Faculdade de Engenharia da Universidade do Porto

Using Blockchain and Smart Contracts in a reverse auction syndicated e-procurement platform

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Abstract

The purpose of this research is to access the possibility of using Blockchain technology and Smart contracts to develop a Syndicated e-procurement platform and if it is justified. Its concept explained, and its features and characteristics presented. Based on Blockchain characteristics, we present the reader with the notion of what a Smart Contract is and what it entails. An attempt to link this technology to possible uses in several types of industries is made and based on the literature research, several issues identified in said industries and the possibility to solve (or minimize) them using this technology arises. An attempt to develop a proof of concept regarding a specific type of service is made, and hence another notable player is born, aggregated syndicated procurement.

Acknowledgments

I Wish to give my kind regards to my dissertation supervisor, professor Mário Amorim Lopes for taking the time to help me focus on my research and to give me a clear path to follow and hopefully I have corresponded satisfactorily. I also wish to give my many thanks to the team that accompanies him that gave up some of their precious time from their work to help me in this quest.

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Chapter 1

Introduction

Saying that the world is changing at a fast pace may seem like a cliché but is a driving force that compels everyone that wants to ride along with that change and has the drive to do it. People that have that insight of the future have the responsibility to share it with everyone that is unable to keep up with it and may be left behind due to never-ending changes and civilizational advances.

Research about Blockchain and related technologies are gaining traction. Finding gaps in current processes that may be solved by resorting to these types of technologies will help fasten development and prove Blockchain validity and reduce skepticism. An area that is still very unaware of Blockchain is the area of Procurement, as was shown by the research made about the Blockchain and its possible uses. Firstly, this research will focus on Blockchain and its characteristics, on online marketplaces, as a base for extrapolation to the reverse auction syndicated e-Procurement platform features, on the platform itself, finishing with a proposal for a model that serves as a base to the development of the said platform.

1.1 - Motivation

As technology advances faster and faster in an exponential proportion, most of the processes that we know and get used to will probably perish or change dramatically in the short term. Consider Amazon and their service Amazon Go for example. It is now possible to go to a store, take what we want, and leave without having to interact with anyone. So just on this service, there are potentially millions of jobs at risk in the very near future.

If we extrapolate this to self-driving cars, like Uber is already aiming to do, or web-based banks, automation of the processes is not just a concern of the future, it has been present in

our lives for a very long time, ever since humankind began to understand the concept of leisure time.

Has an avid reader and gatherer of all that is tech related, writing this thesis and doing the related study will allow the researcher to gain a better understanding of Blockchain technology, Smart contracts and what it entails. It is also perceived as an opportunity to give the researcher an understanding of the tools that may be necessary to apply them to a real use case.

1.2 - Research objective

> *"Blockchain is as significant now as the internet was 25 years ago", Blythe Masters, chief executive of the blockchain start-up Digital Asset Holdings.*

This paper more general and broader objective is to apply Blockchain technology to a practical real-world case, namely, the development of a reverse auction syndicated e-procurement platform. The narrower objectives are to explain **the main characteristics of the technology and explore possible uses, and by learning about its characteristics find issues on existing industries and justify the use of the technology to solve them.**

1.3 - Research methodology

Reading and analyzing the literature regarding the topic at hand, has resulted in the following research question:

- Can blockchain technology or any of its inherent features help solve actual issues that affect industries and lives of everyday people?

This dissertation intends to find new innovative uses using blockchain technology, or possibly expanding and improving an already existing idea, therefore design science approach will be used to conduct the research. This kind of approach is appropriate to develop tech-based solutions to solve relevant business problems. It also has the intent to be adequately presented to both technology-oriented and management-oriented audiences.

1.4 - Dissertation structure

- Chapter 1 – Is given the overview of the research objective and methodology followed.
- Chapter 2 – Literature review about the topic at hand is presented to understand what research was made recently, to help focus research and aid in the current state-of-the-art, which is also present in this chapter.

- Chapter 3 – Blockchain is explained, and its main characteristics and features described. Smart contracts are also addressed, and a practical example is showed for the reader to understand this concept better because it is a concept with of prominent importance.
- Chapter 4 – In this chapter, the concept of an online marketplace is somewhat dissected, in a learning perspective for the solution that we want to build. A link is made between a traditional marketplace and a blockchain marketplace. We also conclude that a thriving online marketplace must have a robust reputation system.
- Chapter 5 – In this chapter, is explored the concept of e-procurement and the processes contained within. Having explained these concepts and other "e-based" concepts, we explore issues and questions that may be resolved by the technology and therefore justify its use.
- Chapter 6 – In this chapter, is developed a conceptual model of a Smart contract in an e-procurement concept, which is a possible use of blockchain technology.
- Chapter 7 – Concludes the dissertation and proposes future studies and recommendations for tech-driven entrepreneurs.

Chapter 2

Theoretical background: The Blockchain

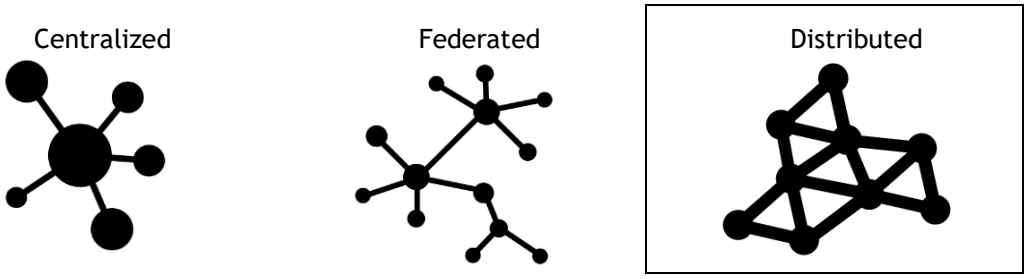
Like the name itself says, it is a group of a particular type of blocks linked to each other. A block has a link to the previous block, which in turn has another link to a previous block, and so on.

2.1 - Distributed Ledger

> *"The ledger provides the transaction history and current balance in each accounting system account, throughout the accounting period. At the end of the period, ledgers, therefore, serve as the authoritative source of data for building a firm's financial accounting reports." (Schmidt, M. 2018).*

Blockchain is a type of distributed ledger, a database which stores all individual blocks in groups, linked to each other in chronological order. This collection of blocks is available for everyone to see and check its validity, so at any given time, can see all the history and origin of past transactions. Because of this, there is no need for a central party to monitor and regulate its use.

Table 1 - Pattern examples



2.2 - Consensus mechanisms

> *"Consensus decision-making is a group decision-making process in which group members develop and agree to support a decision in the best interest of the whole…" (Wikipedia)*

If one wants to add a transaction to the ledger, and for it to be accepted into the chain and validated by everyone, there must be some mechanisms.

Table 2 - Consensus Mechanisms

Proof of Work	Used by Bitcoin.
Proof of Stake	Used by Ethereum.
Delegated Proof of Stake	Used by EOS Blockchain.
Delegated Byzantine Fault Tolerance (dBFT)	Used in NEO Blockchain. Neo, formerly known as Antshares, is often known as the "Ethereum of China".

Each type of consensus mechanism that can be seen depicted on Table 2 has its pros and cons, for example, the mechanism used by Bitcoin blockchain, the "Proof of Work", is notoriously known for using substantial computational resources and energy. Each type of mechanism is what defines how a transaction can be added to the chain itself and validated and accepted by everyone.

2.3 - Immutability

To begin to get a grasp of why Blockchain is immutable, one must understand how blocks in the blockchain are connected amongst themselves, and to do so, concepts like hashing and Merkle Trees come into play.

2.3.1. Hashing

Hashing is a process that processes a string of characters and turns it into a usually shorter fixed-length value or key that serves as a representation of the original string, vastly used in cryptographic algorithms. Bitcoin, for example, uses SHA-256, and no matter the size of the input the output is always of a fixed length and unique.

Table 3 - Hashing example (SHA-256)

Hi	3639efcd08abb273b1619e82e78c29a7df02c1051b1820e99fc395dcaa3326b8
I'm an hash!	8e438b8edb8abcaea3ed5f0770dcdf34d44f1a5e12fabb2289a61c25d1b1325d

To encode and decode data into and from a hash code algorithm is very fast, of almost negligible speed.

Table 4 - Hash code properties

Deterministic	No matter how many times we pass a specific input X through a hash function, the output will always be the same.
Quick Computation	The hash function must be quick in the calculation, or else the system will not be efficient.
Pre-Image Resistance	Given a function H(X) it is infeasible to determine X, where X is the input and H(X) is the output hash. Note that the term is infeasible, not impossible, because we know that given X we get a hash through the hash function. However to discover an unknown input X we had to use random inputs and pass it through the hash function to discover it and that would be time-consuming (years) and resource consuming (computation power) and is just not worth it.
Small changes in the input changes the Hash	Simply changing an uppercase to a lowercase changes the hash significantly, for example: Hi: 3639efcd08abb273b1619e82e78c29a7df02c1051b1820e99fc395dcaa3326b8 hi: 8f434346648f6b96df89dda901c5176b10a6d83961dd3c1ac88b59b2dc327aa4
Collision Resistant	Given two different inputs X and Y it is infeasible that H(X) equals H(Y). No hash function is collision free, but it usually takes so long to find one that you can assume that if H(X) equals H(Y) than X most likely equals Y.
Puzzle Friendly	For every output Y, if Z is chosen from a distribution with high min-entropy, it is infeasible to find an input X such that H(Z|X) = Y. "|" is the symbol for concatenation (example: blue|sky equals bluesky. A number between 1 and 5 is low min-entropy distribution, while a number between 1 and a trillion is high min-entropy distribution.

The importance of Hashing in the blockchain is explained in the following points.

2.3.2. Merkle Tree

Having understood what hashing is, the next step to understand its role on Blockchain is to get to know how it can be used to maintain integrity in a data structure that makes use of hashing, the Merkle Tree. Figure 1 below is a very simplified Merkle tree. The Merkle Tree is composed of "leaf nodes", each one of this "leaf node" contains the hash of its correspondent Data leaf. Between the "leaf nodes" and the tree root, we can see depicted the "Nodes" that

are composed of the hashes of its corresponding child nodes, for example, the "Node" H5 contains the hash of its child nodes, both H1 and H2. The root of this tree is called the "**Merkle Root".** Note that the leaf's of "Data" is not part of the tree.

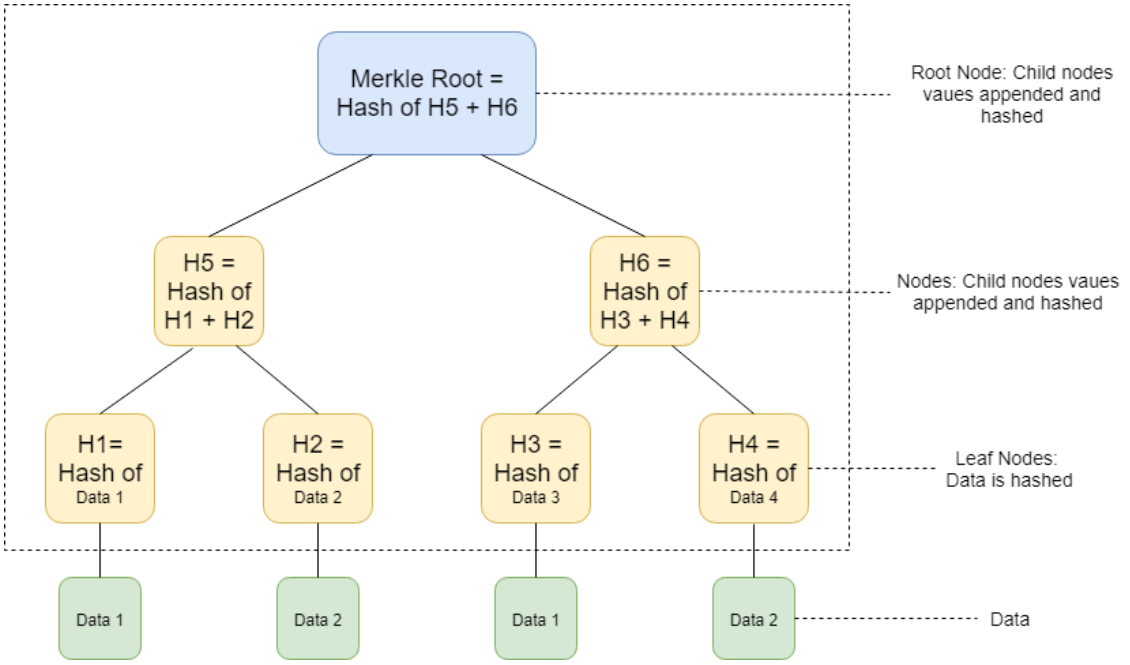
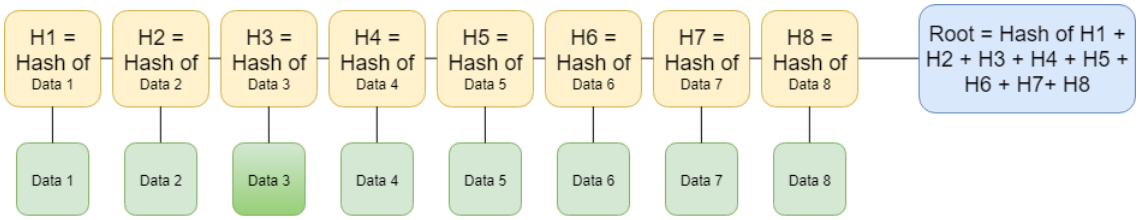


Figure 1 - Merkle Tree

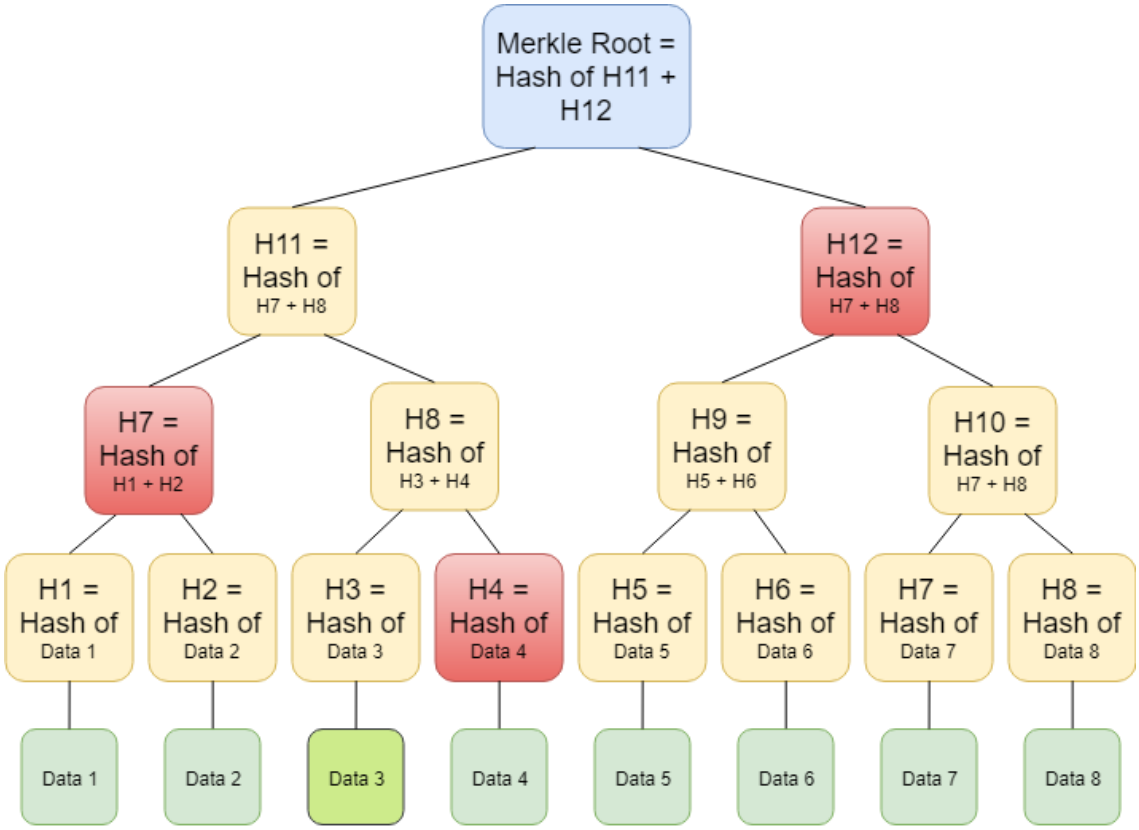
Why use a Merkle Tree instead of, for example, hashing all the data together and obtaining a root with all the hashes appended?



Consider the scenario of when a data chunk is received from an unknown source and is necessary to verify its integrity, in this case, "Data 3", as seen in the image above. The root value is received from a trusted source to be able to verify integrity. To access the validity of "Data 3" it is necessary to receive all the remaining data hashes (H1 + H2 + H4 + H5 + H6 + H7 + H8) whose combination result in the root value, them hash the combination of "Data 3" hash

plus those hashes and compare the result to the root value received from the trusted source. If the value coincides then “Data 3” is valid.

If one has a Merkle Tree, to validate the integrity of “Data 3”, it is only necessary to receive three hashes, as seen depicted in the image below. The hash of “Data 3” is combined with H4, the hash that results of that combination is them hashed and combined with H7 and so on.



Consider then the scenario of having a tree with millions of nodes. It becomes clear that a Merkle tree is incredibly efficient in checking data integrity and is assured to be data free tampering.

2.3.3. Blockchain blocks

The importance of hashing and Merkle Trees becomes apparent once we perceive what a block of the Blockchain is composed of. Each block has a unique hash identifier. It contains an assortment of transactions and a reference to the previous block. To validate transaction

integrity each block contains a checksum of them which is them placed on the header, and because the header is hashed and referenced in the next block header, integrity is achieved.

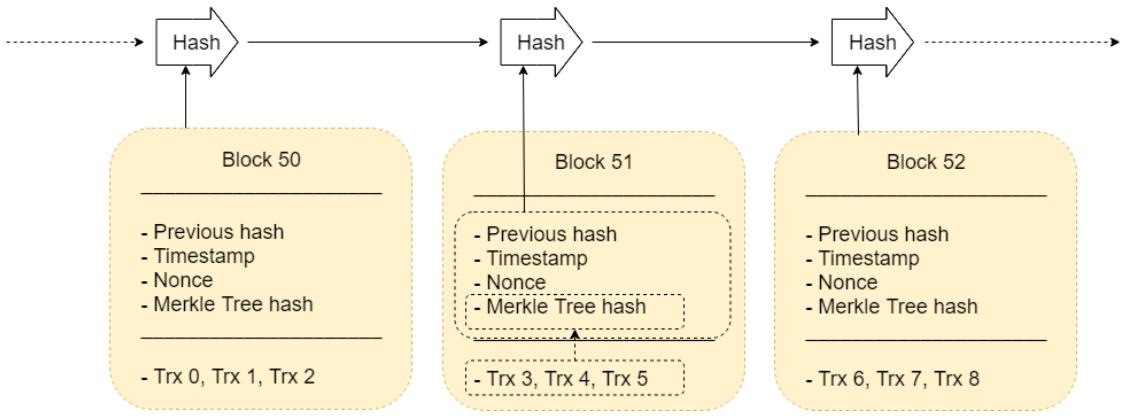


Figure 2 - Blockchain block

Consider the scenario where someone tries to corrupt a block on the chain or wants to change an internal transaction of a block. He would have to remake the hash of that block and then go to every block on the chain and rearrange the hashes and claim validity of the entire chain. Blockchain has resolved this issue by making extremely hard the process of computing a second chain that could become valid to others and overtake the original one, to a point when is just not worth to try to corrupt a block of the chain.

2.3.4.Mining

To achieve the objective of making it impossible to rearrange the chain, we must ensure that each hash value respects a specific parameter, and to achieve that we resort to a number value that is used to compute the hash together with the block, the “nonce” value, which we can see that belongs to a block as depicted in Figure 2. Essentially, to add a block to the chain is necessary to solve a puzzle. Suppose that we want to add the block “I’m an hash” to the chain, whose hash is depicted below, however, suppose that the blockchain only accepts hashes that start with “00”, which means we must resort to the “nonce” value because the hash is invalid.

I'm an hash!	8e438b8edb8abcaea3ed5f0770dcdf34d44f1a5e12fabb2289a61c25d1b1325d

To achieve the pretended hash its necessary to compute the “I’m an hash XXXX” in a way that the resulting hash is valid. The mining process consists of finding that “nonce” value. Because this value is random and the following numbers do not have any connection, the best way is to start in 1 until the end of the range, in this case, value ranges between 1 and 9999.

Table 5 - Mining Process

I'm an hash! 1	c59d2c7c4c3e24667f48f0d69a865389ba5a73135c36d626d2711538355b5c85
I'm an hash! 2	0f4745bc4199a37140a180f2206100681be9f26fc03cda04a380b55f55443a3c
I'm an hash! 3	285143383b2a1a2bae019f2fa89e363c152ecf1c95aa2853a859d70bda0c1155

…

I'm an hash! 199	0074e31be06006683ab496c57885b7441c11b0a69c9b8238c99390c1a6b404db

Depicted in Table 5, we have the scenario in which to obtain a valid hash it was necessary to compute 199 hashes, with difficulty set to very low. We can increase the difficulty by adding one more "0" to the beginning of hash, and by doing so, the "nonce" range increases exponentially. It becomes clear that corrupting a block and having to compute all the other blocks in the chain is near to impossible to do in useful time. Consider Bitcoin, solving this puzzle allows for bitcoin miners to gain bitcoins because each valid hash is a "bitcoin". In Table 2, where consensus is discussed, and proof of work addressed, and basically, that proof is a method that ensures that the information (the new block) was costly (concerning time and consuming power) to be made (i.e., solving the puzzle). However, it must be trivial to access whether the new block satisfies the requirements.

2.4 - Smart contracts

They are a fascinating feature of significant importance in the blockchain and its possible uses. The run of the mill description used in the news is quite general and self-explanatory, it is a piece of computer code that self-executes or executes automatically.

Table 6 - Vending machine example

In a vending machine, the user inserts a 1€ coin and get a beverage or a snack. A quite simple algorithm that we can represent in pseudo-code:

> if a user inserts coin then
>user chooses a product
> if value of coin >= than product value then
> release product

This represents a kind of contract, in the sense that, it executes automatically when certain conditions occur.

In the example above, what happens if the user inserts a fake coin, or the machine runs out of beverages? Moreover, what if instead of a vending machine of diet cokes and ice teas we have precious stones and valuable metals, then trust and ownership are concepts that come to mind.

With blockchain, we can have a contract that is automatic, "written in stone", immutable and has backing by a digital token.

> *"Keep in mind, we've had both computation and execution before. But never one that was finalized in a neutral, provable, trustable way on (digital) stone." (Liulka, V. 2017).*

A smart contract is written in the blockchain, so it inherits its characteristics. It is immutable, so it cannot be tampered with, and nobody can break it, and because of its distributed nature, its outcome is validated by everyone on the network, and that brings about **fraud reduction**.

Due to the distributed nature of the blockchain, smart contracts remove the need from intermediaries and middlemen, which in term promote a transparent and **direct relationship with the other counterpart**.

With no third-parties needed, no single individual or entity is in control of the data or money, and if by some reason someone abandons the blockchain network, the network will not resent it and will continue to function regardless, this translates to **resistance to failure**.

The irrelevance of intermediaries and the ability to interact directly with the counterpart can bring down or even cancel transaction fees, is translated in **cost efficiency**.

Because these business agreements ("contracts") are automatically executed, immutable and therefore unbreakable, they bring about **more trust**.

Due to the nature of how the blockchain connects its contract transactions (in chronological order), they can be accessed along with the complete audit trail, which can be translated to **record keeping**.

2.4.1. Smart contract practical implementation

As previously stated a smart contract is a piece of code. It can be written in "*Solidity*", which is a programming language similar to "*JavaScript*". The vending machine example could be translated in a simple smart contract (used purely for demonstration purposes).

To the right, we can see the contract "Vending Machine" which is composed of two functions:

- ➔ **insertCoin** – A public function called when the user inserts a coin.
- ➔ **releaseProduct** – A private function that releases product to the user when he has inserted the needed amount to purchase the product.

```
contract VendingMachine {

    uint private numberOfProducts = 50;
    uint private pricePerUnit = 10;
    uint private insertedMoney = 0;

    function insertCoin(uint value) public {

        insertedMoney += value;

        if(insertedMoney >= pricePerUnit)
                releaseProduct();
    }

    function releaseProduct() private
    {
        insertedMoney = 0;
        //Release product to the buyer
        numberOfProducts--;
    }
}
```

Figure 3 - Vending Machine Smart contract

The contract is then inserted into a blockchain, signed by the parties and there it remains immutable. It can then be accessed from an interface like a browser, and the function "insertCoin" can be called. The intent of this dissertation is not to go into much detail concerning technical aspects but to justify the use of a smart contract as a valid solution for ongoing business issues.

2.5 - Blockchain business benefits

After having understood the characteristics of the technology, they can be translated into benefits.

Table 7 - Blockchain benefits

	Time & cost efficiency		Security		Transparency		Record Keeping
	Fraud Reduction		Smart Contract		Privacy		Decentralization

Moreover, we can apply those benefits to a variety of areas and businesses (both private and public) that range from conservative industries like banking to trending industries that work on IOT (Internet of things). Concepts like distributed ledger technology (DLT), immutability and smart contracts can be used in payment processes, i.e., is possible to have transactions between two parties with no need to resort to a third party like a bank, what results in reducing costs, automation of processes, and other benefits. Table 8 below depicts what blockchain brings to businesses, along with some examples of real use cases.

Table 8 - Blockchain business benefits

	**Banking**	 Reduced transaction costs & settlement time.  Improved transactions security & data quality.
➢ **Bank Hapoalim** – A collaboration between the Israeli bank and Microsoft to create a blockchain system for managing bank guarantees.		
	**Governance**	 Reducing corruption at a state level.  More opportunities for business to manage their assets.
➢ **Govcoin** – The UK Department of Work and Pensions is investigating using blockchain technology to record and administer benefit payments.		
	**Prediction Markets**	 Low fees.  Safe automated payment.  Accurate forecasting & crowdsourced reporting.
➢ **Augur** – Allows the creation of blockchain-based predictions markets for the trading of derivatives and other financial instruments in a decentralized ecosystem.		
	**Supply management & retail**	 Proof of ownership & resale.  Transparency in logistics, storing & tracking.  Increased trust due & information evidence.
➢ **Maersk** – The **shipping** and transport consortium has unveiled plans for a blockchain solution for streamlining marine insurance.		
	**Insurance**	 Eliminating costs & time of processing insurance claims.  Transparency & relevant records keeping.  Reducing the opportunity for insurance fraud.
	**Car Leasing**	 Reducing time from the procurement process.  Simplified leasing process.  Blockchain as the foundation for smart assets.
	**Healthcare**	 Reduced time & increased efficiency in providing insurance quotes.  Tamper-resisting means of storing medical history.  Complete medical history of the patient.

- **MedRec** – An MIT project involving blockchain electronic medical records designed to manage authentication, confidentiality and data sharing.

	**Education**	 Eliminating claims of un-earned educational credits.  Improved verification procedures.  Objectively recognized credentials & records.
	**Law enforcement**	 Automation of contract performance.  Near-instant money transfer.  Recording of all kinds of property ownership and maintaining public records.  Intellectual property rights.
	**Ridesharing**	 A direct connection between drivers and riders. Drivers can build own business & set up own rates.

- **Arcade City** – An application which aims to beat Uber at their own game by moving ride sharing and car hiring onto the blockchain.

	**Charity**	 Transparency of transactions & publicly shared financial reports.

- **Bitgive** – This service aims to provide greater transparency to charity donations and more explicit links **between** giving and project outcomes. It is working with established charities including Save The Children, The Water Project and Medic Mobile.

	**Energy Management**	 Reduced transaction costs and settlement time.  Improved transactions security and data quality.

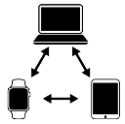
- **Transactivgrid** – A business-led community project based in Brooklyn allowing members to locally produce and sell energy, with the goal of reducing costs involved in energy distribution.

	**Luxury**	 Reducing risk, theft, trafficking & fraud.  Protect the provenance of high-value assets.

- **Blockverify** - A blockchain platform which focuses on anti-counterfeit measures, with initial use cases in the diamond, pharmaceuticals and luxury goods markets.

	**Real Estate**	 No intermediaries lead to cost reduction.  Records transparency & fraud prevention

- **Ubiquity** – This start-up is creating a blockchain-driven system for tracking the complicated legal process which creates friction and expense in real estate transfer.

	**Internet of Things**	Protecting devices interactions information & preventing attacks. Protection against data tampering & trusted data exchange.
	**Digital Identity**	Signing smart contracts by a unique ID. Reliable verification systems. Fraud detection.

- **REMME** - Is a decentralized authentication system which aims to replace logins and passwords with SSL certificates stored on a blockchain.

	**HR Management**	Accelerating the recruitment process Access to verified candidate's records education, employment, training. Smart job contracts & decentralized payments.

Source: Marr, B. (2018)

Chapter 3

Literature review

To conduct the literature review database was used. The main keywords were "Blockchain", "Bitcoin" and "Application". Deliberately words related to finance were left out, to broaden the focus of possible applications that could be of interest to this paper. All the articles found are from 2017, Which indicates that research is current and trending. The articles can be very broadly divided into the following terms:

- **Cryptocurrencies:** articles that address the cryptocurrencies (like bitcoin) issues and correlate it with the blockchain technology. They also talk about current and future uses of cryptocurrencies or explain what this technology is. "The Bitcoin system enables users to transact directly in an open and insecure network, like the Internet, without the use of an intermediary." (Ølnes, S., Jansen, A., 2017).
- **Proof of work/stake:** articles that address the proof of work concept. "PoW (Proof of work) is a consensus strategy used in the Bitcoin network." (Zheng, Z., Xie, S., Dai, H., Chen, X., Wang, H., 2017).
- **Pros:** articles that address the advantages and key features of using the blockchain technology.
- **Cons:** articles that address the possible disadvantages and key features of using the blockchain technology.
- **Increase BC Efficiency:** articles that address possible ways of improving blockchain, for example, mining efficiency and speed.
- **Current uses:** articles that address current uses of blockchain technology and presentation of case studies.
- **New uses:** articles that suggest new uses for blockchain technology and present theoretical proof of concepts.

Table 9 - Literature review concept matrix

Author(s) and year	Keywords/Concepts	Cryptocurrencies Proof of work	Pros	Cons	Current uses	Increase Efficiency	New uses
Nicholson, J. (2017)	Bitcoin, blockchain, developing nations, library and information science, public access	X	X				X
Kuo, T.-T., Kim, H.-E., Ohno-Machado, L. (2017)	Bitcoin Blockchain features, alternatives & applications, Key benefits and biomedical/healthcare applications	X	X	X			X
Zheng, Z., Xie, S., Dai, H., Chen, X., Wang, H. (2017)	Blockchain, decentralization, consensus, scalability		X	X	X		
Kogure, J., Kamakura, K., Shima, T., Kubo, T. (2017)	Confidentiality control technology, data consistency				X		X
Li, J., Liang, G., Liu, T. (2017)	Blockchain, trust degree, multi-link, communication tree, communication performance parameters			X		X	
Yuan, C., Xu, M.-X., Si, X.-M. (2017)	Research on a new signature scheme on blockchain					X	
Ahram, T., Sargolzaei, A., Sargolzaei, S., Daniels, J., Amaba, B. (2017)	Blockchain, Business, Cloud computing, Cloud services, Control Systems, Cybersecurity, DevOps, Finance, Government, Healthcare, IoT, Industry 4.0			X		X	
Pass, R., Shi, E. (2017)	Distributed consensus, blockchains, fairness, Nash equilibrium			X	X	X	
Halpern, J.Y., Pass, R. (2017)	Blockchain protocol, consensus on a public ledger, contract signing						

Toyoda, K., Mathiopoulos, P.T., Sasase, I., Ohtsuki, T. (2017)	Anti-counterfeit technology, POMS (Products Ownership Management System), Blockchain, Ethereum, Security	X				X		X
Ateniese, G., Magri, B., Venturi, D., Andrade, E.R. (2017)	A new framework that makes it possible to re-write or compress the content of any number of blocks in decentralized services exploiting the blockchain technology.							X
Tomescu, A., Devadas, S. (2017)	Catena, an efficiently-verifiable Bitcoin witnessing scheme.	X		X	X			X
Lamberti, F., Gatteschi, V., Demartini, C., Pranteda, C., Santamaria, V. (2017)	blockchain, bitcoin, cryptocurrency, smart contracts, insurance			X	X	X		X
Dinh, T.T.A., Wang, J., Chen, G., Liu, R., Ooi, B.C., Tan, K.-L. (2017)	BlockBench, the first comprehensive benchmark framework for private blockchain systems.	X		X		X		X
Dorri, A., Kanhere, S.S., Jurdak, R. (2017)	Internet of Tings, Security, Privacy, BlockChain							X
Nath, I. (2016)	Application, Adoption, Blockchain, Bitcoin, Centralized, Claims, Decentralization, Data, Digital, Exchange, Fraud, Intelligence, Insurance, Management, Processing, Standard, Technology.			X				X
Ølnes, S., Jansen, A. (2017)	e-Government, Bitcoin, Blockchain, ICT platform, Information infrastructure	X						X
Maxwell, D, Speed, C & Pschetz, L (2017)	The Ledger, the Blocks, the Mining Process		X					
Taylor, M.B. (2017)	Evolution of the hardware underlying the system, from early GPU-based homebrew machines to today's data centers	X						

Dannen, C. (2017)	Ethereum, solidity, cryptocurrency, blockchain, prog. for beginners	X		X	X	X		
Turk, Ž., Klinc, R. (2017)	blockchain, building information modeling, building information management, information systems, intellectual property rights, construction contracts, trust							X
Khan, C., Lewis, A., Rutland, E., Wan, C., Rutter, K., Thompson, C. (2017)	Distributed-Ledger Consortium Model for Collaborative Innovation							X
Bartoletti, M., Pompianu, L. (2017)	Bitcoin protocol allows to save arbitrary data on the blockchain through a particular instruction of the scripting language, called OP RETURN	X						

The articles portrayed in the concept matrix above provide an excellent base to understanding what blockchain technology is and by knowing their key characteristics we can connect them with many possible uses, some of them already depicted in the articles.

Although blockchain is not a new thing, even bitcoin is eight years old, but there is little law and regulation about the subject, and as governments become more sensitive to the issue of cryptocurrencies, new opportunities will undoubtedly appear. Every day there is a constant inflow of news and articles about blockchain. Current uses and new uses are quite important for the proposed research and warrants some concrete examples to have some idea of the state of the art.

> *"The literature examined supports the use of Bitcoin in **developing nations**, with real-world examples including applications for empowering women in Afghanistan." (Nicholson, J., 2017).*

Nicholson, J., (2017) considers the nature of Bitcoin and blockchain and suggests its use to rival traditional fiat currencies and centralized banking models. It considers the technology as a feasible option with real-world applications and suggests the use of Bitcoin as a solution to fight corruption.

> *"Biomedical/healthcare Blockchain applications; **Medical record, insurance claim, healthcare ledger, clinical/biomedical research.**" (Kuo, T.-T., Kim, H.-E., Ohno-Machado, L., 2017).*

Kuo, T.-T., Kim, H.-E. and Ohno-Machado, L., (2017) consider using blockchain technology and its decentralized characteristic to handle and secure patient records, keeping an audit-trail and securing data provenance, increasing safety for the records and reducing the burden of maintaining conventional databases.

> *"The research indicates Blockchain can play a pivotal role in **transforming the digitization of industries** and applications by enabling **secure trust frameworks**, creating agile value chain production, and tighter integration with technologies such as cloud computing, and IoT." (Ahram, T., Sargolzaei, A., Sargolzaei, S., Daniels, J., Amaba, B., 2017).*

Ahram, T., Sargolzaei, A., Sargolzaei, S., Daniels, J. and Amaba, B., (2017) addresses issues such as cybersecurity in healthcare. It suggests a solution that integrates blockchain, cloud computing, and IoT called Healthchain that is used to facilitate access to the patient's history while setting the highest standards for security and robustness.

> *"In this paper, we propose a novel POMS (Product Ownership Management System) of **RFID-attached products** for **anti-counterfeits** that can be used in the post supply chain. For this purpose, we leverage the idea of Bitcoin's blockchain that anyone can check the proof of possession of balance." (Toyoda, K., Mathiopoulos, P.T., Sasase, I., Ohtsuki, T., 2017).*

Toyoda, K., Mathiopoulos, P.T., Sasase, I., and Ohtsuki (2017) suggest using blockchain technology in the supply chain, assuring valid provenance and reducing counterfeiting, more precisely using work of proof (used in Bitcoin) to check for ownership of RFIDs (Radio Frequency Identification).

> *"This paper introduces the concept of Blockchain and its application in **sharing fraud intelligence data in the Insurance marketplace**." (Nath, I., 2016).*

Nath, I. (2016) suggest using blockchain to handle insurance claims, making them more efficient and streamlined, resulting in improved customer experience. It also defends that such an approach could help reduce (if not entirely prevent) fraud if identity management is also enforced through blockchain.

> *"This paper argues that we need to look beyond the currency applications and investigate the potential use of the blockchain technology in **governmental tasks such as digital ID management and secure document handling**." (Ølnes, S., Jansen, A., 2017).*

Ølnes, S., Jansen, A., (2017) suggests the use of blockchain in an e-Government context, taking out the focus from what, he thinks, has been the focus of blockchain on the recent years, namely its use as currency. He suggests using the technology for identity management and document authentication,

> *"Even if building information modeling (BIM) is used, which assumes a centralized building information model, there is a role for blockchain to manage information on who did what and when and thus provide a basis for any legal arguments that might occur. On the construction site blockchain can* ***improve the reliability and trustworthiness of construction logbooks****, works performed and material quantities recorded. In the facility maintenance phase, blockchain's* ***main potential is the secure storage of sensor data which are sensitive to privacy****." (Turk, Ž., Klinc, R., 2017).*

Turk, Ž., Klinc, R., (2017) suggests using blockchain technology to connect the several parties that are part of a construction lifecycle, by increasing trust and safety in the communications and decentralizing the construction process software. He also suggests using this technology in maintaining the construction log book, namely, keeping materials quantities records secure.

It seems clear that many of the current uses and proposed new uses for blockchain are based on the reliability of the blockchain protocol and the uniqueness of every transaction. We can also point out that it can be used in many industries (medical for example), by governments, NGO's and non-profit organizations.

Consider also real case uses depicted in Table 8, along with the article's research, we can conclude that many researchers and entrepreneurs consider blockchain technology will bring added value to many areas and industries.

Chapter 4

Learning from an e-Marketplace

Platforms like Amazon, eBay, Uber attribute their success to the confidence that they instill in their users, and many others that are emerging must follow the same recipe because transparency and confidence are of capital importance in those type of services.

> *"e-marketplace is a virtual online market platform where companies can register as buyers and sellers to conduct business to business transactions over the internet. The use of the internet has helped remove intermediaries in a transaction. It is a web-based information system which provides opportunities for both suppliers and buyers." (MBA Skool-Study.Lear.Share)*

The image below can help us get a perspective of how an online Marketplace works. Online Marketplaces allow suppliers and buyers to do their business there. On the supply side, the vendor must submit business forms and official documents to confirm authenticity, but that may not even be required, because sometimes a vendor does not even have to have storage or a billing system in place. Amazon provides that service, the vendor pays a fee, buys the goods and ships them to Amazon's seller central and they handle shipment, returns, billing, among others. The vendor must, however, market its goods.

On the other hand, the buyer has an account on the marketplace and can browse through many goods from all over the world. Of course, a lot is going on the technical end of it all.

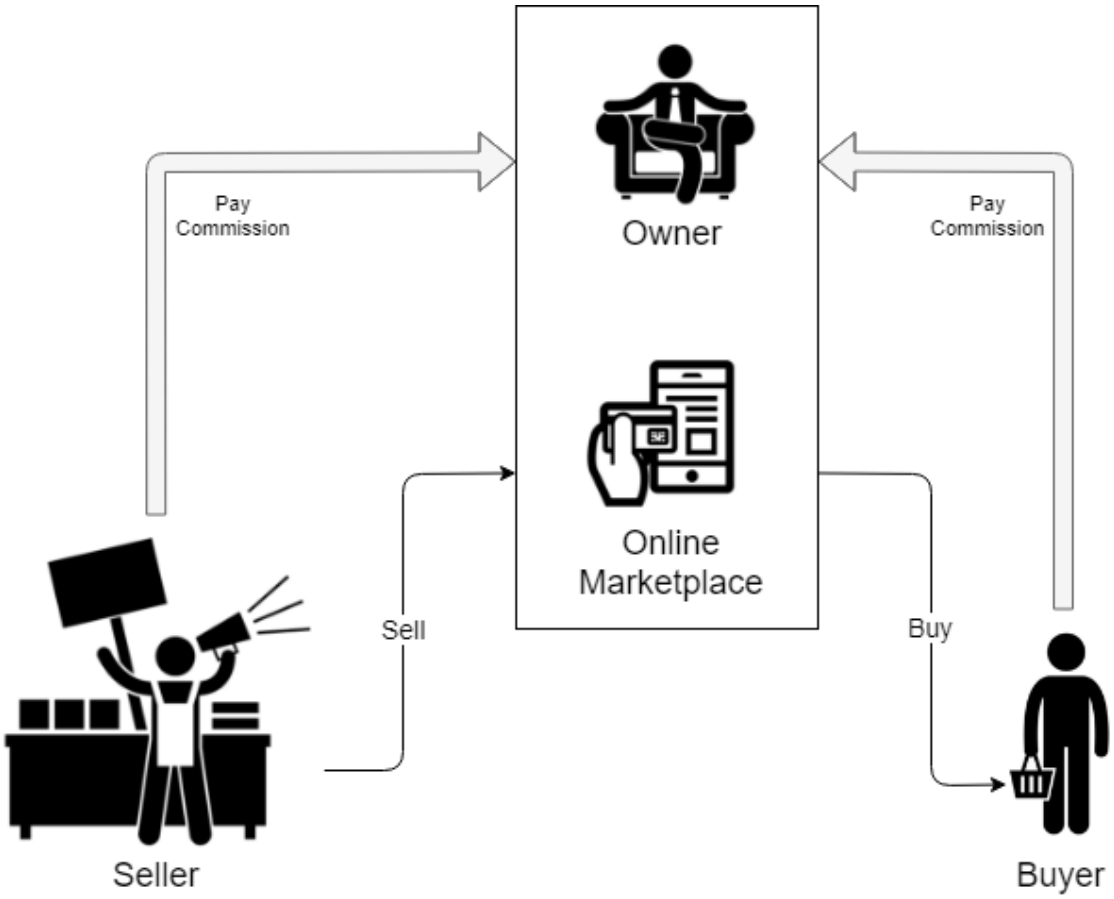


Figure 4 - Online e-Marketplace Concept

4.1 - Blockchain Marketplace vs. Traditional Marketplace

Undoubtedly platforms like Amazon or eBay are companies that earn their place in the world by their right, but despite that, we can consider them as a traditional marketplace, and by traditional, it is meant, a long established successful system, but even that system can be ameliorated. When we take concepts like decentralization and the possibility of third-party removal on payments, for example, we can transform the traditional marketplace via Blockchain technology.

Table 10 - Blockchain marketplace vs. Traditional marketplace

Marketplace Aspects	**Blockchain Marketplace**	**Traditional Marketplace**
Network Model	➢ Decentralized. ➢ Supported by users or nodes that contribute their computing power to the network, ensuring 24/7 availability and maintenance.	➢ Owned and regulated by a third party. ➢ Platform users must comply with terms set by the third party.

Payment and Fees	➢ Direct payment by cryptocurrency (token), which can be exchanged for Bitcoin or fiat. ➢ May offer low fees(around 0.0001 BTC ~ 1 USD) for transaction validation or even charge no fees.	➢ Payment systems or credit card transactions. ➢ Charges a percentage of every transaction, which is different for each marketplace: ○ Amazon ~15% ○ eBay ~ 10% ○ Etsy ~ 2.5–3.5%
Payment Processing Time	➢ Payments are instant & don't require an intermediary.	➢ Payments go through third-party financial services.
Information Security	➢ Data is immutable, so it cannot be deleted or changed. ➢ Validation by network prevents fraud.	➢ Personal information can be hacked and stolen.
Privacy	➢ Digitally signed smart contracts. ➢ Contracts are unbreakable. ➢ No intermediaries required, as smart contracts are executed automatically.	➢ Terms of agreements can change. ➢ Regulation by a third party.

It seems clear that making the bridge from the traditional marketplace to a new paradigm is viable and changes can be almost transparent. All these changes can bring about transparency and cost reductions which will be then transferred to the end user. There are already companies whose developments show the path towards a decentralized marketplace under Blockchain umbrella.

> *"Ink Protocol's vision is to decentralize peer-to-peer marketplaces, taking power away from the companies that run them and giving it back to the buyers and sellers. As a result, more value is distributed back to the actual user." (Brady, D., 2018)*

4.2 - Reputation and Feedback Systems in Online Platform Markets

There's been a surge in online marketplaces in the past decade, that range from eBay to Amazon, Uber or Airbnb. Confidence and trust are crucial factors in the normal functioning of this e-marketplaces, and both buyers and sellers need to trust that the other part will do its part.

Online marketplaces are also successful due to the easiness on which buyers and suppliers can find each other and to the feedback and reputations system that they have in place that facilitate and bring about trust on all participants.

> *"For a marketplace to flourish, therefore, it is necessary that both sides of the market feel comfortable trusting each other, and for that, they need to have safeguards that alleviate the problems caused by asymmetric information. It is largely understood today that eBay's success was not only due to the relative simplicity and transparency of its auction format, but also to a brilliant innovation introduced first by eBay and later copied in one form or another by practically every other marketplace: the use of a feedback and reputation mechanism. Indeed, feedback and reputation systems are central to the operations of every e-commerce marketplace and trace some of their heritage to ancient ancestor institutions that were used in the physical marketplaces of the Middle Ages." (Tadelis, S. 2016)*

4.2.1. Explicit reputation system

Reviews historically are what supports a reputation system. Whether the review refers to 5 stars rating or just simple comments, they consist of explicit feedback given by both buyers and sellers. By explicit reputation system, we are referring to explicitly giving a review, with the whole system depending on the action of an interested party, whether he is a buyer, seller or supplier. When we have something that depends on people's opinions issues arise because they are very subjective. Besides the subjectivity of one's opinion, other aspects must be considered, behavioral or psychological that may interfere with the reviews. Another important aspect is the quality of the review and apparent lack of standardization in reviewing something that was acquired, although the platform can help in that, by asking specific questions and relying on the willingness of the user to answer them. Some issues that affect an explicit reputation system are depicted below and are strong points on why it is important to have metrics that don't rely on user's opinions.

4.2.1.1. Reciprocal Reviewing issues

As the name suggests, this type of system allows both buyers and sellers to review each other. The main advantage is that it builds trust on both sides of the spectrum. However, when both sides have eyes on its counterpart review, fear of retaliation may hinder reviewers from giving poor feedback. To minimize this issue, one could resort to "simultaneous reveal." "A *simultaneous revelation of reviews reduces the strategic problems associated with reciprocal reviewing" Luca, M. 2017).* However, even this might not be enough due to fear of discouraging others from incurring in any transactions with the reviewer. Increasing anonymity could allow for more honest reviews while stripping down the fear of retaliation.

4.2.1.2. Self-Selection issues

Online reviews are voluntary, and due to this, they can suffer from selection bias, in a sense that reviews are done by people that chose both to acquire the product or service and leave feedback. Users are also more likely to leave feedback after a, particularly bad or enjoyable experience. "*Hu et al. (2009) find that reviews on Amazon tend to exhibit an asymmetric bimodal (J-shaped) distribution, with more positive than negative reviews. They argue that experiences for many products are more likely to resemble a normal distribution, and hence the J-shape suggests that people are more likely to leave reviews after extreme experiences. Masterov et al. (2015) find consistent evidence from eBay, where buyers are more likely to leave a review after a good experience." (Luca, M., 2017)*

4.2.1.3. Bad faith issues

Undermining competition by covertly leaving positive feedback about themselves or competitors is a potential source of another bias issue. *"Beyond verification of transactions, there are several other potential approaches to reducing promotional content: spam can be identified through algorithms that mine review text and characteristics (e.g., Ott et al. 2011, Akoglu et al. 2013)." (Luca, M., 2017)*

4.3 - e-Marketplace to e-Procurement

There exists a myriad of online marketplaces nowadays.

Figure 5 - Online Marketplaces (source: Linnworks.com)

Big players like Amazon are already looking at Blockchain as another way to cut down costs or increase the multitude of service offers to their users.

> *"AWS provides the broadest and deepest capabilities and the largest global infrastructure for building end-to-end blockchain platforms, cost efficiently and at scale. APN Technology and Consulting partners offer a rapidly growing selection of blockchain and distributed ledger solutions with support for multiple protocols." (AWS Blockchain Partners - Amazon)*

Investing in this area can, of course, be rewarding but competition is fierce. From the literature review made and post research, there emerges a concept that still has very few players on the market and, if supported by Blockchain technology, can help both users and buyers in on one hand save costs in acquiring goods and on the other hand bring more business to sellers with large volume transactions, which is syndicated reverse auction. On the next chapters of this dissertation, we shall do a deep dive and try to connect concepts like procurement, syndication and reverse auctions. The final objective will be to use Blockchain technology to conceptually construct the first steps to a reverse auction syndicated e-procurement platform.

Chapter 5

Procurement

"The act of obtaining or buying goods and services. The process includes preparation and processing of demand as well as the end receipt and approval of payment." (BusinessDictionary)

5.1 - Direct vs. indirect procurement

Depending on the nature of the goods one wants to acquire and the objective that the buyer wants them to serve, we can divide the act of purchasing these goods in two distinct definitions, namely "direct" and "indirect" procurement. If the purpose of the buyer is to acquire for example "raw goods/materials" needed to produce products that will later be sold to external entities, then we are referring to direct procurement. On the other hand, if the required goods are to be used for internal consumption (for example office supplies), then we are referring to indirect procurement.

Table 11 - Direct vs. indirect procurement

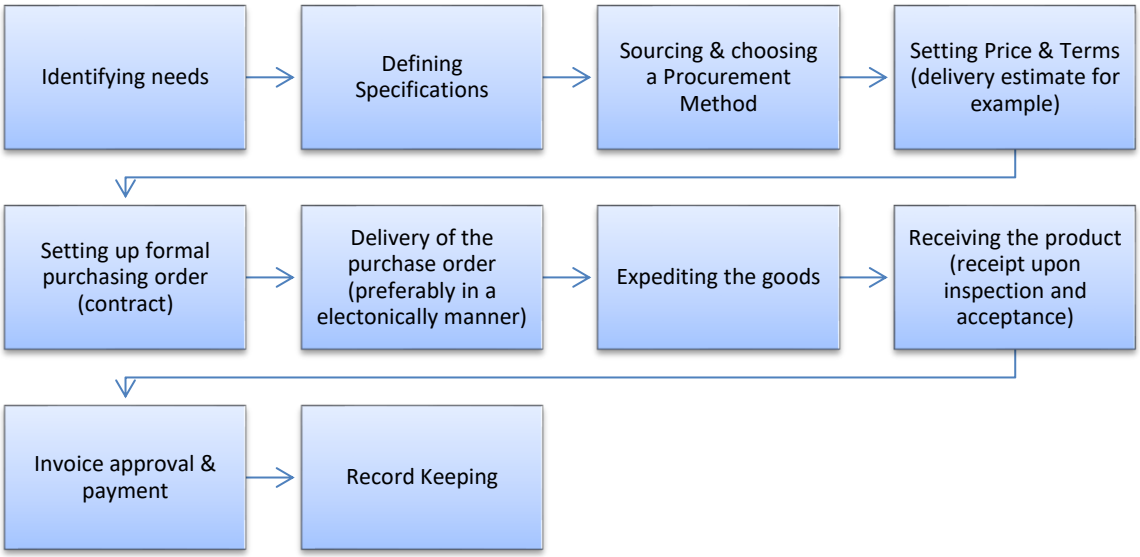
Direct procurement	Indirect procurement
➢ Perceived as critical, because it has implications for profit margins, operational efficiency, product quality/design and on the end-user experience. ➢ Problems that arise in direct procurement functions can compromise the buyer's ability to function correctly (for example, to be able to manufacture or create revenue).	➢ Perceived as a more administrative process suitable to control spending. ➢ Problems that arise in indirect procurement will affect the buyer's effectiveness (for example, lack of office supplies will hinder a buyer's ability to work properly).

Example: A company whose core business is to provide cloud functionalities will view computing equipment for its data centers as direct procurement. A company whose core is to design kitchen utensils will view its computing equipment as indirect procurement.

5.2 - Procurement process

Procurement has risen in importance over the past few years. Nowadays, procurement can be a critical factor in undertaking a successful enterprise, and although is seemingly an easy concept to grasp, the basic process itself is comprised of several essential phases, which can be seen depicted in the table below.

Table 12 - Basic phases of Procurement process



Note: Prepared by the author based on Sean Kolenko, 2014

5.3 - Electronic Procurement (e-Procurement or supplier exchange)

Min, H. and Galle, W. P. (2003) defined that e-procurement as "*business-to-business purchasing practice that utilizes electronic commerce to identify potential sources of supply, to purchase goods and services, to transfer payment and to interact with suppliers*." So, it means the marriage between technological tools and purchasing activities that take place within supply chains, which is to say that is a way to obtain gains and benefits from technology instead of the traditional practices.

So, the idea behind this concept is to envelop and automate the stages that exist in a procurement process, in Internet-based applications and technology. There are nowadays many

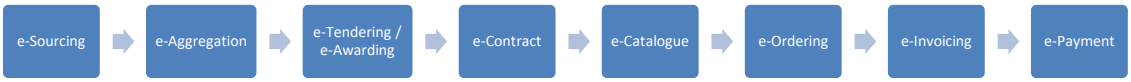
software developing companies whose business core is focused on supplying software solutions that implement the whole (or only a part) of the e-procurement lifecycle. This automation brings forth many benefits.

- **Reduced Transaction Time:** Without the need for manual intervention, transactions are completed on a real-time basis.
- **Electronic Catalogues:** Buyers can look at various offers from different vendors with ease and price transparency.
- **Increased Supplier Bases:** Virtual e-Procurement portals are web-based; therefore, buyers can browse the world wide web. Of course, with greater distances, shipping costs must also be considered.
- **Simplified Global Procurement**: Regardless of language and place, e-Procurement applications support different languages, currencies, international taxation and financing, shipping regulations and more, making easy for buyers and suppliers to "talk" amongst themselves.
- **Increased Productivity**: Automated processes, which were typically handled by employees, will free up time and resources.
- **Customization and Scalability**: E-procurement applications allow for different configurations that can be tailored to satisfy their users. With a proper selection of the software vendor (or even built in-house), these applications can grow with their customer needs.
- **Cost Efficiency**: All the benefits depicted above, such as time reduction, increased supplier selection, trading communities and so forth, make e-procurement much more cost efficient than the traditional procurement.
- **Trading Communities**: Being web-based, the opportunity to develop both vertical and horizontal trading communities emerges. Different buyers can increase their buying power via consortia, which means that smaller volume buyers can access prices historically reserved for more prominent buyers.
    - A formal trading community consists of a website or network of websites that facilitate and track trade transactions. Some websites charge transactional fees per trade.
        - Key features: **Transactional tracking; Ratings and feedback system; Content listing, referencing, and matching**.

E-Procurement has a very positive impact on the profits of the organization because it can decrease time and resources (like money) used on the purchasing cycle.

To reap the benefits of having an e-Procurement web-based solution that handles all the necessary steps, all the links in the following chain should be present:

Table 13 - Stages of the e-procurement process



5.4 - e-Sourcing

Refers to the process of getting bids from different suppliers via a single online portal. Being that the simplest primary requisite, to fulfill it well, the process should follow the below steps:

1. **Requisites definitions** – Defining product specifications, bidder qualification criteria, evaluation criteria and definition of date and place delivery.
2. **Request For Quotes** – Handling the process on the platform and the qualified bidders, then inviting/awarding the selected bidders.
3. **Quote** analysis – Analyzing financial capacity and technical specificities and run a comparative analysis of the quotes.
4. **Evaluation/negotiation** – Evaluate and clarify requirements, present counter proposals and run the electronic auction.
5. **Contract** – Select and notify all involved suppliers, accept the contract and handle ERP integration.
6. **Contract management** – Monitor dates and amounts, contract repository, handle orders and inquiries.

It should be extended in a way that implements other "basic" tools that will aid the buyer or buyers considerably:

- **Collaboration** - Making the bridge between colleagues, supervisors, and suppliers by streamlining communications and bidding processes so that data can flow to wherever is needed transparently. Built-in communication is a plus.
- **Comparison** - Pointing out the difference between bids in a central hub and simulating different scenarios will take out the guesswork of choosing a bid, aiding the user to make more rational decisions.
- **Workflow** - After the sourcing process is complete, the process should naturally flow into contract creation, with all past contracts being accessible to search and analysis.
- **Analytics** - By having a bit of business intelligence and the ability to export reports that are easy to understand, its use will result in better business decisions.
- **Customization** - It should allow the user to undertake some changes that will be unique to the user's business. It must be easily adaptable to different requirements by allowing to build dashboards or any other control that will be relevant to one's business.

5.4.1.Auction automation

Implementing automated auctions and bidding will result in the dematerialization of the business process associated to a commercial relationship, boosting transparency in the process and easiness of inclusion of a broad base of potential suppliers, increasing competition between them, and reducing the time frame of the negotiating process. There are several types of auctions. The most popular of them can be seen below in Table 14. It can be argued that auctions that take advantage of emotion, such as the Reverse English Auction, usually push prices beyond closed auctions.

Table 14 - Types of auctions

➢ **Reverse English auction** – One buyer and many sellers. Bidders offer decreasing prices and bidding price will continually decrease until an item can be sold. Vastly used in internet auctions. ➢ **Dutch** – The starting bid is very low and automatically and gradually increases. It will end when the first bidder accepts the current value. ➢ **American** – Similar to the closed proposal auction, however, the winning bid price goes by the second-best proposal.	➢ **Closed Proposal** – A limited time frame for the participants to submit a single proposal. No bidder knows of the competitor's proposal, and the lowest offer wins. ➢ **Japanese** – The stating bid automatically and gradually decreases and each bidder confirms that he wishes to remain in the tender. It ends when there is only one bidder left.

5.4.2.e-Aggregation & e-Clusters

Aggregation is a way of combining consumer demand into large volume orders to get a decrease in the price. It is also known as a buying community or demand aggregation.

Business clusters function as a basis for gaining competitive advantage. The first definitions stated that they form a group of companies that are in "close" proximity, whether a country, a region or even a city. Later definitions added the concept of virtual links between them, forsaking somewhat the physical location. These links, however, make more sense for big companies that work on a global scale, meaning that small and medium businesses will significantly benefit at a more regional scale.

> "These clusters are intended to achieve better economies of scale, increased efficiency enabled by proximity to other supply chain partners,

> co-production with other cluster members, access to human capital and reduced business risk." (Adebanjo, D., 2010)

There are easily recognizable clusters at a global level, such as Silicon Valley, a well-known information technology cluster, where are companies like Apple and Google headquartered. In Hollywood, there is a cluster that is famous for being the base of the cinematographic industry. In Portugal, we can highlight the cluster of mattresses located in São João da Madeira or the Cluster of Furniture in Paços de Ferreira.

Of course, information and communications technology (ICT) somewhat disperse the focus on the regional economy, and because nowadays software solutions are widely available for all companies, small or big, more and more clusters may be negatively affected.

Due to the nature of the e-Cluster, they could serve as e-Marketplaces and enable trading between e-Cluster members or between them and their supply chain partners.

5.5 - Procurement auctions

In a procurement auction (i.e., reverse auction), the goal is to find new suppliers, while guaranteeing that existing suppliers also can offer better prices or better terms. This type of auction is usually held online and is composed of the following activities:

1. A buyer sets up a contract with a market maker (which is usually an online platform specialized in this type of work.
2. A Request for Proposal (RFP) is issued on the platform to fulfill a request for a group of products or services. This RFP lasts a certain length of time or bidding rounds.
3. Potential suppliers will visit the site and input their bid.
4. Time constraints and dynamic bidding will ensure that prices move downwards.
5. The buyer chooses the best bid (focused only on price or taking into consideration other aspects, such as quality or better terms).

Table 15 - Disadvantages and advantages of procurement auctions

Disadvantages	Advantages
➢ Low bidding may result in loss of quality ➢ Lack of information or unawareness of the auction may hinder suppliers from bidding.	➢ Suppliers are encouraged to bid low but also to provide good terms to win the contract. ➢ These types of auctions are perceived as a just way of awarding government

➢ If suppliers are (naturally) bidding low, this may mean that they are only biding on a small part of their product range. ➢ Some suppliers may be tempted to work around the predetermined auction rules. ➢ If there was a previous supplier, the cost of moving to a new one must be factored in.	contracts as well as those from large monopolistic companies. ➢ Low cost and faster way of finding new suppliers. ➢ No (or almost none) negotiating costs

Source: Purchasing & Procurement Center

5.5.1. Procurement auctions vs. negotiations

In an auction, it is the supplier's burden to make concessions, because it is a more competitive environment than a negotiation, and many different suppliers may enter the bidding war. If time is a factor (short period auctions), the winning offer might even be non-profitable, due to overbidding and time pressure.

These factors may deter suppliers from entering auctions. However, during more prolonged periods, both parties can still enjoy profitable and efficient contracts.

Admissible bids and winning bids are announced to all the suppliers, which may serve as a guideline for suppliers to make progressive bids and, serves as an indicator to the existence of many bidders, which in turn may lead to even more competition.

Table 16 - Procurement auctions vs. Negotiations

Procurement auctions	Negotiations
+ Efficient (in terms of Pareto optimality) + Foster competition + Proposals (different suppliers) + Buyers bargaining power + Competitive + Buyers gains - Suppliers profits + Suppliers concessions + Focus on economic aspects (e.g., Saving costs and profit gains)	+ Balanced contracts between buyers and suppliers. + Suppliers profits + Higher assessment of the projects and the outcomes + Buyers concessions + Focus on social aspects (e.g., public procurement)

Note: Adapted from Wu, S., Kersten, G. E. (2017).

5.5.1.1.Negotiating strategies

Table 17 - The continuum of negotiation approaches

Distributive	Compromise	Integrative
Characteristics		
➢ Focus on immediate results. ➢ Discussion of positions. ➢ Rigid thinking. ➢ Harder behavior. ➢ Domain of the situation -tries to impose the wishes. ➢ Harm the relationship in the process. ➢ Search for the best price. ➢ Search for "largest piece of the pie". ➢ No creative agreement ➢ Focus on individual goals. ➢ Winning at any cost.	➢ Focus on earnings sharing. ➢ Preserve the current and future relationship ➢ May result in partial gains for both sides. ➢ Alternative to collaborative, to avoid win-lose. ➢ Both parties transfer: distributed gains and losses. ➢ Low availability of time and other resources (e.g., financial).	➢ Creating joint earnings. ➢ Discussion based on the pursuit of common interests. ➢ Long-term relationship Thinking "with" and not "against". ➢ Maximization of gains on both parts - "pie expansion". ➢ Satisfaction of needs. ➢ Result in more innovative solutions. ➢ Construction of value. ➢ Open information exchange. ➢ Focus on problem.
Tactics		
➢ Search for opponents' weaknesses ➢ How and when to make the 1st offer? ➢ Overcoming objections ➢ Use of techniques for reading body language ➢ Rigid attitude, threat	➢ Give and take ➢ Split concessions between the two sides ➢ Intermediate solutions ➢ Work with the possible agreement zone (value of entry and exit of the negotiation)	➢ How to build trust ➢ Communication study ➢ Focus on interest rather than positions ➢ Brainstorming ideas ➢ Consider cultural differences
Immediate results do not focus on the relationship		**Long-term results and relationship**

Source: Prado, L. S., Martinelli, D.P. (2018)

Depending on the type of needs, the interested parties assume different strategies. If it is a sporadic relationship (a one-time deal), then the focus will be on immediate gain, regardless of possible damages to future business with the other party. If a future business is considered, then focus is shifted towards resolution and a greater disposition to concede better terms in detriment of greater short-term profit. Whether wanting to maximize profit or wanting to establish a long-term business relationship, the negotiating parties will undergo different approaches and tactics to achieve their goals. The reasons the negotiating parties have are the triggers to the negotiating approach.

Table 18 - Reasons to adopt specific negotiation strategies

Strategy	Seller's Reasons	Buyer's Reasons
Collaborative	1. Strengthening/maintaining trust 2. Influence of existing relationship 3. Positive influence on negotiation conclusion 4. Maximizing mutual gain 5. Strengthening the relationship 6. Expansion of negotiation value 7. Maximizing long-term return 8. Improving customer satisfaction 9. Style - personality traits	1. Influence of existing relationship 2. Maximizing mutual gains 3. Strengthening the relationship/supplier Maintenance 4. Improvement of the seller's satisfaction
Compromise	1. Protection against attack from competitors in the short term for continuity of the relationship - future earnings 2. Conclusion of the negotiation 3. Division of gains	1. Influence of existing relationship 2. Division of gains 3. Improved satisfaction on both sides
Competitive	1. Defense of self -interest 2. Compete, because the other side will compete. 3. A better way to face the other side	1. Defense of self-interest 2. Styles /personality traits 3. Reduction of the price paid 4. External environmental pressures 5. Expansion of individual earnings 6. Interest in substantial results 7. Availability of equivalent alternatives

Source: Prado, L. S., & Martinelli, D.P. (2018)

5.5.2.Multi-attribute auctions

This type of auction extends the traditional auction by allowing the bidding to occur not only over price but also over other attributes. For example, in a procurement issue, the multi-attribute auction will allow the suppliers to compete on both price and attributes value.

Example: Consider a company that wants to hold a procurement multi-attribute auction:

Table 19 - Multi-attribute procurement auction example

Parameters	Supplier bid
Number of units: 500 Desktop PCs. Maximum price: 100.000€ (200€/unit) Requirements: - 500GB Hard drive - 8 GB RAM Memory - Windows 10	Number of units: 500 Desktop PCs. Maximum price: 75.000€ (150€/unit) Requirements: - 500GB Hard drive - 4 GB RAM Memory - Windows 10

A supplier could bid over the attribute of the requirement while maintaining (or changing) the price. This bid would then become available to the other suppliers/bidders if and only if accepted or rejected.

5.5.3.Multi-attribute Procurement Mechanisms

Table 20 - Procurement mechanisms

Request For Quotation (RFQ)	Request For Proposal (RFP)
➢ Detailed specifications to the suppliers. ➢ Suppliers are required to meet the specifications. ➢ Buyer selects among those suppliers based on cost.	➢ Detailed specifications to the suppliers. ➢ Suppliers submit proposals which are evaluated by the buyer. ➢ The contract is awarded to the best overall supplier, as determined by the buyer, perhaps using a score function.

Two-stage sourcing process (TSP)	Performance-based contracting (PBC)
1. Stage - Qualification Stage - The potential suppliers are screened for various nonprice capabilities. 2. Stage - Supplier Selection Stage - The qualified suppliers are	➢ Suppliers participate in a price-only reverse auction. After the awarding of the contract, the winning supplier receives a penalty (or reward) based on his realized performance. ➢ Useful when the suppliers' nonprice attributes are unknown to the buyer at the time of bidding.

invited to compete in a price-only procurement auction. ➢ Suppliers tend to keep to quality levels. ➢ Quality is assessed before supplier selection.	➢ Also referred to as a fixed price auction with incentives. ➢ Suppliers are induced to go beyond quality levels. ➢ Quality is evaluated after the awarding of the contract.

Note: Adapted from Jin, Y., Ryan, J. K (2016)

Table 21 - TSP vs. PBC – Pros & Cons

Two-stage sourcing process (TSP)	**Performance-based contracting (PBC)**
+ Imposes a minimum quality level across all the potential suppliers. - Does not provide the same level of flexibility for the suppliers to adjust their quality levels to their cost structure. - Only a subset of qualified suppliers can bid. The supplier's preference for TSP is strongest when the number of suppliers is large, the spread of the suppliers' costs is small, and the unit warranty cost is large.	+ Outperforms TSP from the perspective of the buyer. + Provides suppliers with the flexibility to choose the quality level to minimize their costs. + All potential suppliers can bid (More competition favors buyers). + Most beneficial to the buyer when the spread in the potential suppliers' costs is large and when the unit warranty cost is large. + Delivered quality is generally higher and the gap between the quality levels is largest when the spread in the potential suppliers' costs is large and when the number of potential suppliers and unit warranty cost are small.
We find that the expected delivered quality will increase towards the system optimal quality level as the number of potential suppliers increases. Finally, while the buyer always prefers to source through PBC, we find that the winning supplier is generally better off under TSP.	

Note: Adapted from Jin, Y., Ryan, J. K (2016)

5.6 - Syndicated procurement

It is a purchasing method that involves a group of entities pooling their respective needs. A syndicate manager is appointed and on behalf of the interested parties undergoes and concludes a contract with a supplier.

Table 22 - Syndicated procurement example

Buyer A: Number of units: 100 Desktop PCs. Requirements: - 500GB Hard drive - 8 GB RAM Memory	
Buyer B: Number of units: 200 Desktop PCs. Requirements: - 500GB Hard drive - 8 GB RAM Memory	**Syndicated manager** Number of units: **500** Desktop PCs. Requirements: - 500GB Hard drive - 8 GB RAM Memory
Buyer C: Number of units: 300 Desktop PCs. Requirements: - 500GB Hard drive - 8 GB RAM Memory	

It is very likely that the three buyers depicted above will achieve betters terms (e.g., Price wise) by combining their needs and thus achieving a higher bargaining power than on the other hand dealing individually with a supplier.

5.7 - e-Procurement

Procurement is a term connoted with the public sector and governments worldwide have already taken the first steps to turn procurement into e-procurement.

***Key issue**: Lack of integration of information along the procurement process making it impossible to control and monitor.*	***Solution**: Develop an end-to-end technological model to ensure not only transparent and cost-effective procurement processes but also the construction of the knowledge base that is needed to support strategic decisions towards public expenditure reduction and optimization.*

Source: Public Procurement in the EU, the 2020 Agenda

Many private enterprises focus on e-marketplaces and group buying, like “Amazon” or “Groupon”. There are some that focus on some parts of the e-procurement process, as depicted

in Table 13, a good example is “Saphety”, a Portuguese company that is owned by “Sonae.” However, private they may be, these few companies are mainly present on the B2B segment.

Many companies must endeavor in procurement activities to purchase products that are needed for everyday functions, whether office supplies or specialized products. Finding trustworthy suppliers that deliver in due time at competitive costs is no easy feat.

Seems only natural that making the bridge between buyers that share the same need will aid in that quest. Moreover, by providing possible suppliers with access to more significant volume transactions will result in decreasing the cost per product by exploring their economies of scale.

> *“Economies of scale are **the cost advantages** that a business can exploit by **expanding their scale of production**. The effect of economies of scale is to reduce the average (unit) costs of production.” (Riley, J.)*

Confidence and lack of, the fact that procurement, and more precisely syndicated procurement, is a costly process both in time and resources, will hinder many SME’s (small and medium-sized enterprises) from partnering up with other companies and/or regular people that may want the same product or service and by doing that gaining leverage on the negotiating table.

Now is the time to invest in the automatization of this process. By resorting to already existing technology, such as blockchain and smart contracts, we can bring to that table confidence to this process and decrease time spent and consequently decrease in the overall cost. We propose an online platform that will ease aggregation between different buyers and allow suppliers to approach this group and fulfill their needs in a way that every party wins.

5.8 - Barriers to the “e” concept

Technology and automation are already household terms that are present in everybody’s mind, but when we refer to high volume transactions, the implementation may not be so linear. So, what may stop the adoptability by possible users of the solution that is hereby proposed?

> *“A recent white paper put out by JP Morgan suggests that the current set of buying channels that exists in most organizational supply chains is a mammoth—literally a dinosaur in this case! This study suggests that for business-to-business (B2B) transactions, despite the new developments in payments, a large extent of businesses in the United States still rely on*

checks for paying their vendors and suppliers. A commonly cited reason for this is that "checks work"...." (Handfield, R., 2017)

Table 23 - Barriers to Increasing Use of Electronic Payments

	Major Barrier	**Minor Barrier**	**Not a Barrier**
Shortage of IT resources for implementation	38%	39%	24%
Lack of integration between electronic payment and accounting systems	32	37	31
No standard format for remittance information	28	43	29
Difficult to convince customers to pay electronically	22	56	22
Collecting and storing bank account information	20	38	42
Difficult to convince suppliers to accept electronic payments	19	57	24
Privacy/security of bank account information	19	41	40
My trading partners cannot send or receive automated remittance information with electronic payments	14	44	42
Check systems work well	12	37	51
My organization cannot send or receive automated remittance information with electronic payments	12	27	61
Loss of check float	9	28	63
My organization needs to open/hold a current account to make or receive payments in foreign currencies	5	16	79
Banking partners that do not offer all the currencies in which my organization makes payments	3	16	81

Source: 2016 AFP - Electronic Payments Survey - JP Morgan

There are still nowadays, a myriad of processes and areas that rely heavily on paper for many different reasons, if we extrapolate from the above table, we can point out, some reasons that spread to other areas, namely lack of standardization, shortage of IT resources, lack of integration with third parties system, or merely fear/resistance of/to change.

By design, blockchain is a secure log of transactions and trades of value, so its application naturally fits online payments by taking third parties out of the equation and by being entirely digital. We can also take the principal characteristics of this technology like immutability, tamper-proof data, and smart contracts that inherit those same features because they are built on top of blockchain and apply them on the construction of a digital platform and consequently solve many of the issues that are present in the table above.

Chapter 6

Applying Smart contracts to a reverse auction syndicated e-procurement platform

A Smart contract is code that will execute automatically taking the burden and human error out of the equation. With an interface that runs on a browser or app, whether the user is a buyer or a supplier, they will have at their disposal a solution that makes transparent the whole process, since submitting proposals and offers until their acceptance. At the same time, the behind logic such as buyer aggregation (syndication), auction automation, and reputation system is handled automatically.

A buyer or supplier will, therefore, have a unique address that is used in their authentication in the platform. Anonymity will be maintained among the several interested parties and like many successful online businesses that connect buyers and suppliers, it must have a reputation and feedback system. Despite the type of system used or the algorithms used to calculate buyers and supplier's reputability, past data is needed and must be safeguarded from the beginning.

Blockchain is a linked database that keeps data secure, and it can be used to safely and confidently track every action (automatic or manual) that was made by every participant, due to that, the rating and feedback system can be built on top of it and can be fine-tuned at later stages without fear of losing any earlier data.

6.1 - Conceptual Smart contract aggregation model

The objective of this aggregation model is to combine similar buyers needs in a single proposal to be then showed to suppliers and posteriorly subject to bidding. The needs are relative not only to price but other items, such as the number of units, price per unit and region.

Consider Table 22, there is shown a syndicated procurement example, in that table, three buyers share the same need, varying only in the number of products required, and those needs results in a single proposal. That proposal also establishes a length of time for which it remains open for bidding.

The supplier has two options available, making a bid based on a unitary price on an existing proposal or make an offer that can later be evaluated when new proposals appear. Consider this smart contract as a program that receives as inputs proposals from buyers and offers from suppliers and manages them automatically, with no possibility of tampering.

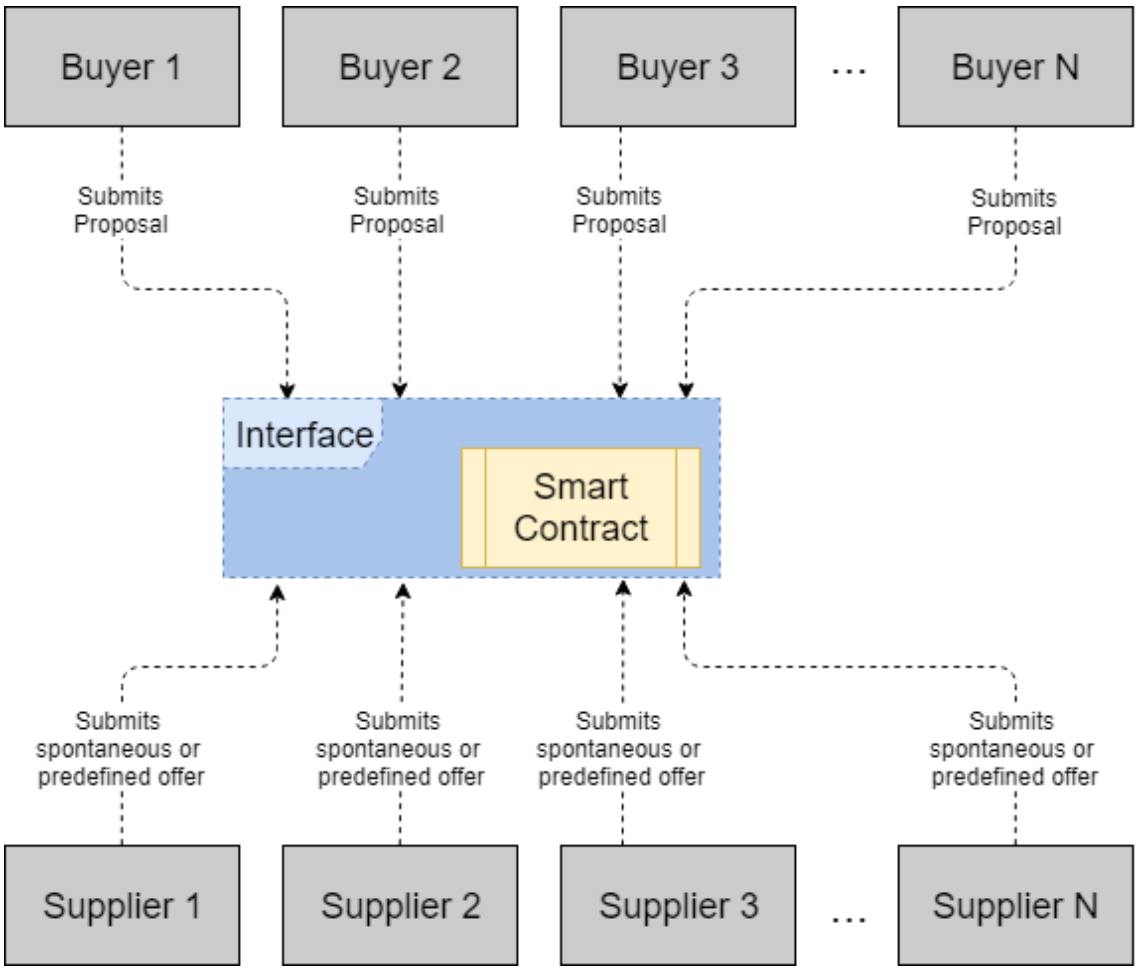


Figure 6 - Aggregation Model

An interface is available to buyers and suppliers to allow them to interact with the platform. In the smart contract, a proposal can be individual or joined and will become a closed proposal when the time is due. An offer can be spontaneous or predefined, depending on whether it is pertaining to an existing closed proposal or not. In the points below is depicted what happens in each case.

- **Individual Proposal** – A request submitted by the buyer that reflects its needs, namely:
    - The product, number of units, price per unit and region.
    - The buyer also defines whether the proposal can be joined by other buyers or will remain a standalone proposal.
- **Joined Proposal** – If other buyers join an Individual Proposal, then it becomes a joined proposal, and the original proposal is the first of a list that is defined inside the joined proposal.
    - It, therefore, contains a list of individual proposals that share the same characteristics and the end date until when other buyers can join this proposal.
- **Closed Proposal** – A final proposal whose aggregation period is over or an individual proposal that could not be joined in the first place.
    - It contains a list of offers from the various sellers that wish to satisfy the proposal.

- **Spontaneous Offer** – A request submitted by a supplier that targets a specific closed proposal. If the closed proposal is still active this offer is added to the list of offers that will be considered in said proposal.
- **Predefined Offer** – A request submitted by a supplier that does not fit in any existing proposal.
    - It, therefore, contains a set of parameters such as product, minimum quantity and maximum quantity, price per unit and region.
    - Whenever any new closed proposal is created, every predefined offer that fits the proposal will be taken into consideration, and the ones with the best conditions are added as offers to said proposal.

Consider Figure 7 below to get a better grasp of how the smart contract will behave according to each event.

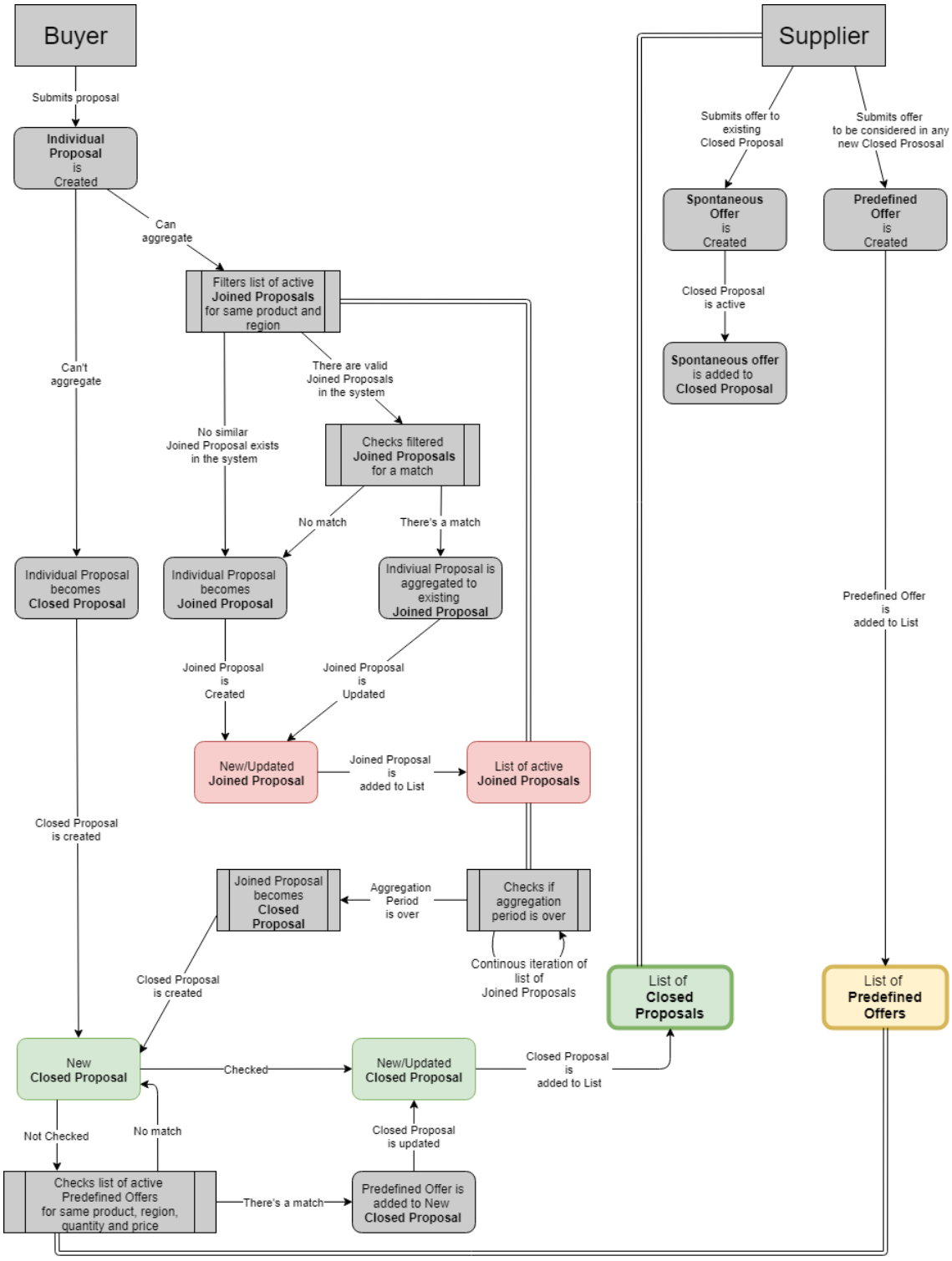


Figure 7 - Smart contract aggregation model Schematics

6.2 - Implicit Reputation System

As seen in point 4.2.1, an essential element in online marketplaces refers to reputation systems, for a variety of reasons already explained. A platform such as this is no exception, and because issues such as trust and confidence are of paramount importance, a reputation

system must be developed. Consider the issues that affect current marketplaces (e.g., Amazon) rating system. All issues that result from biased ratings, poor-quality reviews and overall subjectivity of opinions. An explicit reputation system should be considered to assure ratings that derive from objective metrics. To take advantage of blockchain technology, more particularly smart contracts, the platform must use metrics that can be handled automatically throughout the process and can objectively contribute in assessing buyer or supplier reliability.

6.2.1. Measuring supplier performance

By taking subjectivity off the equation, we can point out objective metrics that can be used to assess supplier performance. We can base this assessment on quantity, price and time and use these points to calculate several metrics.

Example: Suppose there's a purchase order of 110 units made by January 1st and is due by the 15 of the same month, and the order is delivered in 4 tranches:

- ➔ Purchase orders: 110 units due on the 15 of the current month.
- ➔ Quantity received
  - 25 at day 13
  - 25 at day 14
  - 33 at day 15
    - Sub-total of 83.000 (on-time delivery)
  - 5 at day 16 (late delivery)
    - Total of 88 of 110 units
- ➔ Returned to supplier
  - 15 units (rejected units)

Table 24 - Metrics

Metrics	Performance
➢ **On-Time** – This metric shows the percentage of delivered goods that are on time, early and late by a period.	Delivered Goods (ahead of time, on time, later) * 100 / Total Goods ➔ Early: 50 * 100 / 110 ≈ **45%** ➔ On time: 83 * 100 / 110 ≈ **75%** ➔ Later: 5 * 100 / 110 ≈ **5%**
➢ **Quantity Ordered versus Quantity Received** – This metric will track the percentage of the received goods versus the ordered quantity.	Total Delivered Goods * 100 / Total Goods ➔ 88 * 100 / 110 = 80%

➢ **Quality** – This metric calculates the delivered goods versus the returned goods, excluding incomplete deliveries.	(1 – Total Delivered Goods / Returned Goods) * 100 ➔ (1 – 88 / 15) * 100 ≈ **98%**

6.2.1.1.Lead Time

Is the time that spans from when the moment an order was placed, until the moment it is delivered to the buyer. It is an important measure and metric used in supply chain management or project management. However, it can also be advantageous to measure supplier performance, in the sense that it can help the buyer to perceives supplier reliability regarding delivery on time.

- **Requested Order Lead Time (ROLT)** – Represents the time between order entry date and the buyer requested delivery date.
- **Confirmed Order Lead Time (COLT)** – Represents the time between order entry date and the supplier confirmed delivery date.
- **Quote Order Lead Time (QOLT)** - Represents the time between order entry date and the agreed upon Quote delivery date.
- **Actual Order Lead Time (AOLT)**- Represents the time between order entry date and the final delivery of the order.

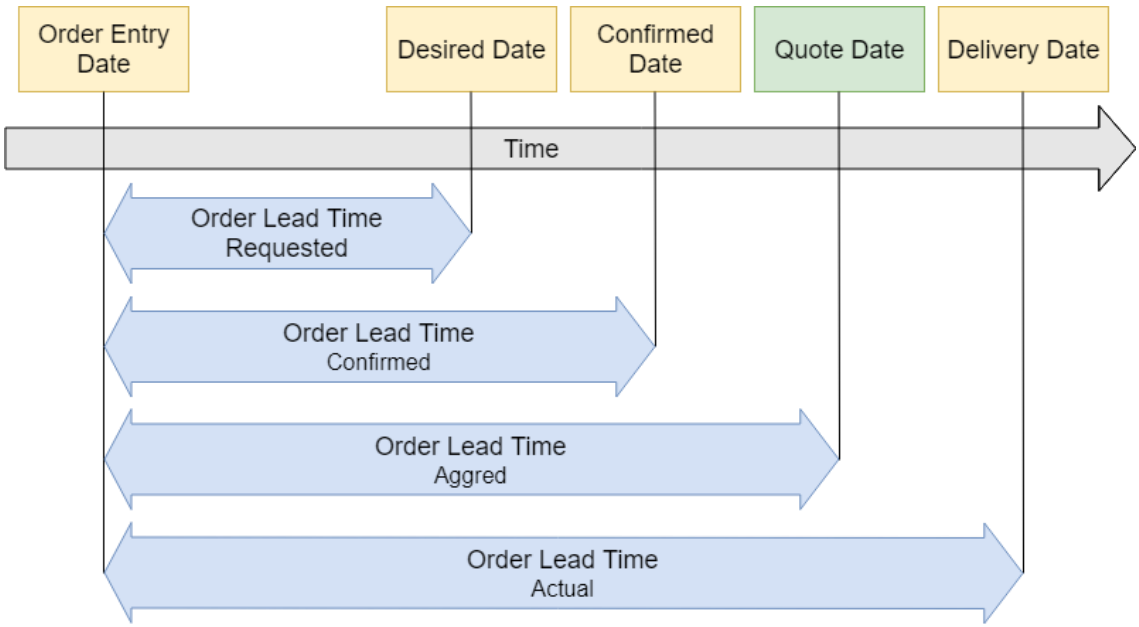


Figure 8 - Order Lead Times

To assess supplier performance, we can use the agreed upon quote date and delivery date difference.

6.3 - Suggested metrics and flowchart

To take advantage of automation and to remove possible bias from the system, it is suggested that an implied reputation system is used, which is to say, take metrics that are not the result of human interaction. Because all actions are stored and easily accessed, namely, the prices, quantities, product returns, lead times, or others. It is "only" a matter of combining all these inputs into an output that matters to all interested parties and to assess the whole system performance.

On the system flowchart depicted below, we can see a general overview of how the system may work. The Smart Contract (marked with a *) implemented over a Blockchain is a central piece of the system that gives it the automation and confidence. Of course, integration with third parties must be considered, for example regarding paying for and delivering the goods, however, that is outside the scope of this research.

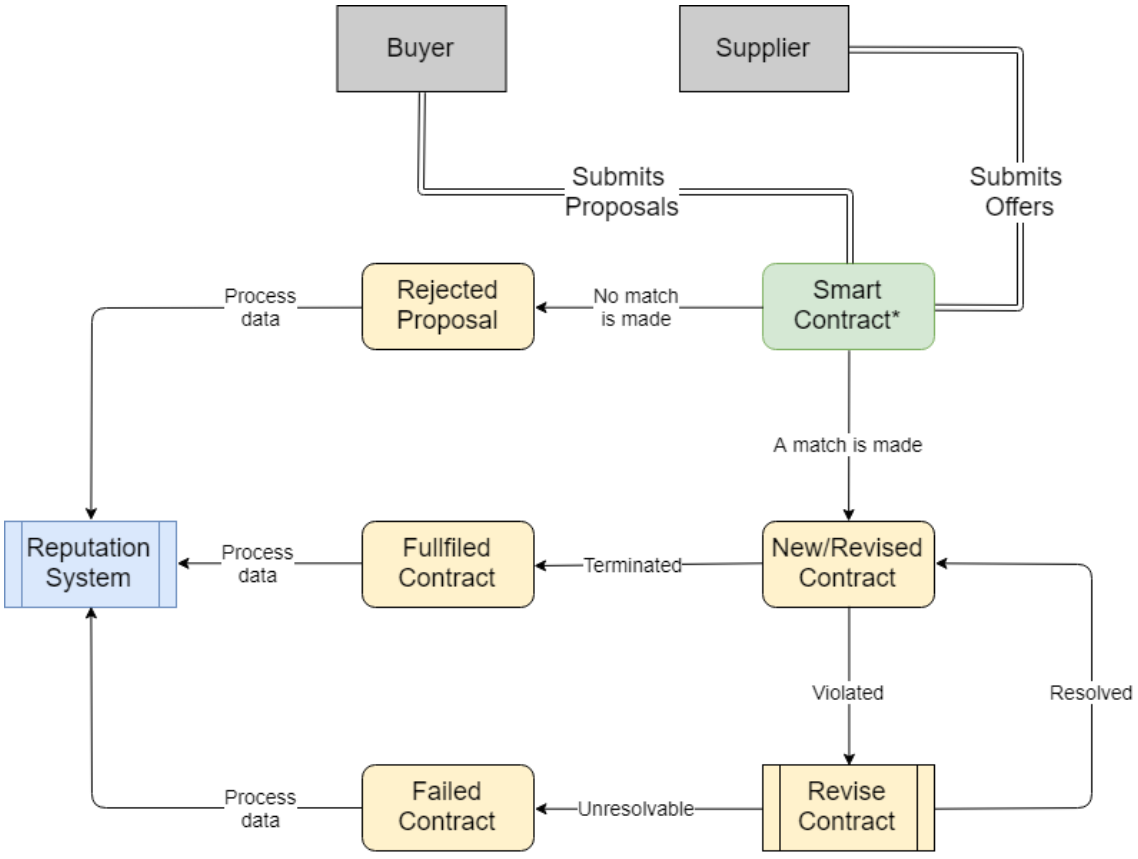


Figure 9 - System flowchart

Key players in the system are the customers (buyers) and the suppliers. The platform should ensure confidence.

Chapter 7

Conclusions

By analyzing features of the Blockchain technology and by making use of Smart Contracts, which inherit Blockchain characteristics and correlating them with issues that affect various industries, we were able to find gaps that technology could help fill. This can be concluded by the companies and start-ups that are investing in this technology, whether they intend to ameliorate existing processes or even replace them. Some examples of this real use cases are present in Table 8 - Blockchain business benefits. The literature review also demonstrates that researchers are confident that this technology has future in many areas.

Through the study of online marketplaces, is concluded that applying blockchain to this type of platform will help solve issues regarding lack of security or high fees and payments to third parties. It is also concluded also that rating systems are paramount in the success of this type of platforms because they are perceived to increase trust and confidence throughout the platform, although they suffer from bias and high subjectivity in the user's opinions.

The study of online marketplaces and its issues helped in making the transaction in the process of understanding procurement. The objective of this dissertation of developing a reverse auction syndicated e-procurement platform implied the study of how the procurement processes work. Is concluded that the processes are more intricate, also because procurement involves large order quantities, more control of billing how the money changes hands, and of course trust in the process is of great importance.

Through the study of syndication and how auctions take place in procurement processes, an automatic model of aggregation was developed using smart contracts. Considering online marketplaces and its rating system, it also concluded that such a system must be part of the

platform. To take advantage of automation and to reduce bias of the opinions, objective metrics must be used.

Despite what limitations this research may have and the future work that is required for the advancement of the project, this study contains points that can aid future developers in said advancement. The objective of understanding the technology and its possible uses and the development of a real use case, as deemed the final objective as fulfilled.

7.1 - Recommendations for developers

"He who would learn to fly one day must first learn to walk and run and climb and dance; one cannot fly into flying." (Nietzsche, F.)

The making of the Smart Contract as a central piece is a starting point to the full development of the system, and although preparation and method are paramount on an endeavor of this magnitude, and because Blockchain technology is trending, time to market should be deemed of utmost importance, and hence development should quicken.

7.2 - Recommendations for entrepreneurs

"The best way to predict the future is to create it." (Drucker, P.)

An important part of being an entrepreneur is to find gaps in current models or processes and find ways to solve them or make them better. The way to reach that goal can suffer many twists and turns. At the beginning of this research, the spectrum was vast, the technology itself was vaguely known, even the final objective had to be thoroughly researched to get a firm grasp of the subject. There was a significant concern in justifying the use of Blockchain technology in the platform. However, for the final user, the technology used does not matter, what matters is the perception the user will have of the service, so if by some reason Blockchain technology would fail to fulfill the gaps found, other would have to be used and researched. Nevertheless, following a consistent research method, resorting to the tools learned in the master's that this dissertation was carried out under, and continuously narrowing the focus of the research, lead to the conclusion that the characteristics of the technology fit well with the gaps that a platform such as this presents, which are fundamentally confidence and trust issues, automation and implementation issues, and cost issues.

To increase the chances of success, the entrepreneur must be knowledgeable (or at least have some notions) of several subjects, from law (applying patents for example), to economy (knowing how much resources will it take to bring the business to the right port), and especially innovation (risk-taking and being able to see the bigger picture), among others. All these are

tools that can be learned and will aid the entrepreneur in its quest. In the case of this research, the technology itself was a mean to an end, but it is essential to understand and be aware of the path taken, keeping, of course, the focus on the final objective.

7.3 - Future work

Besides the aggregation model, made with a smart contract, many improvements to increase the features present in the platform must be addressed. The type of auctions depicted in Table 14 is an excellent example to include in future developments because the success of an auction often depends on the type of buyers, sellers, and products, the platform should allow for the buyer to choose how the auction will be conducted.

We have dabbled with smart contracts and demonstrated that processes with little to no human interaction could be made into code that executes automatically. If we break down the processes contained within a project (let's say an e-procurement platform) we can make several automations that will hasten all the project by itself. Future work should involve the development of these processes.

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