, in the same year, a Proposition of Law on regulation, taxation, communication of the legal use of cryptocurrencies and blockchain technology was approved by the Finance and Public Service Commission of the Congress of Deputies [34].

Table II summarizes the incursion of blockchain and Smart contracts in the public sector based on information from the European Union Observatory and Blockchain Forum [35].

The opportunities offered by the Blockchain are multiple, not only with a business vision. Regarding the public sector, some projects currently in the process of innovation are listed below:

1. Bit Nation

BitNation is a project based on smart contracts and Ethereum technology, and is defined as a "Decentralized Voluntary Nation without Borders" or digital nation. It is an open government, governance project that proposes solutions to have protected but demonstrable identity documentation, "public" coverage or insurance systems, management of "bitreputation" or reliability between commercial agents, and generation of procedures, such as birth certificates, among others [36].

2. D-Cent Project

D-Cent is a European-funded project that is in the research stage, to generate publicly owned "Citizen Participation Technologies", but seeking greater agility and public or diversified innovation. This project brings together various European initiatives, including those generated in Finland, Iceland and Spain (in the latter case, represented by projects promoted by the municipalities of Madrid and Barcelona).

One of the technological bases is the Blockchain, and thus seeks to generate technologies for the democratic management of Big Data (data generated by citizens and cities), to protect and ensure privacy and data protection with regulations, or manage spaces of digital public debate and deliberation [37].

3. DECODE Project

It is a European funding project that works on the idea of how citizens will be able to decide and manage their data in a scenario of greater transparency, automation and digitization of the data of cities and identities, as well as the economic impact that they could generate in these cities.

Barcelona and Amsterdam were the chosen cities to promote pilot projects. Specifically, in Barcelona it will revolve around the management of Open Democracy and the Internet of Things, while in Amsterdam it will focus on collaborative economies and the Internet of Things [38].

4. Property Registration

Blockchain allows the "tokenization" of assets, so that its transmission can be carried out with the confidence that the seller is who he says he is and can answer for the buyer, the payment is who he says he is and is the owner of the property that is transmitted and a Smart contract is in charge of automatically verifying all those circumstances and making payment for the property and registering it on behalf of the new owner [39].

In this sense, Germany, Dubai, South Korea, Ghana, Kenya, Singapore, Sweden, the United Kingdom, Brazil, Japan, the Indian state of Andhra Pradesh, the American state of Illinois, Ukraine, Croatia, Russia, etc., they are in the process or have already implemented property registration through Blockchain and try, to a greater or lesser extent, to solve similar problems such as fraud, corruption, transparency, the absence or multiplicity of data on the ground.

V. Results and Discussion

A. Potential of Blockchain in Public Procurement

The World Economic Forum estimates that the costs generated by

TABLE II. Blockchain and Smart Contracts Applications in the Public Sector

Country	Application	Status	Observations
Estonia	Online vote	Working	
Australia	Electronic Vote	Initiative	It would start with corporate and community elections before escalating to parliamentary elections.
United Kingdom	Online vote	Tests	
Sweden	Registration of property titles	Prototype	
Georgia	Registration of property titles	Prototype	
Honduras	Registration of property titles	Prototype	
Ghana	Registration of property titles	Prototype	
Russia	Registration of property titles	Prototype	The project aims to mitigate the possibility of corruption, while providing clients with secure and verifiable electronic receipts. It enables independent smart contract audits, as well as decentralized identity management, it has the potential to simplify the public registration process and ongoing maintenance through digital channels.
Switzerland	Online vote	Working	
Denmark	Online vote	Tests	
France	Online vote	Tests	
Holland	Online vote	Tests	
Australia	Digital identity	Initiative	It will allow people to verify their identity in a short time through a smartphone using biometric data.
China	Tax administration and electronic invoice issuance	Initiative	The Chinese government will use blockchain technology to organize and administer the system for collecting taxes and issuing electronic invoices. Reports indicate that China's existing tax system generates nearly two and a half trillion dollars in revenue, but officials believe there is a widespread tax evasion.
Dubai	Verification of electronic medical records between hospitals and clinics	Initiative	
Italy	Digital identity	Initiative	The pilot scheme will be implemented with the Estonian blockchain provider, and will include the existing manual process that will be replaced with a system that uses blockchain technology that can automatically transfer and verify patient records in seconds.
Vancouver	Public repository of verifiable claims on organizations.	No information	
Vancouver	Land registry	In verification	
United States	Electronic vote	In production	
United States	Elimination of paper records	No information	The Senate suggests that the use of a distributed ledger would eliminate the need for paper records and in-person updating of such data. Subsequently, the blockchain system would solve the existing data collection and retention problems in the state and create a more secure registry.
United States	Manage the identification of state residents, as well as tokenize assets in the public sector to improve efficiency and reduce rights fraud.	No information	Using a blockchain-based platform would allow state citizens to access and store all of their identifying information, such as taxes, voting and driver's licenses, etc., as decentralized nodes.
United States	Transfer of ownership		
	Digital identity		Birth records allow the state to issue a digital identity linked to the birth of a person that could be managed in a distributed ledger, adding attributes as the citizen interacts with different agencies throughout his life.
United States	Urban planning and public space (city planning and design)	Pilot	
	Citizen security		

corruption amount to more than 2.6 trillion dollars (more than 5% of the World Gross Product) [40], while in a report entitled "Myths and realities of governance and corruption", the World Bank has estimated that more than one trillion dollars per year is paid in bribes only [41]. This indicates that close to 2% of the World Gross Product ends up in the hands of corrupt government agents who intervene in the execution of various acts of the States and that, if the technology of smart contracts is implemented efficiently, they could be left without the power they use with illegitimate purposes for their own benefit or those of third parties, for example in public tenders that are automatically assigned to companies that have been the best bidders and not to those whose officials have offered some type of unofficial incentive or handouts, eliminating the possibility that There is an intermediary who can facilitate the completion of this payment or that the contractor collects without having executed the agreed work.

Using blockchain technology, each of the transactions can be traced to their origin, which contributes significantly to the prosecution of an eventual act of corruption. The differential that smart contracts provide over other solutions based on blockchain technology is in the self-execution of the instructions and the operations that they regulate, which generates an impossibility or, at least, an increase in the difficulty of executing acts of corruption.

Based on the above, it is important to state the issue of public procurement as one of the largest generators of corruption, given that it represents a substantial part of taxpayers' money worldwide, and remains the most vulnerable activity to waste, the fraud and corruption. Evidence of this is provided by data from the Open Government Partnership [42], which accounts for around 50% of the total spending of a typical government in low- and middle-income countries, and about 30% in high-income countries [43].

On average, 10-20% of procurement budgets can be wasted depending on the degree of corruption and waste and inefficiencies. Corruption distorts a fair adjudication system, limits the equality of opportunities between bidders, harming competition and consequently, decreasing the quality of public works, supplies and services, which also ends up undermining confidence in public institutions [43]

Recently the Communication COM (2017) 572 final from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, explicitly recognizes that the strictest provisions on the integrity and transparency of Directives are aimed at fighting corruption and fraud, and presents a public procurement strategy that establishes the general policy framework and defines clear priorities for improving procurement in practice and supporting investments within the EU, in the fight corruption in public procurement occupies a prevailing place [44].

On the other hand, the Organization for Economic Cooperation and Development (OECD) in its "Principles for integrity in Public Procurement" [45] maintains that integrity in public procurement is implemented in practice through four principles: good management, transparency, prevention of misconduct and accountability.

On the other hand, the Open Government Partnership (OGP) global report highlights that "*corruption in public procurement can reduce the value of contracts by up to 15% (depending on the estimate used). Open contracting - including the publication of contracts and citizen participation, monitoring and supervision - have shown that it has the potential to generate tax savings, reduce corruption and strengthen business participation*" [43], which demonstrates the great potential of block chain to improve indicators of fight against corruption worldwide.

In accordance with the aforementioned, the simple digitization of the contracting procedures from start to finish, and the establishment of publication of practically all the events of the procedure through applications in open and interoperable formats[46], consistent with the legislation of each country, and the multiplication of control mechanisms, introduce elements of transparency in the contracting process that by themselves reduce the possibilities of fraud, corruption and inefficiency. However, the characteristics of immutability, confidentiality, traceability and transparency of Blockchain together with the automation and disintermediation that Smart Contracts involve, makes it especially useful in the fight against corruption and fraud.

In addition, Botto and Castrovinci have pointed out as novelties that the use of Blockchain would report, in addition to the possibility of establishing a mechanism to control the integrity of the documentation and the process carried out by the bidding companies themselves, the reduction in the calendar of the procedures associated with tenders, given precisely because a Smart contract has already defined the execution rules [47]. In fact, if you plan to go beyond the award, Morris Gitonga points out that the use of Blockchain technology can prevent corruption in the management of awarded tenders insofar as all events are transparent and verifiable by each bidder [48].

In conclusion, given the characteristics of immutability, confidentiality, traceability and transparency of Blockchain together with the automation that Smart Contracts imply, it makes contracting procedures in the public sector the ideal field for its implementation, which would not eliminate corruption but if it would allow its early detection so that corrective and preventive measures can be taken.

Now for the development of this type of applications, a development platform is required that allows the incorporation of Blockchain and Smart contracts; within which, the University of Malaga in "On blockchain and its integration with IoT. Challenges and opportunities" [12] identifies various tools available for this type of development. Table III is a comparative table that evaluates this type of platform under four criteria: Blockchain type, consensus, cryptocurrency and smart contracts".

TABLE III. Blockchain Platforms for Creating Blockchain Applications (Taken From [12])

Platform	Blockchain	Consensus	Crypto currency	Smart contracts
Ethereum	Public and permission-based	PoS	Ether (ETH)	Yes
Hyperledger Fabric	Permission-based	PBTF/SIEVE	None	Yes
Multichain	Permission-based	PBTF	Multi-currency	Yes
Litecoin	Public	Scrypt	litecoins (LTC)	No
Lisk	Public and permission-based	DPoS	LSK	Yes
Quorum	Permission-based	Multiple	ETH	Yes
HDAC	Permission-based	ePoW,Trust-based	Multiasset	Yes

Based on Table III, the criteria to determine the most favorable platforms for the development of the application proposed here are evaluated, that is, they must allow the integration of Blockchain and Smart contracts as a minimum. Thus, Litecoin, Hyperledger Fabric, Multichain and Quorum are discarded, the first of them because it is not incorporating Smart contracts, and the others because they are limited to operating as managers of financial resources, under private

blockchain [49]. The rest meet the established criteria, however HDAC is ruled out, since it is a platform still under development [12]. Therefore Ethereum pioneered smart contracts and implementation in various areas [50] and Lisk, which enables the creation and implementation of decentralized applications, would be the recommended platforms to advance this solution [49].

Additionally, Ethereum and Lisk are determined as possible applications, because they are supported by public Blockchain technology, that is, it allows unrestricted access and the transparency parameter [51] prevails, allowing participation to be open, without loss of the attributes of security, transparency and traceability; this is just what it is required for the public sector.

The elements that make up the selected applications are built from the public BlockChain data structure and the Smart contracts that are derived from it, give the tool versatility without neglecting security, configuring a suitable space to be an axis of interaction, between the state, the bidders and the citizens interested in the contracting process, where each one can use and participate in the network, thus efficiently connecting to the various actors present, streamlining the stages of the process, having better access and data control, but allowing transparency in evaluation and adjudication.

B. Experiences of the Use of Blockchain in Public Procurement

There are several initiatives for the use of Blockchain in the public procurement that are presented below, however, no information on projects in operation was found except in the case of Peru:

- In Peru, the government agency for public procurement "Perú Compras" included the use of Blockchain in April 2018, to register purchase orders digitally. Since then, the country has registered nearly 50,000 purchase orders through its Electronic Catalogs platform [52]. Peru recognizes the application of Blockchain technology as an effective tool to provide transparency to the field of public procurement. Perú Compras operates through the Blockchain LAC-Chain network, a decentralized project of the Inter-American Development Bank (IDB) [53]. Since integration with the project, the objective is to promote the use of block technology among the countries of Latin America and the Caribbean.
- In Mexico, attendees at Talent Land 2018 were able to appreciate how a purchasing unit can make a call for tenders and how a company can apply to offer its products and services to the government, all through the blockchain, which makes transactions immutable and fully traceable [53]. This project currently has a design, a prototype in an alpha version with transactionality, it is expected to allow it to fulfill a period of maturity until reaching a beta version and then evaluate the possibility of applying it in a real case that goes along with Compranet, the Transactional system that allows public institutions in Mexico to carry out contracting procedures electronically, mixed or in person. The project has not been implemented due to regulatory problems that arise from introducing a technology into a government administrative process.
- In 2018, Canada successfully conducted the first ever use of public Blockchain technology (on Ethereum) in public contracts in order to enable transparent administration of government contracts [39].
- In the United States, the United States Government General Services Agency (GSA), through its Office of Emerging Citizen Technology, announced the launch of the United States Federal Blockchain Program with the objective that federal agencies and American companies can explore Blockchain technology [39].
- In Chile, in July 2018, a pilot test began for the use of Blockchain in public procurement, with the aim of improving Confidence indexes, transparency and less bureaucracy[54]. However, the results of the pilot test are not known and in September 2019, Chile established a cooperation agreement with Peru so that between both central Public Procurement they promote the exchange of successful experiences in state procurement processes and optimize electronic systems contracting in both countries.
- In Japan the application of Blockchain to Public Procurement is being tested. At the end of 2019, a meeting was held between Peru Purchases and the Korean contracting entity, in which the Asian representatives were interested in learning more about the application of technology in the public procurement sector [55].

C. Blockchain in the Tender and Award Procedure

The use of blockchain in public procurement should be oriented to respond to different models according to the legislation of the country where it is implemented, but there are common themes and activities that have been identified in the model for presentation and evaluation of offers proposed by Freya Sheer Hardwick, et al. [56], presented in Fig. 1.

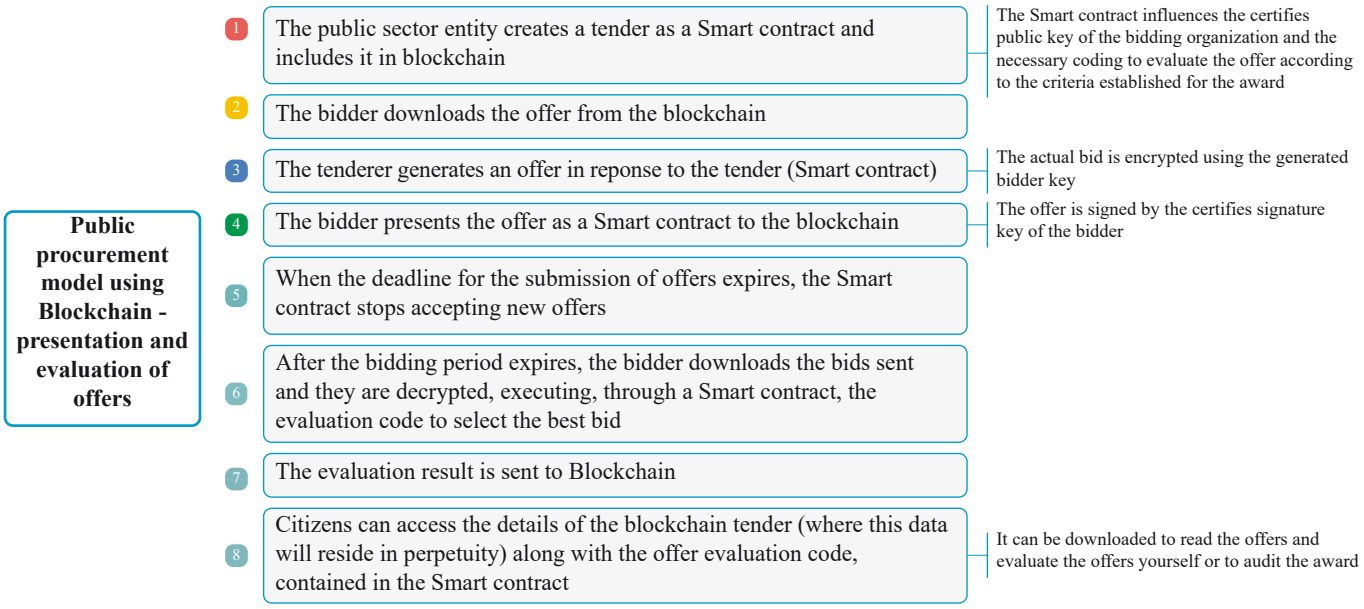

Fig. 1. Example of evaluation of bids under the smart contract approach (based on [56]).

D. Blockchain on the Confidentiality of the Documents of the Contractual Process

Blockchain technology can act as a guarantee of security and confidentiality in relation to the information that public sector entities place in the hands of the bidders in the bidding process, in which case the proof of the existence of consent for their access is marked and stored on Blockchain.

Obtaining consent must be a "block" before access to information classified as confidential by any subject outside the contracting authority. In fact, with the help of Blockchain cryptographic keys, no one will be able to access confidential information until they obtain the consent of the owner of said information. Each blockchain transaction can have an associated lock and the transactions can be pending and activated at a specific time in the agreed contract

Freya Sheer Hardwick, et al., cited above, point out a series of confidentiality and security requirements that in any case a tender system such as the one described should comply:

- Once bidders have uploaded their offer to the blockchain, they cannot modify it.
- The bidding organization cannot read the offer until the deadline expires.
- Bidders cannot change bids from another organization.
- Bidders cannot see who else made a bid.
- Blockchain network miners cannot affect the bidding process.

Therefore, the decentralized, transparent and secure properties of the Blockchain protocol can meet the conditions of public entities regarding the confidential information they handle, thus obtaining a more transparent and reliable process for its treatment.

E. Blockchain in the Procedure for Obtaining Guarantees

The presentation and return of guarantees, which are not applicable to all public procurement processes, refer to an additional novelty of complexity that can also be simplified and automated with the application of blockchain. The sequence is shown in Fig. 2.

VI. Conclusions

For the deployment of blockchain technology for the provision of services to the public administration, the following barriers should be overcome in the first instance:

At this time, there are areas of administrative action in which the use of blockchain is not allowed due to lack of legal coverage, so any development of technology of this type applied to solve any problem in the public sector, requires a review of regulations in the country that is intended to apply, among which is, the regulations associated with state contracting, transparency, good governance, budget, and those that regulate finance issues, whether at the national or territorial level (regional and local); the above so that the way to promote the use of blockchain is obtained, without later implementation having problems that prevent the development and maturity of the application.

In this case, the European Union, focuses on the regulation of transparency and cybernetics, while the lack of regulation in Latin America means that the foray into the issue has only just begun in countries like Peru.

On the other hand, when introducing blockchain technology in the administrative procedures of the public sector, it requires its detailed analysis and to be preceded by a review of the procedures on which they operate, a reflection on their need, and assess the possibilities of its simplification.

Also, the question of the infrastructure on which the blockchains will be deployed must be addressed, a question that cannot be addressed without taking into account the different administrative levels. It should be noted that this technology will bring multiple benefits, given that, unlike other technological fields, there are no obstacles to face [57], having as another point in favor that the implementation does not require large investments in terms of facilities and requires some personnel.

From a technical point of view, it is required that the solutions that can be developed in the framework of the use of blockchain in conjunction with Smart contracts for the contractual processes celebrated in the public sector, are implemented through platforms such as Ethereum or Lisk, given mainly its flexibility and current development in topics with similar functionalities.

However, it is important that the solution designed and implemented, supported in public blockchain, since not only in contracting but in most applications, it is sought that any citizen access the Blockchain and Smart Contracts without restrictions, based precisely on transparency and as a guarantee of the fight against corruption. Only in exceptional cases, such as voting platforms, is it necessary to shield the process with access restrictions, mainly due to identity, voting privacy and sensitive data management issues.

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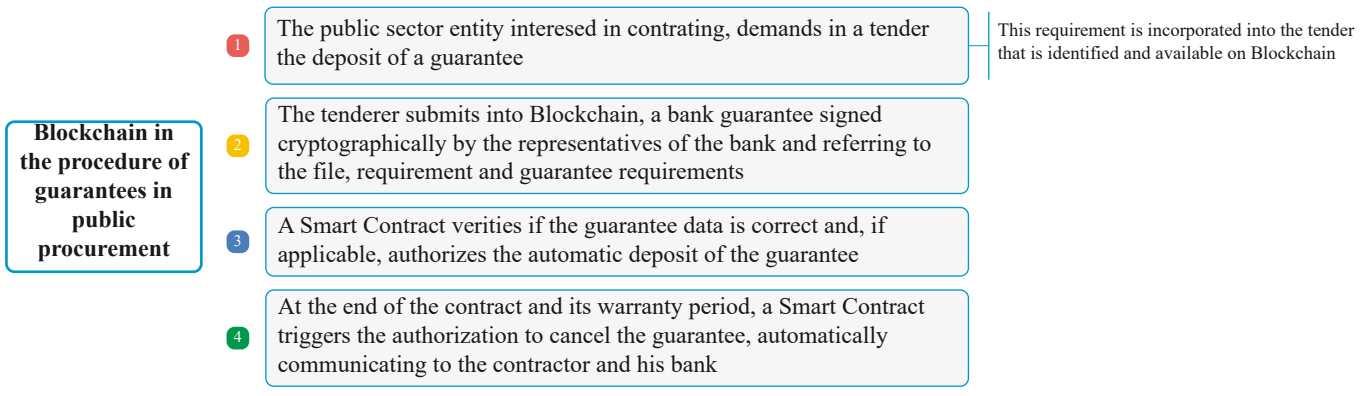

Fig. 2. Example of obtaining guarantees under the blockchain approach (based on [56])

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