

A Development Framework for Blockchain Technologies in Digital Government

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ABSTRACT

Blockchain Technologies, known as BCT have been praised by most people as a new and revolutionary means of ensuring secure and transparent data sharing and record keeping with potential uses in a number of sectors. The government sector is one of them. The potentials of DLTs are among the motivating reasons why most government agencies are looking to this technology to help make them become more efficient, accountable, cost-effective, and transparent. Some, on the other hand, are looking for ways in which the DLTs can help increase the trust in government agencies as well as various governmental institutions.

Despite the endless potentials of the DLTs, they are still in infant stage and at the same time having a number of risks that may deter its future integration and use. This paper proposes a framework towards the integration of DLTs into government organizations of various levels like municipalities and public services that will help in introduction of them in governmental tasks such as digital ID management, secure document handling and voting while keeping them simple for administrators to use and apply in every organization and domain.

CCS CONCEPTS

• **Applied computing** → **Computers in other domains** → Computing in government → *Blockchain*

KEYWORDS

Blockchain, Distributed Ledger Technology, E-government, Transparency

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1. INTRODUCTION

Blockchain Technologies or BCT are capable of solving the problems that countries seeking to integrate them into e-government, have had to face over the years. A Blockchain is a distributed ledger that is capable of storing information. In addition to that, it is a decentralized ledger. Decentralized means that there are no middlemen or intermediaries. One of the many problems of e-government is the presence of too many agencies and governmental intermediaries. These agencies and intermediaries make it quite difficult for the government to pass down relevant information to citizens at the right time [22].

Blockchain technologies are capable of eliminating these middlemen, ensuring that citizens and government are capable of sharing information to one another without obstacles. Decentralizing the system will present a clearer means of passing across information between those in authority and citizens. In the last years, there have been reports of mismanagement of budget from a number of developing and developed nations. When these situations arise, it becomes quite difficult to track where the problem is coming from, thus, making it impossible to solve. Blockchain technology is capable of offering the needed security. Being a distributed ledger, the blockchain technology is capable of storing all information about transactions carried out. With all information regarding the budget and finances stored permanently on this technology, it will be easy to track and eliminate fraud. History of transactions carried out will be made available for the public to see.

Blockchain is a chain of blocks, but not in the traditional sense of those words. When we say the words “block” and “chain” in this context, we are actually talking about digital information (the “block”) stored in a public database (the “chain”). “Blocks” on the

blockchain are made up of digital pieces of information. Specifically, they have three parts:

- 1) Blocks store information about transactions like the date, time, and dollar amount of an online purchase from an online store like Amazon.
- 2) .Blocks store information about who is participating in transactions. A block of a purchase from Amazon would record client's name along with Amazon.com, Inc. Instead of using the actual name, the purchase is recorded without any identifying information using a unique "digital signature," sort of like a username.
- 3) Blocks store information that distinguishes them from other blocks. Much people have names to distinguish us from one another, each block stores a unique code called a "hash" that allows us to tell it apart from every other block. Let's say some one has made a purchase on Amazon, but while it's in transit, he decides he just can't needs a second one. Even though the details of the new transaction would look nearly identical to the earlier purchase, we can still tell the blocks apart because of their unique codes.

This paper consists of five sections. In the following section 2 the background underlying our research is presented. Section 3 and 4 illustrate the methodology we will follow and the expected results. In the final section 5 the conclusions are summarized.

2. BACKGROUND

Blockchain is the cryptographically-secure, distributed ledger protocol, best known as the technology underpinning digital currencies, like *Bitcoin* and *Zcash*, and smart contract platforms like *Ethereum*. Blockchains (also known as Distributed Ledger Technology or DLT) are much more than enablers of cryptocurrencies: a blockchain can be thought of as a distributed record of any type of transactions between parties, where transactions are validated and recorded in chronological order (in a sequence of "blocks" – hence the name) by a decentralized network of peers, without need for a centra/trusted/third party. In other words, blockchain technology facilitates peer-to-peer transactions without intermediaries, while at the same time validating and keeping a permanent public record of all transactions.

It is important to separate cryptocurrencies from blockchain, which is the underlying technology that makes cryptocurrencies possible. A blockchain is a digital, secure, public record book of transactions (a ledger). "Block" describes the way this ledger organizes transactions into blocks of data, which are then organized in a "chain" that links to other blocks of data. The links make it easy to see if anyone has changed any part of the chain, which helps the system protect against illegal transactions.

There are a number of ways blockchain technology can be used in e-government, including [22, 24]:

Voting

One of the many things that threaten democracy today is the lack of transparency in the electoral voting system. To vote on the blockchain, each eligible and registered voter will be given a private key. Each of these keys will be connected with smart

contracts which will be automated to open officially on the day of the general election. The duty of each voter will be to assign his private key to any party of his choice.

Once this is done, the vote will be recorded as a transaction and would be made public for all to see. Since the blockchain technology works in real-time, the time each private key is assigned is updated on the blockchain for the general public. With this process, trust is restored to the voting system. In addition to that, the general voting system will be convenient as voters will not have to visit an electoral booth to cast their votes. Right from the comfort of their homes, they are able to vote for any party of their choice.

Land Registration Process

Lack of proper and advanced technology has made it impossible to digitalize the land registration process. In most countries, land registration processes is maintained and validated in paper-based formats between a number of agencies. This leads to inaccuracy of information as well as fraud cases. In fact, paper-based land registration process makes it difficult to easily ascertain the rightful owner of a particular property. Additionally, the number of third-party agencies and intermediaries that would need to sign the necessary documents make it difficult for the entire process to be completed at the right time. With the blockchain technology, the sharing of information will be seamless and accurate. Also, the verification of pieces of land bought will be faster and convenient.

Tax Management

In the taxing industry, relevant agencies will have to rely on information about each taxpayer and his merchandise to determine the tax percentage to be paid. Currently, it has been prescribed by law that revenue agencies should exchange relevant information to other departments to enable them to determine accurately the tax percentage each taxpayer is required to pay. To explain better, information stored by the Income Tax (IT) department can be shared with the Goods and Service Tax department. While this is an ideal move, the lack of accuracy of the information shared has made it almost impossible for these departments to function at an optimal level. The blockchain technology works in such a way that the information of every taxpayer is stored and updated in real-time. All records pertaining to the determination and collection of fees, taxes, and charges at different departmental levels will be maintained in a permanent and secure manner on the blockchain technology. Each department responsible for handling taxes will have a copy of the ledger. In addition, each update or information that is recorded will be instantaneously updated across all copies of the ledger.

In table 2, There is an overview of main obstacles that may arise during the incorporation of Blockchain Technologies in the public sector.

Table 2: Obstacles for Blockchain Technologies

TOPIC	REFERENCE	DETAILS
SCALABILITY	[50]	Since only few

		transactions per second can be processed, transactions might be delayed.
PRIVACY LEAKAGE	[50]	Public keys of any transaction are being visible, so safety challenges may be detected
SELFISH MINING	[21],[50]	Selfish miners may try computing power in order to reverse transactions.
TRUST OF THE TECHNOLOGY	[31]	A blind trust which relies technology may include risks
LEGALLY BINDING	[36]	Although chain is accessible by any node, information may be invalid in other nation states.
APPLICABILITY IN TERMS OF GDPR	HBH WORKSHOP [41]	GDPR's goal is opposite effective in some cases compared the domain of personal data.

The existence of quite many obstacles in the integration of DLT's leads to a creation of a hybrid of agile and traditional techniques methodology with the usage of Ethereum platform in order to apply these technologies into everyday citizens' transactions and study the outcomes.

Technology (Ethereum)

Ethereum is a decentralized system, which means it is not controlled by any single governing entity. An absolute majority of online services, businesses and enterprises are built on a centralized system of governance. This approach has been used for hundreds of years, and while history proved time and time again that it's flawed, its implementation is still necessary when the parties don't trust each other.

Every Ethereum node is connected to other nodes to form a network. A full node broadcasts transactions and blocks to the network and receives other transactions and blocks from it. The full node is also responsible of synchronising the current state of the chain with the rest of the network.

Ethereum, being a decentralized system, is fully autonomous and is not controlled by anyone at all. It has no central point of failure, as it is being run from thousands of volunteers' computers around the globe, which means it can never go offline. Moreover, users' personal information stays on their own computers, while content, such as apps, videos, etc., stays in full control of its creators without having to obey by the rules imposed by hosting services such as App Store and YouTube.

Ethereum took the technology behind Bitcoin and substantially expanded its capabilities. It is a whole network, with its own Internet browser, coding language and payment system. Most importantly, it enables users to create decentralized applications on Ethereum's Blockchain.

Those applications can either be entirely new ideas or decentralized reworks of already existing concepts. This essentially cuts out the middleman and all the expenses associated with the involvement of a third party. For example, the only profit that comes from users 'liking' and 'sharing' their favorite musician's

posts on Facebook is generated from an advertisement placed on their page and it goes directly to Facebook. In an Ethereum version of such social network, both the artists and the audience would receive awards for positive communication and support. Similarly, In a decentralized version of Kickstarter, someone won't be getting just some artifact for his contribution to the company, he will be receiving a part of the company's future profits. Finally, Ethereum-based applications will remove all sorts of payments to third parties.[42]

Blockchain's potential is rooted in enabling four things [24].

- **Transparency:** Anyone with access to the network can view a history of transactions in real time. Potential impact: The money trail can be tracked and monitored more accurately in areas like aid distribution.
- **Immutability:** Blockchain protects data from tampering; no one entity is able to change past data without alerting the network. Potential impact: Immutability protects areas like voter authentication and land title registrations.
- **Reduced counterparty risk (and subsequently lower cost payments):** Blockchain allows anyone to send money to anyone without an expensive or corrupt intermediary. Potential impact: Money sent across borders or into natural disaster zones will move quickly. In addition, many critical elements of our economy allow people to trade with each other without fear that the other party will back out. Banks perform this function, but often add high administration costs and slow processing times into the system. Blockchain's smart contracts guarantee that a contract will be fulfilled when a specific action is completed. Potential impact: Eliminating intermediaries reduces counterparty risk, thus reducing costs.
- **Efficient provisioning of identities.** Blockchains can create and manage identities for people in a lower cost, secure way through digital signature technology, which gives people a public key (similar to an account number) and a private key (similar to a password). Potential impact: Underserved populations, like the unbanked, receive access services never to before possible.

A blockchain-based digital government can protect data, streamline processes, and reduce fraud, waste, and abuse while simultaneously increasing trust and accountability. On a blockchain-based government model, individuals, businesses, and governments share resources over a distributed ledger secured using cryptography. This structure eliminates a single point of failure and inherently protects sensitive citizen and government data.

In General the benefits of using Blockchain Technologies are summarized in table 1 [23]:

Table 1: Benefits of Blockchain Technologies

TOPIC	REFERENCE	DETAILS
QUALITY & QUANTITY	[28]	Blockchain can empower public services by improving their interoperability, the speed of service and Increasing their predictive capability
PROCESSES SIMPLIFICATION	[28]	Blockchain boosts processes by speeding up necessary sub-processes since is easiest and quickest.
TRANSPARENCY	[28],[29]	Transactions and historical data of transactions are publicly visible on a chain and cannot be modified.
OPENESS - ACCESSIBLE	[31],[32]	Information stored in a chain is open and accessible by anyone.
INFORMATION SHARING	[31]	Stored data in a chain can be easily shared among all participants (organizations, citizens etc.)
DATA SAFETY	[33]	Consensus mechanism is being used by Blockchain and ensures the integrity of the chain (data).
PRIVACY	[34],[35]	User's or information's anonymity can be accomplished by the usage of private keys
REDUCE COST	[36]	Transaction's costs can be reduced since by using Blockchain the need for third parties is being removed.
GOVERNMENT CREDIBILITY	[37],[38]	Blockchain -based platforms can be used to give citizens access to reliable governmental information trust to governments.
FLEXIBILITY	HBH WORKSHOP[41]	Blockchain can be used in several ways in order to improve public services

Among the compelling cases of using Blockchain to innovate existing markets and processes are: finance (e.g. redesigning clearing and settlement systems), real estate (create tamper-proof records of home/land ownership), voting (increasing transparency and combating fraud), health (enabling individuals, health care providers and medical researchers to securely share electronic

health data, without compromising on patient privacy), shipping (using Blockchain to streamline and secure cross-border supply chain operations), agriculture (traceability, transparency, and efficiency for actors across the entire supply chain, from farmers to consumers) and others. For the first time in history, a technology exists that allows an un-mediated process of transparent and incorruptible activity, while keeping sensitive personal or business information private and secure. It has been called “*the World Wide Ledger*” by D. Tapscott, who maintains that ‘*with its advent, we will not need to trust each other in the traditional sense, because trust is built into the system itself*’ [26]– a truly revolutionary phenomenon that the Economist has called “*the trust machine*”[27]. The phenomenon will have profound consequences for the world, just like the Internet had a couple of decades ago, enabling new forms of finance (digital currencies, like Bitcoin), new forms of commerce (such as machine-to-machine transactions) and new forms of economic organization (such as decentralized autonomous organizations).

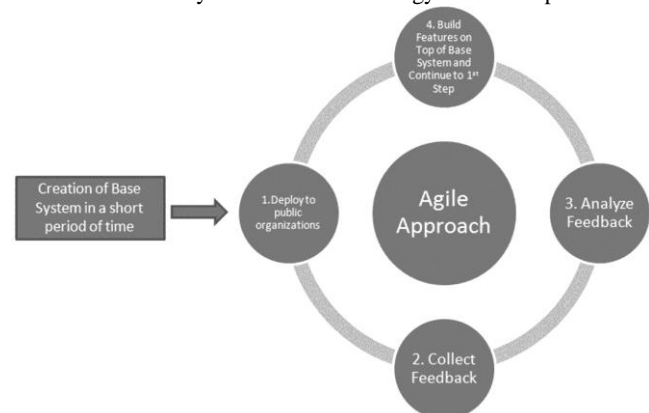
3. METHODOLOGY

The methodological approach of this research study proposal is presented in the current section.

An initial review of the literature will to enlighten all the key characteristics of BlockChain, with particular focus on the e-government solutions which use Blockchain technologies

At the time writing, there is an ongoing process regarding the implementation of the system to be used as a base for the features to be added, using the results and feedback from users across several governmental organizations. In this research, pilot users and administrators will be involved from the first time in order to avoid creating another system that will be difficult to use inside the organization.

Because blockchain is a quite novel technology, the research will be based on this model. On the interaction between governmental organizations and an already running system in order to measure how easy Blockchain technology can be adopted.

**Figure 1: Methodology to be followed**

At first, a base system will be created using Ethereum Blockchain. Ethereum[5,6] is a platform that can be used to create any decentralized application (known as a dapp, which works over a peer-to-peer network rather than a centralized client-server

network), so the functionality is only limited by what programs could potentially do and not do, and by consequence, what programmers develop, but it can theoretically be used for any economic or governance activity. The system will also include a user interface which with help through a smart wizard module to configure the infrastructure and tailor it to the needs of the organization he is an administrator.

1) Deploy to public organizations

After the implementation of the base system there will be the first phase of installation to one or more of the the collaborating governmental organizations. This phase comes from the continuous delivery of software projects which brings great benefits including[3,4]:

- Better end-to-end visibility to trace the changes and error codes
- Writing new and quality code improving software quality and research results
- Integrated compliance and security best practices
- Faster feedback loops from governmental organizations

2) Collect Feedback

The collection of feedback from users will be conducted via[2]:

- Participants contact forms
- Participants personal email communication
- Exploratory interviews

3) Analyze Feedback

The analysis of feedback will consist of three steps:

- All feedback will be analyzed and taken into consideration
- Feedback will be categorized
- Attention will be given to positive as to negative feedback also

4) Build features on top of base system and Re-deploy

After the analysis of the feedback from the users, new improvements will be added to the system and a new deployment will happen again in order to proceed with the next review from the users. Thus, in every cycle of this process new reports will be published, describing the permeation and the impact of blockchain technologies into the public sector, leading to an efficient model of incorporating DTL technologies in e-government.

Following the above approach there are many problems that can be eliminated regarding the delivery of the search results:

- The proposed approach will not lose time in trying to understand the needs of public regarding blockchain. The research will be involved with the partnering governmental organizations from the beginning, trying to implement a blockchain solution for the problems it faces and study how this advanced technology helps the citizens.
- Because there are no rules to determine when a solution is complete, the research will be always ongoing and deliver results regarding the topic of blockchain and continuously propose improvements.

At first two applications will be introduced to the public organizations One for Data Entry Securement and one for Smart Contracts.

a) Data Entry Securement Application

The application for Data entry securement Blockchain will provide security and quality during the data entry process so that when data is entered, it will create a verified, encrypted sequence of time validated blocks. Some Benefits of this will be:

Encryption and Validation

Blockchain platform ensures that data is encrypted, which means that modification in data is a difficult task. Also it is possible to save a cryptographic signature of a document or file on a Blockchain. This would give users a way to ensure a file is un-tampered, without needing to save the entire file on the Blockchain. Because of its decentralized nature, also someone can cross check file signatures across all the ledgers on all the nodes in the network and verify that they haven't been changed. When someone looks at a file, he can guarantee that it is the same version of the document that existed at another time. If someone does change a record, then the signature is rendered invalid. Blockchain offers reliable, independent data verification which is undeniable.

Decentralized way of securing data

Since blockchain as a technology is decentralized in nature it does not rely on one central point of control. It is a digital ledger of transactions with every computer having a complete copy of the data. A lack of a single authority makes the system fairer and considerably more secure. Instead of depending on a central authority to securely transact with other users, blockchain utilizes innovative consensus protocols across a network of nodes, to validate transactions and record data in a manner that is incorruptible. As blockchain is a ledger of information it is extremely important that the information being stored is honest and accurate. Since the data is saved on multiple computers, it is extremely secured even if one or two computers malfunction.

Difficulties in hacking

As the name implies blockchain is a chain of digital "blocks" that contain records of transactions. Because they aren't contained in a central location, blockchains don't have a single point of failure and cannot be changed from a single computer. They are decentralized and distributed ledgers across peer-to-peer networks that are continually updated and kept in sync. Each block is connected to all the blocks before and after it. While hackers can break into traditional networks and find all the data in a single repository and exfiltrate it or corrupt it, the blockchain makes this unfeasibly hard.

b) Smart Contracts in land Registration Application

Today, when a purchaser seeks to buy property, he or she must identify and secure the land title or any accepted document, such as existing deeds of sale, and have the lawful owner sign it over.

For a large number of residential titleholders in developing countries, flawed paperwork, forged signatures and defects in foreclosure and mortgage documents have marred proper documentation of property ownership. The resulting situation is that the property no longer has a 'good title' attached to it, being no longer legally sellable and leaving the prospective buyer in many cases with no remedies. Besides, agricultural land ownership is often regulated by customary practices without any written documentation.

Generally speaking, blockchain serves the same functionalities as the filing system inside a sound land registry: it knows who owns what at a certain time, ensures single-ownership and Blockchain is a continuously growing list of records stored in blocks, which are cryptographically secured and linked across a network of computers. Even if 99% of the computers are disabled, the records will remain available and secure on other parts of the network.

In comparison to a traditional registry, however, blockchain promises to make land documentation more secure, incorruptible and transparent. From a bird's eyes perspective, the blockchain will capture and permanently store (a hash of) each transaction of land titles, which permits near real-time traceability of ownership change as well as transparency in the state of the property, removing the possibility for manipulation of the titles. More precisely, imagine two citizen who have agreed on the sale of a land parcel and now wish to register the sales contract with their countries land administration. Similar to the registration process in a traditional land registry, the seller and the buyer go to the governmental administrator with the sales contract signed by both parties and enter it into the blockchain powered land registry database in the form of a cryptographic hash. The public ledger will contain only a reduced privacy-enabled set of data including the fingerprint or hash of the full transaction. Once the transaction is approved by the network and added to the blockchain, the transfer of ownership is immutably recorded on the ledger which becomes a single-point-of truth, preventing document forgery and corrupt land transfers. If there are doubts as to the validity of a land ownership claim, the public ledger can be used for validation by all relevant stakeholders involved. The user front-end will be available for anyone with internet connectivity e.g. via smartphone.[45]

4.Results(expected)

As an expected result, the application of the above technique aims to produce a fully customizable Blockchain Technologies system which will guide the integration of BCT in various governmental contexts. Also the social and public sector needs and business requirements will be analyzed, identifying benefits and barriers related to the adoption of BCT in public service provision. Finally the transferability and applicability of the proposed methodological and technical framework in any domain will be evaluated, producing knowledge on the transformative capacity of BCT in the public sector.

The proposed approach adheres the following principles to be integrated in the everyday transactions of citizens via the final outcome of this research proposal as defined by the eGovernment Action Plan for 2016-2020[1]:

- Digital by Default: DLTs enables public sector organizations to interact with other organizations or users in the digital world.
- Once only principle: Ledgers string information that can be retrieved by multiple actors, ensuring the necessary encryption and security level and reuse of this information for any service.
- Inclusiveness and accessibility: Intuitive user interfaces will be embedded to services in order to resemble the

physical interaction of service recipients with public servants and with the minimal technological background.

- Openness & transparency
- Cross-border by default: The architecture by design enables accessibility of ledgers from any country, which will also be demonstrated through the two cross-country use cases.
- Interoperability by default: The envisaged architecture allows the largest possible extent of reusability of data and web services, increasing the transferability of services to other countries and contexts.
- Trustworthiness & Security dedicated security infrastructure will be designed and embedded in the service architecture, addressing the needs for personal data and privacy protection and: A management of intellectual rights management. The privacy policy will be communicated clearly to the citizens in order to increase transparency and trust.

5.Conclusions

The scope of this paper is the proposal of a new, agile based framework in order to study the integration of Distributed ledger technologies in governmental applications and to implement a new system that integrates these technologies in real life public sector scenarios. With a combination from methods from software industry and systematic studying of the field, the results of this new approach will be promising and with direct impact by eliminating the challenges and problems that would hinder blockchain development into governmental organizations.

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