Vincenzo Morabito

Business Innovation Through Blockchain

The B^3 Perspective

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Foreword

The word "blockchain" is one of the most hyped IT buzzwords to have emerged in the last couple of years. Blockchain has found its way into major media headlines on a near-daily basis, but a year and a half ago, it was a word used by a relatively small number of people to describe the peer-to-peer distributed ledger technology that underpins bitcoin. What is so special about blockchain, and is it deserving of all the hype?

I was happy to discover that Bocconi University Prof. Vincenzo Morabito, whom I recently had the good pleasure to meet, was writing this book about blockchain technology and its impact on business. Dr. Morabito's aim in this book is to take readers thorough the current state of the art on blockchain technology, as well as its future economic and practical implications. Readers who are new to the topic of blockchain will be surprised by the extensive and very diverse range of applications it enables, while those who are more familiar with the subject will gain from Dr. Morabito's perspective and insights.

The challenge of innovation in an increasingly digitized business world requires a clear understanding about the role of information technologies like blockchain and how they can be fastened to shape new business models. Addressing the impact of blockchain is likely to require significant change on the part of both organizations and individuals, and significant change is something that many (if not most) of us often find hard to do.

The function and impact of complex technologies such as blockchain can often be difficult to grasp, and I hope Prof. Morabito's book will positively effect blockchain literacy among not just business people but also policymakers, who will play a key role in shaping blockchain's future.

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Preface

In this book, we aim to discuss and present the main challenges and trends related to blockchain for digital business innovation to a composite audience of practitioners and scholars. Blockchain became a hype topic, thanks to bitcoin diffusion at a global level. However, this cryptocurrency is often considered the main application of blockchain, and today, we are assisting to the implementation of blockchain also in other domains; property transfer and digital identity are among the most common examples. Industries that will be soon involved in this phenomenon are telco, data storage, registration services, insurance, and so on. Furthermore, notwithstanding the interest that surrounds blockchain as a key trend, especially with regard to the financial technology (*fintech*) industry, the phenomenon has been not yet fully investigated from a strategic and organizational perspective by both academic and practitioners. Actually, apart from the volume by Tapscott and Tapscott [1], most of the published monographic contributions concern technical, computational, and engineering facets of blockchain.

Taking these issues into account, this volume aims to provide a unified survey of current academic and practitioners' work on blockchain and related phenomena such as bitcoin, considering different perspectives, from information systems as well as technology management and innovation research to computer science and engineering, among others. Consequently, the main goal of this book is to connect research and industry practices suitable to be used by practitioners in their day-to-day activities as well as an update on what academia may offer with regard to the industry proposals. Yet, this book follows the same mission of the former volumes published by the author, thus aiming to identify the challenges, ideas, and trends that may represent "food for thoughts" to practitioners. Accordingly, as in previous books, each topic considered will be analyzed in its technical and managerial aspects, also through the use of case studies and examples.

Finally, please note that in this book, two topics are being used across all chapters: bitcoin and the distributed autonomous organization (DAO). The reasons behind using these two concepts at different points in this book are twofold: First, bitcoin and DAO have been the cornerstone for the advent of blockchain, and therefore, these will naturally emerge when we look at the blockchain from the different viewpoints adopted in each chapter. Second, the chapters of this book are meant to be part of a coherent whole, but also are meant to be read individually

without the need to read all other chapters, so the readers can select those chapters and themes that are more relevant to their personal interests. Therefore, it is needed to introduce and repeat some concepts of bitcoin and DAO to contextualize them within the chapter's theme.

Outline of this Book

This book argument is developed along three main axes. We consider first (*Part I*) *Blockchain Technology and Management* issues that are the structure and characteristics of the blockchain *paradigm change* (Chap. 1), its *value system* (Chap. 2), *governance* (Chap. 3), and *security layers*, by focusing on the challenges, advantages, and limitations of blockchain from a security point of view, likewise (Chap. 4). Subsequently, *Part II* (*Bitcoin Phenomenon and Trends*) will focus on *digital currencies* (Chap. 5), *smart contracts*, and *licensing* (Chap. 6), particularly discussing how organizations can leverage the smart contract technology and the blockchain for the purpose of overseeing agreements and licensing. An analysis of how blockchain can fit into the world of *enterprise systems* (ES) conclude this part of this book, by comparing the value system of existing enterprise systems to that of the blockchain technology (Chap. 7). Finally (*Part III*), this book will present and review cases of *business innovation* related to blockchain at a global level in a section called *Blockchain practices* (Chap. 8) and will end by presenting the B^3 *perspective* we propose for blockchain business innovation (Chap. 9).

As in my previous volumes [2–5], this book adopts both a scientific approach and a concrete stance to introduce blockchain characteristics, challenges, and opportunity from the viewpoints of managers, thus adopting a clear and easy-to-understand language.

Milan, Italy Vincenzo Morabito

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Vincenzo Morabito

Contents

Acronyms

API	Application Programming Interface
CEO	Chief Executive Officer
CIO	Chief Information Officer
CMO	Chief Marketing Officer
COO	Chief Operating Officer
CRM	Customer Relationship Management
CTO	Chief Technology Officer
DAO	Decentralized Autonomous Organizations
DLT	Distributed ledger technology
DNS	Domain Name System
ERP	Enterprise Resource Planning
EU	European Union
HTTP	Hyper Text Transfer Protocol
ICTs	Information and Communication Technologies
ID	Identification; Identity
IO	Input/Output device
IP	Internet Protocol address
IS	Information Systems
IT	Information technology
KSI	Keyless Signature Infrastructure
KYC	Know Your Customer
KYCC	Know Your Customer's Customer
LOC	Letter of Credit
MBA	Master of Business Administration
PLM	Product Life Cycle Management
PoS	Proof of stake
PoW	Proof of work
RFID	Radio-frequency identification
ROI	Return on investment
SCM	Supply Chain Management
SHA	Secure Hash Algorithm
SME	Small to medium-sized enterprise
SRM	Supplier Relationship Management

SSH	Secure Shell
SWIFT	Society for Worldwide Interbank Financial Telecommunication
TCP	Transmission Control Protocol
UK	United Kingdom
URL	Uniform Resource Locator
US	The United States
USD	United States dollar(s)

Part I
Blockchain Technology and Management

The Blockchain Paradigm Change Structure

1

Abstract

Technological advancements and innovation is constantly evolving and growing at such a fast rate that everyone is required to stay abreast of these advancements and innovations. The paradigm change of Blockchain is not left out from this evolution. The technological concept behind the Blockchain is interestingly closely identical to that of a database. However, it is clearly one of the key concepts that needs to be understood for the future. There are five key concepts that not only need to be understood but also explored in a manner that examines how they interrelate one to another: smart contracts, decentralized consensus, the Blockchain, trusted computing and proof of work/state. This exciting computing paradigm is critically important because it will be instrumental to the creation of decentralized applications. This chapter will explore 4 main key concepts of Blockchain Technology—Blockchain, Decentralized databases application consensus, Proof of work/stake and Smart contracts—while appreciating the Blockchain paradigm change structure.

1.1 Introduction

Following the over two decades of scientific examinations in order to seek principles, techniques advances and theories, there have been immense acceleration in the areas of decentralized (peer-to-peer) computer networking as well as communication security (cryptography). As a result of this, a new technology referred to as 'Blockchain' emerged.

It is to no surprise that Blockchain technology being a buzzword of the day has attracted the attention of entrepreneurs, Governments, banks and plenty more. They all seem to be allocating portions of investments and resources to quickly gain a more vivid understanding of the Blockchain paradigm while attempting to jump

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ahead of what seems to be a key technology of the future. Blockchain can be easily be seen as next level from distributed computing architectural constructs, to a universally global database of interfaces and data which will integrate loads of machines also plugin various sources of data.

Blockchain refers to a distributed, encrypted database, which is a public depository of information that cannot be reversed and is incorruptible [1]. In other words, a Blockchain can be defined as a distributed public ledger or database of records of every transaction that has been carried out and shared among those participating in the network [2]. Every transaction or digital event in the public ledger has to be authenticated via the agreement of more than half of those participating in the network [2]. This implies that no participant or user as an individual can modify any data within a Blockchain without the consent of other users (participants). It could be observed clearly, that the technological concept behind the Blockchain is interestingly closely identical to that of a database.

The Blockchain makes it possible for first time participants to reach an agreement on how a specific transaction or digital event can occur without requiring any controlling authority. This technology (Blockchain technology) is unique in the sense that it reduces the function of the middleman. This allows a distinctive piece of data to be transferred to participants in a secure and safe manner.

Moreover, the Blockchain technology can produce 'smart contracts'. These smart contracts are defined as digital currencies that are independent of any governmental institution as they are termed 'self-enforcing digital contracts'. They do not require any form of regulation or human involvement.

It is to no surprise that Blockchain technology being a buzzword of the day has attracted the attention of entrepreneurs, governments, banks and many more people across the globe see the advent of the Blockchain technology to 'the Internet'. Also, they foresee the shift of power balance from centralized bodies in the communications and business sectors [1].

The technology of Blockchain is not contentious as it has in a long time functioned impeccably and is being applied to financial and non-financial sectors applications successfully [2]. This exciting computing paradigm is critically important because it will be instrumental to the creation of decentralized applications.

1.2 The Blockchain Phenomena

In the past couple of years, a key technological innovation referred to as the 'Blockchain' appeared to be a possible disturbing technological innovation. The fundamental of this technology is built around the theory of 'distributed ledger' in which the ledger is stored and maintained on a distributed computer network [3].

Moreover, the ledger brings about the possibility of the network as a whole to cooperatively produce, develop and record past transactions as well as consecutive digital events. In recent times, cryptocurrency has been the foremost application of

Blockchain technology. This cryptocurrency is referred to as Bitcoin. Given the popularity and importance of Bitcoin, it will be used throughout this book highlighting different aspects of this digital asset.

Bitcoin used a ledger referred to as 'Blockchain', which was where the name (Blockchain technology) was derived from [3]. However, Bitcoin is the first of the numerous possible lists of Blockchain technological applications.

Furthermore, when numerous users are required to be dependent on the same data historically, Blockchain technology then comes to play.

Blockchain technology is a data store that is characterized by the following:

- It subsists within a decentralized peer-to-peer network
- Specific users can write it
- It employs the use of digital signatures and communication security(cryptography) to authenticate, verify user identity and implement access rights in a read or write format
- Its scheme brings about a huge difficulty in altering historical records
- Its scheme brings about a great level of ease in the awareness of users in cases of any attempt to alter historical records
- Financial transactions are typically a part of the constituent of Blockchain technology
- Specific users as well as an extensive audience can read it
- In virtually real-time, it is reproduced throughout a couple of systems on the network.

Figures 1.1 and 1.2 show the centralized database and the decentralized database. In the centralized database, there is the need for intermediaries (third parties) whereas in the decentralized database, the need for intermediaries (third parties) has been eliminated [4].

The four key concepts of Blockchain Technology—*Blockchain*, *Decentralized Databases*, *Proof of Work/Stake* and *Smart Contracts* will be looked into.

1.2.1 Blockchain

The Blockchain was brought to life as a result of Bitcoin and this Blockchain is otherwise called Bitcoin Blockchain. Before we discuss the Bitcoin Blockchain, it will be ideal to have an overview of Bitcoin.

Bitcoin is one of the most widely used digital currency that was launched in 2009 and has not looked back ever since. It is an innovative technology that deals with payment systems. It is an example of virtual currency, which is built on a log of transaction and is circulated across participating users within the network. It makes use of the 'Distributed Ledger' scheme.

Furthermore, the reason behind the design of Bitcoin was for it to perform three main purposes of traditional money. These three main purposes are:

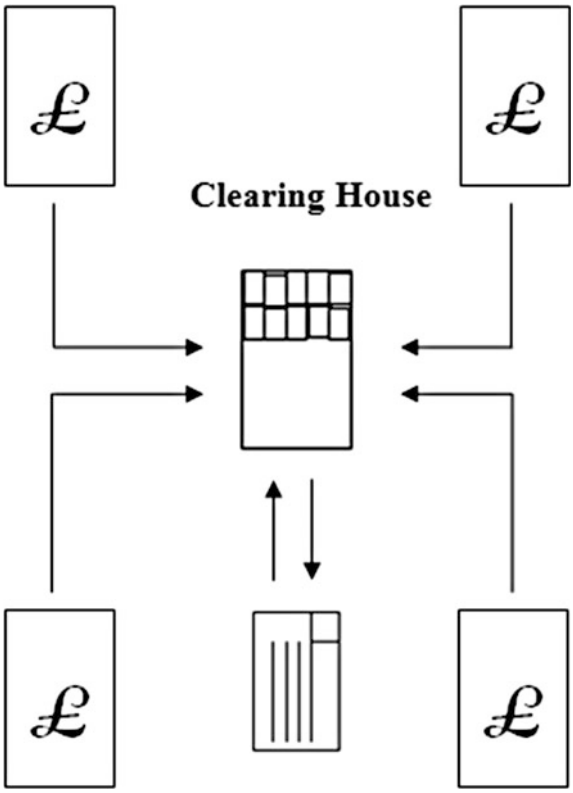

Fig. 1.1 Centralized Database. Adapted from Lewis et al. [4]

- To simplify exchange commercially
- To store value by users for future purpose
- To act as the basic unit for measuring the values of market goods and services rendered [5].

Before the invention of Bitcoin and its Blockchain, digital currencies were perceived not to be practicable as a result of the comparative effortlessness in the manner digital currencies could be replicated. This was referred to as '*double-spend*' problem in which every transaction bears a risk [3]. This risk involves the sending of a copy of the digital transaction to the merchant by the holder whereas the holder keeps the original copy of the digital transaction. This risk was conventionally guarded against by deploying a trusted centralized intermediary to keep up to date with every transaction carried out.

However, with Bitcoin Blockchain in which the history of transactions and authentication of such transactions by participants within the network system, the obligation of keeping up to date with every transaction has been transferred to the entire network system. A well-structured and detailed diagram explaining the Blockchain value system can be seen in Chap. 2. It can be seen that there are nodes

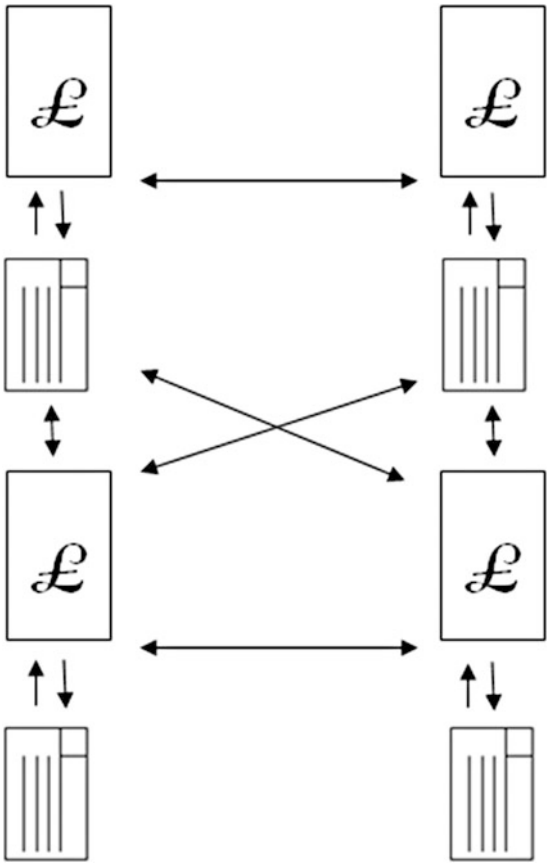

Fig. 1.2 Decentralized Database. Adapted from Lewis et al. [4]

(users of the network) and these nodes hold a Blockchain made up of all the historical transactions carried out on the network. The system of the Bitcoin Blockchain is really a multifaceted system as it has the following aims.

- The ability of anyone to write to the Blockchain and
- Centralized control should be eliminated
- The system of Bitcoin Blockchain performs in a way similar to a network or system of computer-generated databases with each consisting of historical transactions of Bitcoin.

The approach of Bitcoin to various decisions can be grouped into seven different categories. These are; data storage, data distribution, mechanism of agreement, mechanism upgrade, criteria for participation, defense mechanism and incentivization scheme. Table 1.1 highlights the categories, questions and approaches of Bitcoin [6]. It is of utmost importance that people would want to ask some

Table 1.1 The categories, questions and approaches of Bitcoin

Category	Question	Approach of Bitcoin
Data storage	How should data be stored?	Data should be stored via the blockchain technology
Data distribution	How should the distribution of new data be?	The distribution of new data should be in a peer-to-peer format
Mechanism of agreement	How should conflicts be resolved?	Conflicts should be resolved via the longest chain rule
Mechanism upgrade	How do the rules change?	The rules change via; BIPs (for writing the rules) Vote by hashing power (for the implementation of the rules)
Criteria for participation	Who can submit transactions?	Transaction submission is anonymous and open
Criteria for participation	Who can read data?	Data reading is anonymous and open
Criteria for participation	Who can authenticate transactions?	Transaction authentication is anonymous and open
Defense Mechanism	How is bad behaviour prevented?	Bad behaviour is prevent through the use of proof-of-work
Incentivisation scheme	How are block-makers incentivised?	Block-makers are incentivised through block reward and is to be replaced by transaction fees
Incentivisation scheme	How are transaction validators incentivised?	How transaction validators are incentivised is not considered

Adapted from Lewis [6]

questions with regards to the outlined categories. However, the approach of Bitcoin with regards to each category provides suitable answers to some of these questions as shown in Table 1.1.

1.2.2 Public Blockchains and Private Blockchains

A highpoint of public Blockchains is the high capability of this innovation to uphold transactional agreement in the network, which gives room for blocks of transactions to be written to the Blockchains (*distributed ledgers*) by anyone, the creation of transactions and the ability to send such transactions. Moreover, all these do not require the approval of any third party or intermediary (middleman).

On the other hand, the limitations of users in the private Blockchains involve the use of firewalls within the private network. The systemized pattern of the private Blockchains can be done in such a way that only known participants (users) can include data to the Blockchain. Moreover, the private Blockchains do not give neither read nor write access to unknown participants (Table 1.2).

Table 1.2 The differences between Public Blockchains and Private Blockchains

Public Blockchains	Private Blockchains
Participants are not necessarily known	Participants are known and trusted
Participants are not necessarily trusted	Participants are trusted
Anyone without permission granted by another authority can read data	Only permitted participants can read data
Anyone without permission granted by another authority can write data	Only permitted participants can write data

Adapted from Lewis [6]

Examples of public Blockchains and private Blockchains include; *Ripple* (which could be placed between both public Blockchains and private Blockchains) [4] and *Ethereum* (which employs the use of public Blockchains) [4]. We will now take a look at *Decentralized Database*, which is another key concept of Blockchain technology.

1.2.3 Decentralized Database

Blockchains have been having an immense influence on the manner in which communication as well as data sharing online is concerned. This impact is as a result of the fact that Blockchains employ the use of decentralized database.

Moreover, with the advent of decentralized database, the necessity of routing communications or sharing of files (photos and videos) via a centralized network or electronic platforms such as Google Drive, Yahoo, Gmail and so on has been less essential. With the use of a decentralized and encrypted communication protocols, messages can be transferred, stored and retrieved at anytime without any form of intervention from the government [7].

Decentralized Database also allows both decentralized and secure manner of data exchange. If required, information can be published and distributed across a huge number of computers in an encrypted manner thereby eliminating the ability of a single entity to censor [1]. An example of the Decentralized Database is the *Anonymous Decentralized Cloud Storage System*, which employ the use of Blockchain technology in collaboration with other peer-to-peer technology to make it possible for people to use surplus space on hard disks [1]. This looks like the centralized cloud computing platforms to users, but form the technological view, the mode of operation of such platforms is not similar [1].

As a result of the advent of Blockchain technology, organizations are now looking for a way to use the features of Decentralized Database, which Blockchain technology offers to make it possible for unrelated people to vote over the internet or using their mobile devices securely [1]. This is due to the ability of Decentralized Database to function as distributed irreversible and encrypted public paper, which can be effortlessly audited as every voter would be able to validate that their votes

were counted [1]. By reason of the encryption of any voting system that is based on Blockchain technology, such voting system is not vulnerable to hacking.

Decentralized Database systems are perceived to be a technical replacement for the Domain Name System (DNS) that support the whole Internet [1].

1.2.4 Proof of Work

A decentralized ledger is the fundamental structure of the database used for digital currencies transactions including Bitcoin transactions as it serves as storage for all historical transactions [8]. It is of utmost importance to note that the operation of digital currency schemes should include a means of security against attacks on the Blockchain. If an attacker decides to spend a particular amount of money and then tries to reverse that particular transaction, the attacker could broadcast his own version of the Blockchain in which that particular transaction is not included, then the participants would not have any form of awareness as to the valid version of the ledger prior to the attack.

The Bitcoin network security is dependent on a network security protocol called '*proof of work*' *(PoW)*. In 1993, Cynthia Dwork and Moni Naor initially proposed this network security protocol (proof of work). This network security protocol is a piece of data that is expensive to create in order to meet particular prerequisites and its verification is inconsequential. This implies that in order to perform a specific role, this protocol inserts an extra cost. This concept will be revised in Chap. 4, when we look at the security aspects of blockchain.

Putting Bitcoin into consideration, it should be noted that within a specific period of time, every transaction carried out is recorded and stored into the Bitcoin block. The block is then broadcasted to all the participating nodes within the Bitcoin network [9]. The *Hashcash* proof of work scheme is used in this case. This Hashcash proof of work scheme was introduced in 1997 by Adam Back (see [9]). Under this Hashcash proof of work scheme, each participant adds a piece of data referred to as 'nonce' to the block to form a 'block + nonce'. This 'block + nonce' is then taken and placed in an algorithm referred to as 'hash algorithm'.

This hash algorithm consists of a hash that matches up to some particular prerequisites. The hash algorithm then comes up with a complex mathematical computation in which each participating node tries to provide a solution to using the SHA (Secure Hash Algorithm)-256 hash function. As soon as a solution is provided to the mathematical computation by a node, the particular prerequisites by the proof of work scheme is then thought to be met and this now becomes 'block + nonce + hash'. As soon as this occurs, the 'block + nonce + hash' is then included with the Bitcoin Blockchain and broadcasted to every of the participating nodes within the network.

Furthermore, the Bitcoin protocol (proof of work protocol) operates in a manner that physically scarce resources assist the network. These physically scarce resources are:

- the hardware required to run the mathematical computations and
- the electric power required to run the hardware [8].

This implies that the use of Bitcoin protocol (proof of work protocol) is highly demanding on resources. As a result of this, many similar systems not based on costly computations have been built for which 'proof of stake' is one.

Proof of work protocol as used in emails have as well been recommended as a form of measure for visiting websites, guarding against denial-of-service attacks, rate limiting TCP connections and the provision of motivation to peer-to-peer systems [10].

1.2.5 Proof of Stake

Proof of stake (PoS) scheme serves as an alternative to the proof of work scheme. Proof of stake is a scheme built on less-costly computations. This implies that the proof of stake scheme is not based on costly computations as compared to the proof of wok scheme. Rather than depending on the scarce resources (costly computations), the proof of stake scheme is dependent on the entities that hold stake within the network (this implies a proof of stake holding). In other words, we can say that the resource that the network security is dependent on is the ownership of the coin itself, which implies *proof-of-ownership* that is also scarce. For the authentication and reception of a transaction to occur (whether fees of transaction or new coins), some of the coin must be owned by a miner [9]. The probability that a miner is successful in the creation of a new block is dependent on the amount of coin owned by the miner and not dependent on the computational power whenever the proof of stake scheme is used [9]. Therefore, the energy cost in this transaction is every minute. In order to dent the reliability of the system, one would have ownership of over 50% of the coin presently being staked, which would be very costly [9].

Proof of stake scheme has more advantages over the proof of work scheme. One advantage PoS has over PoW is the low latency ability of PoS, however, it is not free from challenges. Also, it has proven not to be efficient in guarding against the risks encountered by cryptocurrencies.

One of the challenges encountered by the proof of stake scheme is the issue of centralization as the stakeholders with large stake holdings could attempt to display a level of domination over the network.

A hybrid of both proof of work and proof of stake schemes was later created. We will now discuss the Hybrid proof of work and proof of stake scheme.

1.2.6 Hybrid Proof of Work and Proof of Stake

The hybrid proof of work and proof of stake scheme was first recommended and applied by Scott Nadal and Sunny King in their whitepaper "PPCoin: Peer-to-Peer Crypto-Currency with Proof-of-Stake". The hybrid proof of work and proof of

Table 1.3 The major characteristics of the proof of work, proof of stake and hybrid proof of work and proof of stake schemes

Scheme	Low latency	Long-run low energy cost
Proof of Work (PoW)	No	No
Proof of Stake (PoS)	Yes	Yes
Hybrid Proof of Work and Proof of Stake (PoW/PoS)	Yes	Yes

Adapted from Farell [9]

stake scheme employs the use of the proof of work scheme for the mining and distribution at the initial stage and this implies that it makes it possible for the distribution of new coins to miners via the network [9]. The proof of stake scheme provides the cryptocurrency with good energy effectiveness.

Furthermore, the generation of block in this hybrid scheme is dependent on a model referred to as 'coinage', which is the multiplication of the total amount of coin a miner owns and the span of ownership the present coin owner has. Hence, the block generation goes to the block with the highest coinage [9]. The low consumption of energy by this scheme is one of the standout features of this scheme.

Table 1.3 highlights the major characteristics of the proof of work, proof of stake and Hybrid proof of work and proof of stake schemes. It can be seen from Table 1.3 that the proof of work scheme has high latency the energy cost on the long-run for proof of work is high while the proof of stake scheme as well as the hybrid proof of work and proof of stake scheme have low latency and their energy cost based on the long-run is low.

1.3 Benefits of Blockchain Technology

There are immense benefits the Blockchain technology provides. Some of these benefits include; *Trust*, *Openness*, *Independence*, *Speed*, *Robustness*, *Global Nature* and *Effectiveness*.

Before any data is added to an explicitly defined Blockchain, it is expected that a greater number of users of the system reach an agreement. This pattern is quite distinct from the centralized pattern in which there is a central authority. A more trustworthy system is created when majority of the users have a say over the writing, creation and alteration of such data [4]. This high level of trust has been the case of the innovation brought about by Blockchain technology.

Also, through the use of smart contracts that reconciles in real-time, the level of openness has drastically improved with the advent of Blockchain technology. Also, since trade data is published to a common platform, trades can be viewed by participants in real-time [4]. This helps to forestall any form of manipulations or alterations.

The design of Blockchain technology was done in such a manner that this technology is not dependent on any financial institution such as banks or government. This makes it more attractive and less prone to regulations. Furthermore, the technology of Blockchain has enhanced the level of speed of transactions. Since Blockchains can automate messages by the addition of code snippets called 'smart contracts' that does not involve the involvement of any human in any way, the speed of payment is enhanced. This implies that there will be a lower transaction completion time as third parties have been eliminated. The robustness of the Blockchain technology makes it possible for data to be stored across a large number of nodes [4]. The higher the number of nodes, the more resilient the data [4].

Also, the ability for Blockchain technology to serve both locally and globally makes it more attractive. Moreover, the technology of Blockchain has enhanced the level of effectiveness that exists when reconciliation is brought to play in the financial sector. Taking banks for example, banks usually delegate a system to serve as the trade data for a specific security and this will result into deficiencies in reconciliation. Since Blockchain technology exists, reconciliation is carried out in real-time.

1.4 Future of Blockchain

Blockchain technology has a great future if well harnessed and implemented on various platforms. Blockchain technology could govern the future of finance as it will result into huge reduction of cost for all participants in the market thereby changing global banking [11].

Just of recent, the governor of the Bank of Japan (Haruhiko Kuroda) highlighted that with the development of Blockchain technology, there could be an evolution in the manner in which financial services are designed [12]. He pointed out that artificial intelligence and Blockchain technology could bring about an immense impact on financial services and he also highlighted that ledgers (the basic information infrastructure) have significantly supported the development of financial services [12]. Furthermore, in May 2016, the deputy governor of Bank of Japan (Hiroshi Nakato) stated that a close monitoring of the development of Blockchain technology and digital currencies should be done by the central banks [12]. Actually, Blockchain technology can be applied in areas which include; trade finance, the capital market, payments and a host of other areas [13]. We will now discuss these three key areas that Blockchain technology can be applied to.

1.4.1 Trade Finance

This area is one of the key areas that Blockchain technology can be applied. It has great potential. If some banks make a decision to position the financial supply chain by putting the letters of credit on the Blockchain, this will be immense as these

letters have highly complicated and sophisticated flow of information, even if a Blockchain solution is used mainly by a small number of participants [13].

Recently, HSBC and Bank of America Merrill Lynch venture and financial technology firm R3 separately reported that they have been able to generate ways by which Blockchain technology can be used to simplify trade finance processes [14]. Furthermore, the two banks highlighted that they had partnered with the Infocomm Development Authority of Singapore to emulate a transaction of Letter of Credit (LOC). These letters of credit are one of the predominantly used means for risk reduction between importers and exporters [14]. Thus, Blockchain technology is important for use in the area of trade finance as it offers solutions which include the ability to trace as Blockchain provides genuineness of products in the supply chain and the ability to be transparent as Blockchain guards against fraud and saves transaction reconciliation cost [14].

The two key areas of trade finance that Blockchain technology could be of immense benefits include; the transfer of the information of trade and financing [15]. We will now highlight these two key areas.

1.4.2 Financing

When Blockchain technology is used in data exchange during trade, it serves to provide irreversible and simple matching of data. Also, it serves to increase the effectiveness and speed of reconciliation (as this is done in real-time) and helps to increase the level of security of transactions between parties involved in buying and selling and their banks.

It is to be noted that a consensus should be reached with regards to the financing terms and the issues of compliance and this should not be done within the distributed ledger. However, the use of common distributed ledgers can serve to activate necessary actions within financing agreement [15].

With the ability to make the events along a supply chain visible in real-time and the ability of non-bank participants such as the shipping companies to keep ledgers up-to-date as soon as transactions are completed, the release of funds can be carried out faster, thus helping banks to save time as well as resource as the banks do away with the manual processing and data matching that is in existence today. This also helps the banks to divert the time and resources saved to other profitable propositions that are key to local and global trade [15].

1.4.3 The Capital Market

As earlier highlighted, some of the benefits the Blockchain technology include: Trust, Openness, Independence, Speed, Robustness, Global Nature and Effectiveness among other benefits. These benefits of Blockchain technology can as well

have an immense impact on the future of the capital market. The capital market has four key areas and these areas are; pre-trade, trade, post-trade and custody and securities servicing [16]. In the area of Pre-Trade in the capital market, the benefits of Blockchain technology are in the authentication of holdings as well as the openness of such holdings, static data mutualisation, reduction in the exposure of credit, easier means to Know Your Customer (KYC) and easier means to Know Your Customer's Customer (KYCC) via look through to holdings [16]. Moreover, higher level of openness in the supervision of market authorities, automatic reporting, secure and real-time matching of transactions, the ability for settlements to be immediately irreversible and improved standard of anti-money laundering are some of the benefits of Blockchain technology in the area of Trade in the capital market [16]. Also, the reduction in the requirements for collateral, higher effectiveness of post-trade processing, the auto-execution of Smart Contracts and the elimination of a central clearing for real-time cash transactions are some of the benefits of Blockchain technology in the area of Post-Trade in the capital market [16].

Direct Primary issuance onto a Blockchain, the ability to have richer datasets, automation of de-duplication of servicing processes and the ability to possess common reference data are some of the benefits of Blockchain technology in the area of Custody and Securities Servicing in the capital market [16].

In order to shape the future of the capital market with regards to the benefits that Blockchain technology provides, the industry is required to take a collective view of and embrace these benefits while also preserving the strengths of the existing ecosystem [16].

1.5 Smart Contracts

Smart Contracts will be thoroughly analyzed in detail in Chap. 6—Smart Contracts and Licensing. In this section, we will take a look at the general overview of Smart Contracts.

Blockchains can automate messages by the addition of code snippets. These code snippets are referred to as 'smart contracts'. These smart contracts employ the use of the 'if-this-then-that' logic. The execution of smart contracts does not involve the use of any human in any way. This signifies that Smart contracts are decentralized and they tend to operate without any middleman or third party regulation. Furthermore, they employ the use of a distributed database so that participants can verify that there is an occurrence of a digital event without requiring any middleman or third party. Moreover, smart contracts are not written in legal languages but are written as computer programs and these computer programs have the ability to define strict rules [17].

In addition, smart contracts can be coded in order to reflect a business logic driven by data. This business logic driven by data could include:

- prioritizing a repayment structured note
- loan collateralization and
- voting for a post in a forum [17].

Figure 1.3 shows the flowchart for the application of business logic with smart contracts. Figure 1.3 is further explained by the use of Table 1.4, which highlights the flowchart number, flowchart event and the respective description of the

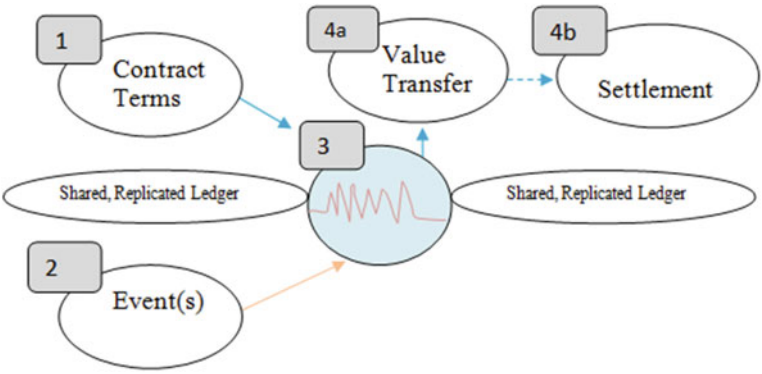

Fig. 1.3 Flowchart for the application of business logic with smart contracts. Adapted from Skinner [14]

Table 1.4 The flowchart number, flowchart event and the respective description of the flowchart

Flowchart number	Flowchart event	Description of flowchart
1	Contract terms	Counterparties establish obligations and settlement instructions Assets put under custody of smart contract Conditions for execution ("If… then…")
2	Event(s)	Event triggers contract execution Event can refer to transaction initiated or information received
3	Business logic	Business logic (Terms of contract) dictate movement of value based on conditions met
4a	Value transferred	Value transferred to intended recipient as dictated by contract terms For digital assets on the chain (Bitcoin) accounts are settled automatically
4b	Settlement	For assets represented off the chain (e.g. securities)accounts off-chain match settlement instructions Changes to accounts will be reflected on ledger

Adapted from Skinner [14]

flowchart. In flowchart number 1 which has a flowchart event called *Contract* Terms, counterparties establish obligations and settle instructions, the assets are put under the custody of the Smart Contract and the conditions for execution are stated. In flowchart number 2, which has a flowchart event, called *Event(s)*, the events can refer to transactions initiated or information received and contract executions are triggered.

In flowchart number 3, which has a flowchart event, called *Business Logic*, the movement of value is dictated by the terms of contract. In flowchart number 4a which has a flowchart event called *Value Transferred*, the value is transferred to the intended recipient as dictated by the contract terms while in flowchart number 4b which has a flowchart event called *Settlement*, the assets represented off the chain (e.g. securities) accounts off-chain match settlement instructions.

The areas of relevance of smart contracts to the financial sector are; in the areas of loans, the capital market, booking of trade and wallet control of cryptocurrency among others. In addition, the growth of smart contracts has been so speedy and up till now, the creation of smart contracts has mainly been to routinely carry out swaps and derivatives. A couple of open source projects, which include Counterparty [18] and Ethereum [19] have advanced technologically to produce programming languages that give rise to the production of state-of-the-art smart contracts.

Point of Attention However, there are some issues related to smart contracts. Some of these issues include; *Flexibility* (as smart contracts believe everything that pertains to negotiations at the commencement of negotiations can be decided by participants and this is sometimes inaccurate), *Liability* (as a result of the lack of intermediaries, regulators could be faced with some level of difficulties) and *Enforcement* (it will be quite difficult if not impossible at present to structure all transactional terms by total reliance on smart contracts) [17].

One of the first market which is expected that smart contracts will be functional is syndicated loans as this market, which is worth about $4 trillion runs on faxes, emails and excel spreadsheets [20]. Smart property requires controlling the ownership of a property (physical property for example a laptop, a house and so on) and non-physical properties such as a company's shares [2].

1.6 Case Studies

In this Section, we shall focus on a digital asset exchange company called *Coinbase* and *Blockstream*, which is a company that develops Bitcoin applications and other applications.

Coinbase was founded by Brian Armstrong and Fred Ehrsam on June 20, 2012 [21]. It has its headquarters in San Francisco, California. The company is known to provide a platform for the creation of a digital currency wallet where digital currency can be securely stored [21]. In addition to web browsers, the wallet operates on Android and Iphone. Coinbase guarantees secure means of storage, protection of insurance, maintenance of absolute private keys control among others.

In March 2016, Coinbase was listed by Richtopia (a company based in UK) as the second most influential Blockchain organizations [22]. It offers API for the building of applications as well as payment acceptance in digital currencies by merchants and developers.

Some of the key functionalities of Coinbase platform are: *Mobile Wallet*, which serves as a platform for sending Bitcoin to friends and shopping with merchants that accept Bitcoin, *Insurance Protection*, in which the Coinbase platform is insured against any form of digital agreement and theft. It is worthy of note that the worth of Bitcoin and Ether this Coinbase platform holds at a particular period of time is less than the insured amount. Another key functionality of the Coinbase platform is *Secure Storage*. Appropriate measures are taken by Coinbase to provide adequate security against any form of theft and this is achieved by the addition of another security layer apart from the username and password.

It is worthy of note that the user value indicator of Coinbase platform is positive with regards to the user interface and user experience and it has a high process impact.

The other case study which is a company called *Blockstream* was founded by Adam Back and Mark Friedenbach in 2014 and is a company that has the development of Bitcoin applications and other applications as its focus [23]. One of the Bitcoin applications is *Sidechain*, which is an open source code as well as developer sidechains for the advancement of Bitcoin. Sidechain is the main innovative area of Blockstream.

In October 2015, the first commercial application of sidechain technology with liquid was announced by Blockstream [24]. This commercial application was to serve as a platform for Bitcoin payment processors, exchanges as well as brokerages [24].

It is worthy of note that the intention for the launching of Blockstream was for new ways of innovations in cryptocurrency, open assets and smart contracts to be developed [25]. Some of the key functionalities of Blockstream are: *Trustless and Permissionless Innovation* in which the Blockstraem platform aims to promote such environment for enabling new innovations and to work towards guaranteeing that developers, asset issuers and users have computing technology that provides both neutral and cryptographical assurance for their financial needs [25] and *Fairness*, *Openness and Accountability* in which its platform aims to power fair and accountable markets that are interoperable.

It is worthy of note that the user value indicator of Blockstream platform is positive with regards to the user interface and user experience and it has a high process impact.

1.7 Summary

In this Chapter, we looked at the introduction into Blockchain technology where we defined Blockchain technology to be a distributed public ledger or database of records of every transaction that has been carried out and shared among those participating in the network [2]. We also looked at Blockchain phenomena, where it was pointed out that there are Centralized and Decentralized Databases and Bitcoin was the first of the numerous possible lists of Blockchain technological applications. Furthermore, we discussed the four main key concepts of Blockchain technology, which are: Blockchain, Decentralized Database, Proof of Work (PoW) and Proof of Stake (PoS), and Smart Contracts.

Blockchain technology involves the distribution and encryption of database in an irreversible and incorruptible manner, then it is of utmost importance to the effectiveness of the financial sector as its benefits such as Trust, Openness, Independence, Speed, Robustness, Global Nature and Effectiveness are key to the development of the capital market, payment systems, trade finance and other areas of the financial and non-financial sectors.

It is paramount to note that this technology is spreading to the non-financial sectors as pointed out by the singer-songwriter and composer Imogen Heap at an event in London in 2015 where he stated that "The biggest problem for an artist right now is payment…[the blockchain] could spark up many new platforms and services that would enrich all our lives" [26]. To a large extent, the future of Blockchain technology is bright if well harnessed.

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Blockchain Value System

2

Abstract

Long before the advent of the blockchain, digital cash had been conceptualized in a setting with a central server trusted to prevent double-spending with the help of public-key cryptography, whereby each agent is assigned a private key (kept secret like a password) and a public key shared with all other agents. In spite of major cryptographic advances, failure to ensure compatibility between centralization, anonymity and double-spending prevention, eventually put the viability of this new form of money into question. Recently, Bitcoin's blockchain model has been proposed as the backbone for a wide range of applications, from asset trading to real estate transactions, from escrow services to even a national income distribution system. A value system is a coherent set of values adopted by an organization, or society as a standard to guide its behavior in preferences in all situations. This chapter discusses blockchain as a value system and expounds the main fundamental principles behind blockchain technology, the way it works, advantages, limitations and challenges of blockchain and finally, some of its cutting-edge applications.

2.1 Introduction

Modern technologies allow people to communicate directly. Voice and video calls, emails, pictures and instant messages travel directly from the sender to the receiver over the internet, while maintaining trust between individuals no matter how far apart they are. However, when it comes to money, people have to trust a third party to be able to complete the transaction, thus, over the past decade; blockchain technology has been slowly invading the internet as a secured alternative digital paradigm. By using math and cryptography, blockchain provides an open decentralized database of any transaction involving value such as money, goods,

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property, work or even votes. In other words, blockchain is a data structure that facilitates the creation, sharing and storing of a digital ledger of transactions among a distributed network of computers, which makes it decentralized and distributed architecture [1, 2]. This allows creating a record whose authenticity can be verified by the entire community, which makes blockchain a "trustless" technology. In this case, "trustless" means that the "value" over a computer network can be verified, monitored and enforced without the need for a trusted third party or central institution. Thus, third party trust organisations such as, e.g., VeriSign may no longer be necessary.

Consequently, the future economy will move towards one of distributed property and trust, where anyone with access to internet can get involved with blockchain based transactions. Blockchain technology can be thought of as wills and contracts that execute themselves. It will become a global decentralized source of trust. Accordingly, the ownership of the system does not belong to a certain company or a person yet everyone can use it and help run it. As a result, as long as one of the computers or "nodes" in the network is safe, the digital ledger is safe [3, 4].

The uses of blockchain technology are endless. Some expect that in less than 10 years, it will be used to collect taxes. Also, since every transaction will be recorded on a public and distributed ledger, it will make it easier for people to transform money to geographical areas where access to financial institutions is limited allowing for financial fraud to be significantly reduced. A huge proportion of trust services that range from banking to notaries will face challenges on price, volume and in some cases, their survival. Public authorities could find it more and more difficult to enforce traditional financial regulations due to the new possibilities offered by blockchain network to bypass traditional financial intermediaries. The organizations that don't adapt with new technological trends will lag and collapse as their success will depend on the strategic choices they make regarding the adoption of new technologies. However, whether the governments and financial and legal institutions will embrace blockchain or not is too soon to judge. It is predictable that not everyone is ready to embrace its features and advantages.

2.2 Fundamental Principles

As described in Chap. 1, Blockchain was developed as the main authentication and verification technology behind the Bitcoin, the first decentralized crypto digital currency. In Bitcoin, a transaction is initiated when the future owner of the coins (or digital tokens) sends his/her public key to the original owner. The coins are transferred by the digital signature of a hash. Public keys are cryptographically generated addresses stored in the blockchain. Every coin is associated with an address, and a transaction in the crypto-economy is simply a trade of coins from one address to another. In blockchain, the data used in the transactions is stored in an immutable public record, or giant spreadsheet, that is secured by concerned members who participate in a peer to peer network and act like verifiers of its

authenticity and credibility [5]. Blockchain technology provides a mechanism to enable "trustless" transactions that don't need intermediary agents to verify or monitor the integrity of the value exchanged through computer networks. Simply put, blockchain allows businesses to transact among each other without central financial institutions such as banks [1].

A blockchain transaction between two parties starts when one of the participants signals a message to the network about the terms and conditions governing the transactions between the two stakeholders. Then, the other participant broadcasts its acceptance to the network, which by default triggers the request for the network participants to authenticate and verify the transaction. Consequently, network members automatically play the role of authenticators that validate and guard the transaction against double spending through a validation system called "proof-of-work", which represents a competition among network members to validate the transaction [1]. At this point, when the transaction is validated, the public ledger (blockchain record) as well as the users of network will be collectively updated with the status of the recently added transaction. This mechanism helps in establishing trust between concerned stakeholders through the use of a decentralized public ledger as well as cryptographic algorithms that can guarantee approved transactions cannot be altered after being validated. The following points summarize the key attributes of blockchain technology:

- ***Decentralization***: It is one of the main characteristics of blockchain where participants are linked together in a market place where they can conduct transactions and transfer ownership of valued assets among them in transparent way and without the help from third party mediators, hence, the name *value network*.
- ***Trust and provenance***: Blockchain technology provides an indisputable mechanism to verify that the data of a transaction has existed at a specific time in the block. Moreover, because each block in the chain contains information about the previous block, then, the history, position and ownership of each block are automatically authenticated, and cannot be altered.
- ***Resilience and irreversibility***: Blockchain resilience stems from its structure since it is designed as distributed network of nodes (computers) in which, each one of these nodes store a copy of the entire chain. Hence, when a transaction is verified and approved by the participating nodes, it is highly impossible to change or alter the transaction's data.

2.3 How Blockchain Works

This section explains how blockchain works. Figure 2.1 illustrates the basic components in the blockchain technology [6].

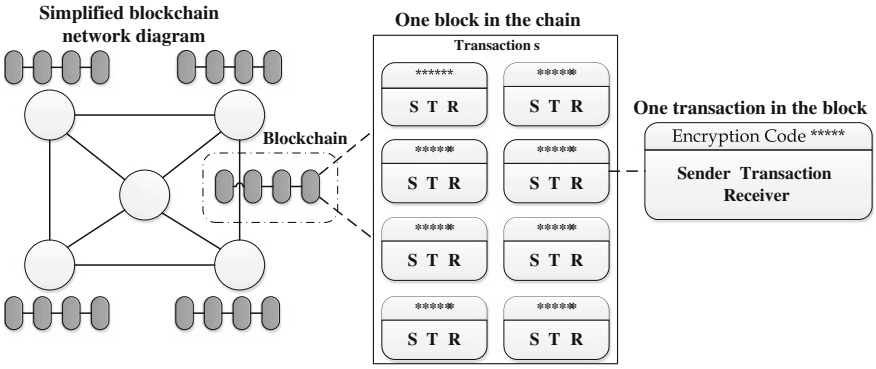

Fig. 2.1 Basic components of blockchain, adapted from [6]

In Fig. 2.1, the transaction is composed of the sender, the transaction information and the receiver, and it is secured by an encryption code. The block contains several transactions and the blockchain is constructed of several blocks. Figure 2.2 illustrates how the transaction is authenticated and how the block is created, chained and validated.

The following points provide descriptions for the steps illustrated in Fig. 2.2, which are:

- ***Transaction definition***: It is the first step where the sender creates a transaction that holds information about the receiver's public address, the value of the transaction and a cryptographic digital signature that verify the transaction's validity and credibility [6].
- ***Transaction authentication***: When the nodes in the network receive the transaction, they first validate the message by decrypting the digital signature and then the message is held temporarily until being used to create the block [6].
- ***Block creation***: One of the nodes in the network uses the pending transactions in order to update the ledger or the block. Then, at a specific time interval the updated block is broadcasted to the other nodes waiting for validation [6].
- ***Block validation***: When the nodes responsible about the validation in the network receive a request to validate an updated block, they go through an iterative process, which requires agreement from the other nodes in order to authenticate the block [6].
- ***Block chaining***: When all the transactions in a block are approved, then, the new block is attached "chained" to the current blockchain, resulting in broadcasting the new state of the block to the rest of the network [6].

These steps can take about 3 to10 s to finish, which gives blockchain a big advantage as a very fast technology for settling financial transactions.

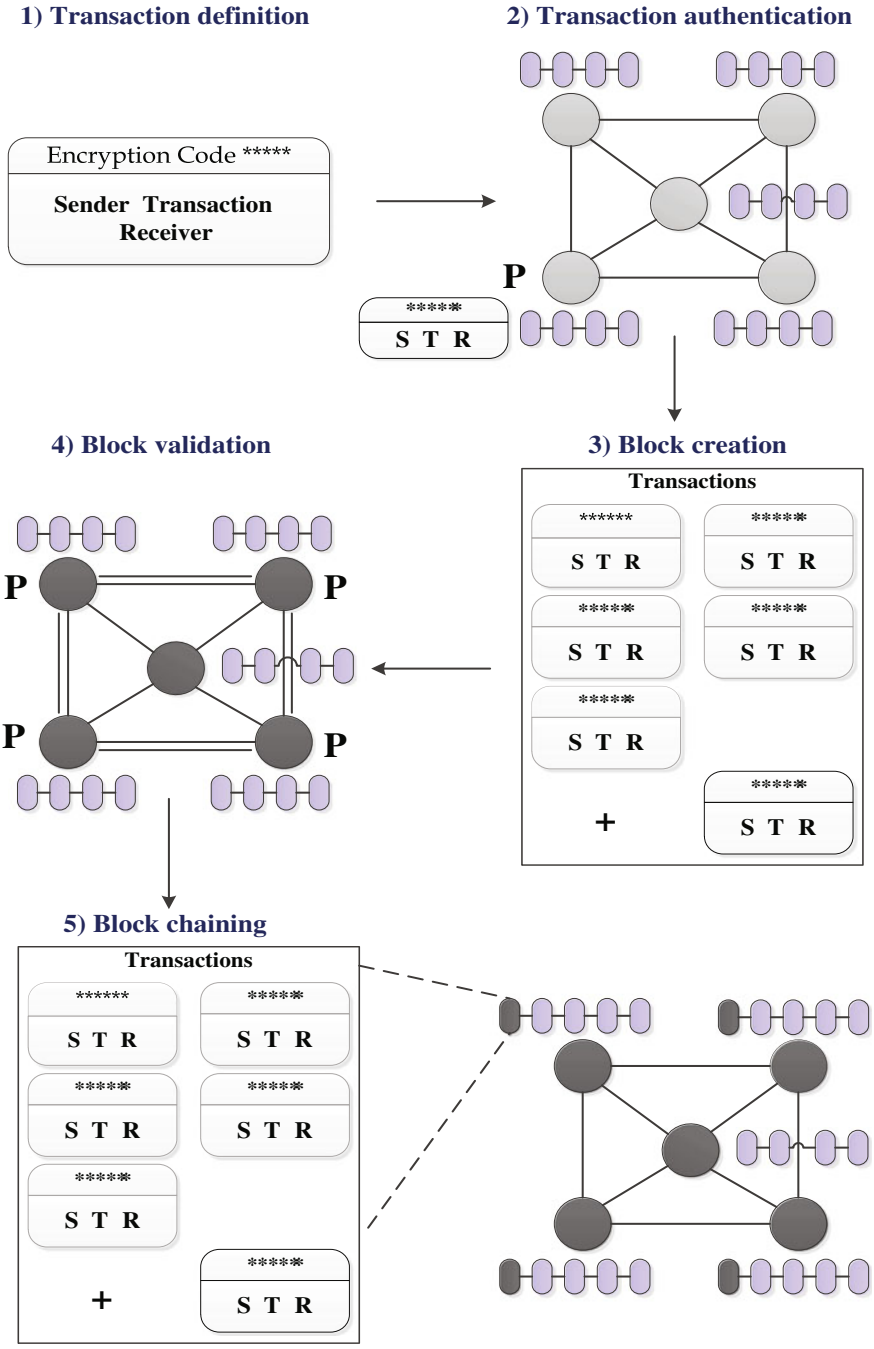

Fig. 2.2 Generalized overview of blockchain transaction, adapted from [6]

2.4 Blockchain's Challenges

Adopting blockchain as a unified method for conducting financial transactions over the Internet, requires a major redesigning task for the network of participating organisations as well as the practiced financial business processes, which is accompanied with many challenges. First, organisations have to come to an agreement that governs the fundamental rules of the new network. However, such arrangement can be a very daunting process, as different organizations and businesses have varying policies and protocols to perform their operations, and determining the best practice could take long and careful negotiations [7]. Additionally, security and privacy issues pose a big concern, since participating organisations need to be satisfied with security levels against attacks as well as regarding the trade information that needs to be known for each financial transaction to be verifiable throughout the network.

In order to overcome the aforementioned challenges, standards would be a good starting point to get the institutions within a certain industry on the same page. Standards promote an equal competitive playing field as well as reduce new technologies' time to market. Thus, the focus of blockchain implementation is more on the standardization of data flows and the intermediate language used to communicate within blockchain rather than the technology that supports its platform [8].

2.5 Advantages and Limitations of Blockchain

Blockchain technology is based on the idea of distributing transactional database into several nodes that are represented by computers. These nodes work together as one system that stores encrypted sequences of the transactional record as a single chained unit or block [2]. As discussed before, by using blockchain, parties can conduct exchanges without depending on a middleman or a third party to provide trust and validate the transaction. However, this is not the only advantage of blockchain. The following list highlights the most important benefits that blockchain can bring to the business world [9]:

- ***Empowered Users***: Blockchain provides the users with the ability to control their information as well as the transaction that they are part of [9].
- ***Durability, reliability and longevity***: Blockchain technology does not depend on a centralized computing architecture, thus, it will not fail because of a single failure [9].
- ***Process with integrity, transparency and immutability***: Transactions conducted using blockchain are viewable by public and cannot be altered, thus, their integrity, transparency and immutability are guaranteed [9].
- ***Faster and lower costs transactions***: Blockchain technology has the potential to radically reduce the time and costs for the transactions by eliminating the intermediaries or third party agents [9].

However, the introduction of a nascent technology such as blockchain technology to the business world faces several challenges because of the principles it is based upon. Thus, dealing with issues related to transaction verification process and data limits per transaction is very important to the adoption of this new technology in vital business sectors such as financial services. Moreover, the list below discusses some other challenges that might hinder the implementation of blockchain [9, 10]:

- ***The rules governing regulatory status***: Currencies currently used in financial transactions are governed by national governments and in order for blockchain to be widely adopted by financial institutions, agreement has to be reached by the those governments to regulate the use of blockchain, otherwise, its status remains unsettled [9].
- ***Security and privacy concerns***: Despite the existing security solutions with strong encryption algorithms, cyber security concerns are considered one of the main important factors that affect public's decisions on sharing personal data using blockchain systems [9]. Blockchain security system will be discussed in more details in Chap. 4 of this book.
- ***Software Vulnerability***: Bugs in software code always exist and poorly written software is especially vulnerable to malicious activity. As software gets more complicated and interconnected, its reliability goes down while the number of bugs goes up. Although we have huge and rapid advancements in technology, software is written by humans and therefore it will always be imperfect. Blockchain is no different. Additionally, the integrity of the software and network are fundamentally important in the evaluation of blockchain as an infrastructure technology. If the technology permeates every major financial system worldwide, the impacts of a glitch or hack could be catastrophic [10].
- ***Integration concerns***: When organisations adopt new technologies to streamline their business process, they face change management challenge to integrate new systems with legacy ones. In this situation, adoption of blockchain technologies is no different, since such projects impose big and difficult task to strategize the transition [9].
- ***To understand the technology***: One of the biggest operational risks with blockchain is that relatively few people understand how it works. Coders and hackers have the expertise to write the software, understand the basic functions and make it work. However, we should be concerned about deploying software when we are unaware of the unknowns. For example, recently, the German automobile manufacturer Volkswagen has admitted that the software programmed by the coders deceived the emission levels by their cars. Consecutively, international fury has been sparked against the company, which led the chief executive to resign [10]. Such software malfunction would have much bigger impact on the financial world if it happens with blockchain.

- ***The decentralized nature of blockchain***: It is true that blockchain is decentralized, which makes it more difficult for all participants to be attacked simultaneously. However, if it is an inside job by a developer with experience of the topology of the network, then, this might cause major disruption to the network [10].
- ***Cultural acceptance***: Public acceptance for the shift brought by the adoption of blockchain is important to the success of the blockchain implementation projects [9].
- ***Initial implementation cost***: The savings promised by the use of blockchain technology are encouraging, however, the initial implementation costs would be considered as an important factor that cannot be neglected [9].

2.6 Potential Applications of Blockchain Technology

Blockchain technology offers many opportunities for saving costs and time as well as increased security for online transactions of any kind. This part discusses some major applications of blockchain technology in financial services, healthcare sector as well as scientific research.

2.6.1 Blockchain Implementation in Financial Services

The interest in blockchain is growing rapidly because of many factors such as the inefficiencies caused by third party trust organisations, logistics processing time, streamlining cumbersome as well as costly and risky correspondent networks [11]. Thus, institutions in financial services sector are showing increasing interest in this technology as an alternative to the current approach for conducting transactions between those organisations [12]. The list of such institutions includes major banks like JP Morgan and Goldman Sachs, where they created a partnership to invest in blockchain technology and develop it according to their needs, standards and expectations. Such investment is vital for those financial institutions as Santander bank has estimated that blockchain technology has the potential to save banks $20bn as a result of eliminating centralized trust agencies and overcoming the aforementioned reasons for investing in blockchain technology [12]. Additionally, when it comes to leans, blockchain facilitates the process of checking check creditworthiness, which results in reducing friction and increasing transparency. Similarly, financial institutions can benefit from blockchain's ability to reduce settlement time required in financial exchanges where post-trade clearing and settling is part of the process [13].

The second use case is about ledger duplication in financial services since each financial institution maintains its own registers. The reconciliation process of these ledgers is costly especially in the case of large banks where they have hundreds of

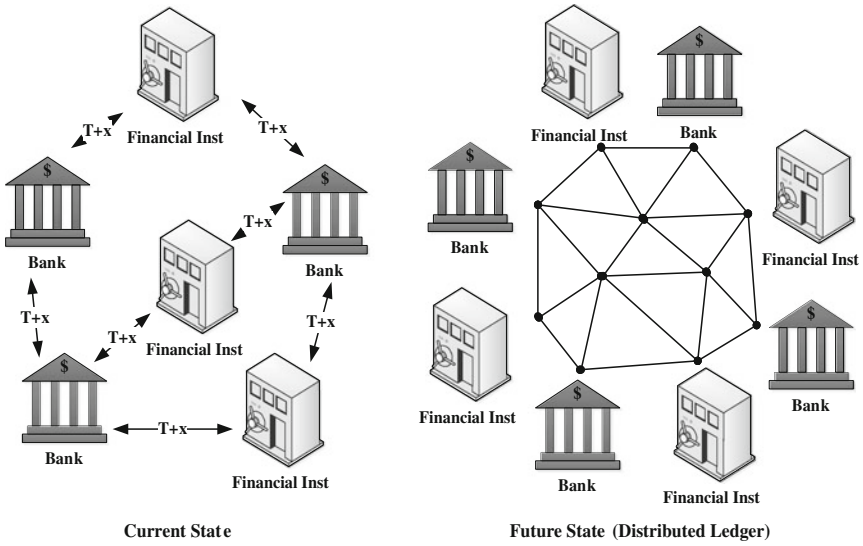

Fig. 2.3 Blockchain's impact on the financial Services, adapted from [14]

ledgers. Also, this process is usually performed by using primitive and unsecured tools such as Visual Basic for Applications (VBA) programming language, which makes it a risky process [14]. Consequently, the need for a technology like blockchain has emerged to tackle the delays caused by such fragmented architectures. Blockchain can deliver a unified ledger for the transactions among the participating financial institutions, resulting in transactions validated in near-real time (see Fig. 2.3).

Utilizing blockchain in the financial services sector could result in several advantages [14]:

- ***Cost reduction*** as a result of elimination of duplication as well as the reduction of post-trade processing such as settlement and reconciliation. It is estimated that banks could save about 15–20bn USD with seven years [14].
- ***Smart Contract*** is another advantage of blockchain since that the majority of financial assets exist in electronic form and smart contract have the ability to automate the existing logic, which could reduce remittance and initiation costs [14]. Smart contracts will be discussed in more details in Chap. 6 of this book.
- ***Risk Management*** can benefit from blockchain technology as well because of the increased speed of settlement, which results in an increased liquidity and decreasing balance sheet risk [14].
- ***Improved regularity compliance*** by having authorized regulator to view a transparent ledger that is distributed among financial organizations. This could also reduce the costs of anti-money laundry and fighting against terrorism financing [14].

2.6.2 Blockchain Implementation in Healthcare

The realization of blockchain benefits for the healthcare industry started to grow as many opportunities started to arise in such vital sector. New models for managing and sharing medical records have emerged using blockchain's ability to provide trust and security while cutting costs, time and resources required by traditional health management infrastructure. As a result, systems such as Health Information Exchange (HIE) and All-Player Claim Database (APCD) became useless [15]. For example, a partnership between the government of Estonia and a cyber-security firm called Guardtime (guardtime.com) in 2007 has emerged to replace HIE and APCD systems. The plan is to make use of blockchain's Keyless Signature Infrastructure (KSI) in order to authenticate and verify the integrity of the medical public data [15]. Additionally, technologies invested in nowadays' wearables provide rich sources for Patient-Generated Health Data (PGHD). However, since this data is not securely accessible, its potential is not yet harvested. Thus, digital health innovators such as Healthbank (healthbank.coop) and Netcetera (netcetera.com) in Switzerland as well as Noser (noser.com) in Germany have started an initiative to securely share personal medical data by investing in and making use of blockchain technology. The intention is to enable the personal to control his\her own data [15].

2.6.3 Blockchain as a Tool to Improve Trust in Scientific Research

Trust in scientific research is an important factor for the credibility of the outcomes especially in vital areas such as medical sciences. However, this factor has suffered trust issues cause by scientific data manipulations such as outcome switching, data cleansing and selective results publication. Thus, a study by Carlisle in 2014 has proved that blockchain can offer a low cost, independently verifiable method to audit and confirm the reliability of the results of scientific studies by using blockchain-timestamped protocols. Carlisle's study shows how blockchain provides an immutable record of the existence, integrity and ownership of a specific medical trial protocol [16].

2.6.4 Applications in Various Industries

Additionally, blockchain technology has applications across several industries. The following point group these application:

- ***Cryptocurrency***: Originally used for value transfer and payments, this blockchain application works by allowing different parties to transact among each other in a trusted manner without the need for third party intermediaries [11]. Additionally, organizations interested in the applications of the distributed

ledger are trying to make use of it for the post trade activities such as clearing, custody and cash management [11].

- ***Proof services***: Blockchain ability to store value at a very detailed level (identity, ownership, membership, etc.…) provides governments with the capability to provide services for citizens related to birth and death certificates, business licenses and property titles [11]. One real life example of this project is the one created by BitNation (bitnation.co) and aims to initiate decentralized governance at global scale such as World Citizenship ID [11].
- ***Smart Contracts***: Smart contracts can enable transactions to self-execute themselves without the involvement of any third party, by the use of the imbedded information such as predetermined terms and conditions, and execution rules [11, 17]. Some startup blockchain-based projects started to offer full featured smart contracts capabilities such as Ethereum project (ethereum.org). Smart contracts will be fully analyzed in Chap. 6.
- ***Decentralized autonomous systems/services***: This could be the most prominent role of blockchain, which is about establishing trust mechanisms between the human and the computer. This is also called Decentralized Autonomous Organizations (DAO) and it can autonomously hire agents on the Internet to perform specialized tasks. However, it is understandable that creating self-organizing and self-governing DAO is not an easy mission, but once properly implemented, it can have a major impact on various industrial sectors such as transportation, healthcare and cloud storage [11].

Table 2.1 illustrates a grouping for the key applications of blockchain technology according to the users of the technology.

Moreover, Fig. 2.4 provides a grouping for the key applications of blockchain technology according to technology sub-domains and time-to-delivery indicator.

2.7 Blockchain Adoption

The introduction of blockchain technology into the world of business promises massive change to organizations' IT infrastructure as well as to the way they transact and conduct business. This section explores the potential of blockchain technology as well as its benefits and obstacles that face its adoption.

2.7.1 Blockchain Potential as SWIFT Replacement

SWIFT stands for Society for Worldwide Interbank Financial Telecommunication and is considered as the most important aspects in banking industry since the 1970s. It is a global system that enables financial institutions to securely exchange information about their financial transactions. Swift is globally used by more than 9000 financial institutions in 209 countries to exchange $5 trillion a day. For all these

Table 2.1 Key blockchain applications groupings according to the users of the technology, adapted from [14]

Institutions	Regulators	Operations	Individuals
FX settlement	Compliance reporting	Client onboarding	Crowd-funding
Trade reconciliation	Risk visualization	Intra-company settlement	Virtual identity
Cross border payments	Basel III compliance	Normalize reference data	Credit scoring
Credit efficiency	Client fraud transparency	Time-stamping	Cross border remittance
Loan settlement	Know your customer/Anti-money laundering	Account portability	Vault/escrow services
OTC derivatives clearing	Trade reporting	Broker fraud identification	Customer deposit cost
Collateral management		Securities agreements as smart contracts	Peer-to-peer lending

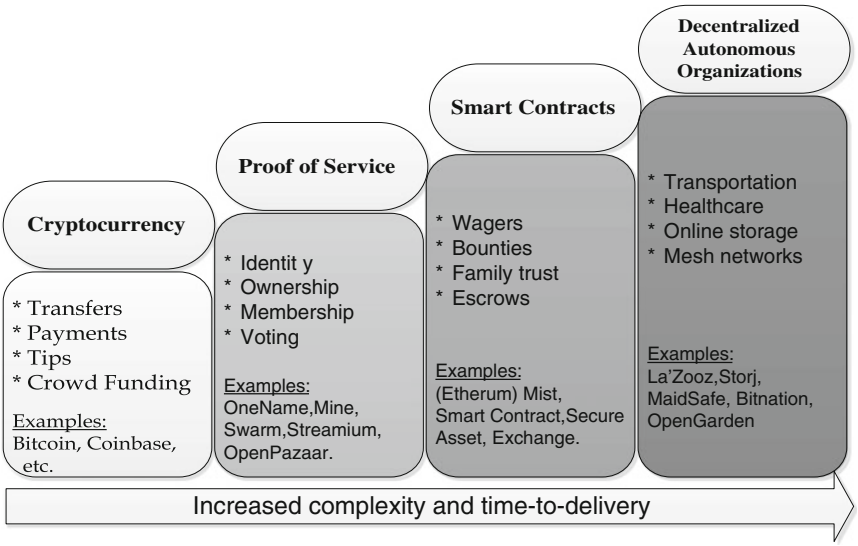

Fig. 2.4 Key blockchain applications groupings according to technology sub-domains, adapted from [11]

reasons, it is difficult for banks and other financial organizations to replace Swift with blockchain, and it is even more difficult for this transition to happen when bankers and executives lack the full understanding of what blockchain is, how it works or its capabilities. Blockchain abilities include recording digital value exchange such as payment or a marriage vows and record securities settlements [18].

2.7.2 Blockchain Adoption by Organizations

Many organizations started to realize the prospective advantages that can be achieved by adopting blockchain technology. IBM for example, is investing in this technology in order to shape the regulations that govern its implantation as well as to develop products that can be used by interested businesses. Additionally, IBM has joined a Chamber of Digital Commerce, which was jointly established by a group of blockchain startups, software firms, financial institutions and interested investors in 2014 in an effort to work closely with US government to set the standards for blockchain development and usage as well as to develop a legal framework that can lead its adoption.

In corporation with Digital Asset Holdings and the Linux Foundation, IBM's idea is to develop open-source blockchain-based software that can become the basis for any future blockchain implementation by interested organisations. Major firms such as JPMorgan Chase, ANZ Bank, Cisco, Accenture, Intel, London Stock Exchange Group, Mitsubishi UFJ Financial Group, IC3 and VMware have already started to invest in what IBM is developing [19]. Furthermore, Deloitte is another example of big organization that realized the potential of blockchain, as it started a partnership with five blockchain specialized firms in order to use the emerging technology effectively in its consulting business by developing blockchain based applications such as digital identities, digital banking, cross-border payments as well as loyalty and rewards [20].

Moreover, capital markets represent an important part of the financial system that uses shares, bonds, and other long-term investments to generate and raise companies' capitals. Figure 2.5 illustrates the benefits of blockchain adoption across the different trading stages within the financial markets. These stages cover pre-trade, trade, post-trade and finally custody and securities servicing.

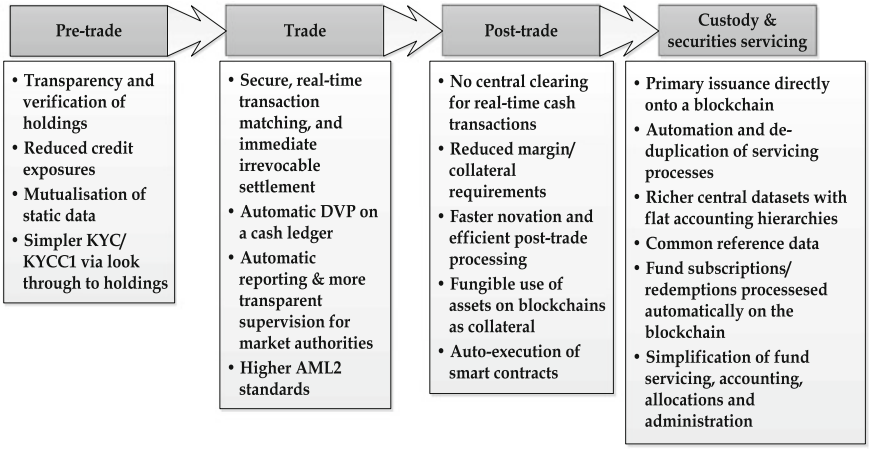

Fig. 2.5 Benefits of blockchain adoption for capital markets, adapted from [21]

Considering the impact of adopting blockchain in capital markets however, it is necessary to consider the obstacles that might hinder or affect its success. Thus, blockchain technology requires further investment in order to have an agreement on its common standards and in order to have scalable enough technology [21]. In the following Section, we outline an implementation timeline suitable to be addressed before widespread adoption will become feasible.

2.7.3 Blockchain Implementation Timeline

It is important for the developers behind new technologies such as blockchain to produce practical applications and solutions in order to ensure ongoing investment and to be able to scale the technology to real-life applications in live environments. Figure 2.6 illustrates the time to market timeline for the adoption and development of blockchain-based applications.

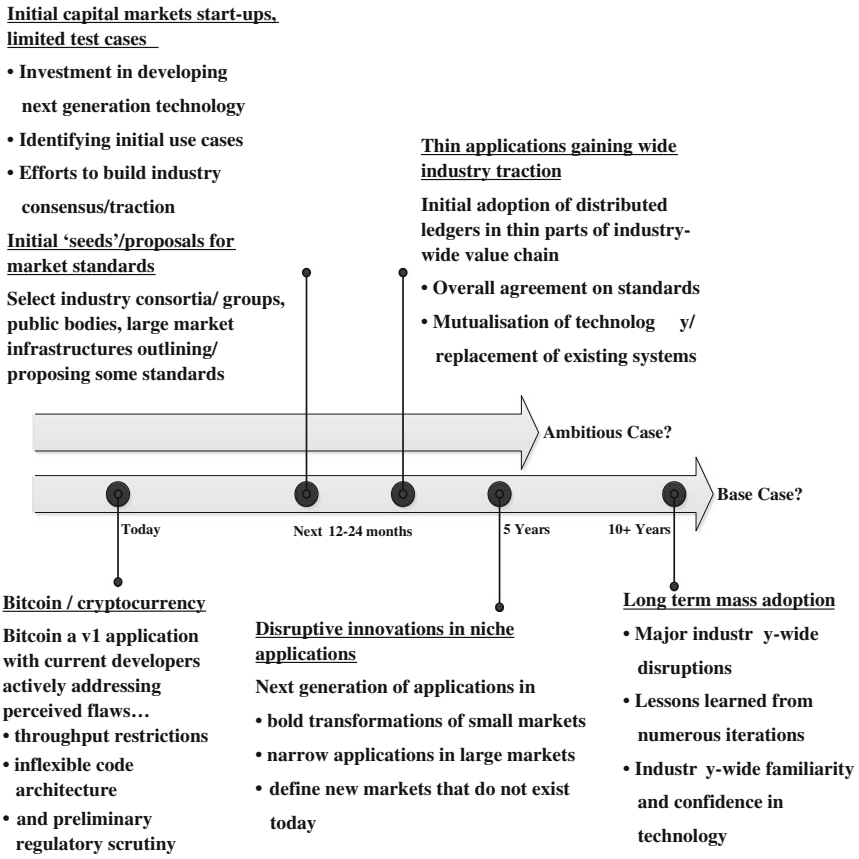

Fig. 2.6 Blockchain adoption and implementation timeline, adapted from [21]

Taking the timeline into account, it is key for organizations to realize the importance of keeping up to date with the emerging technologies, since falling behind, might result in loosing important share of the market or even leaving it. Thus, the following points list several suggestions related the adoption of blockchain for a successful adoption and implementation:

- ***Proofs of concept must be reliable and convincing***: Technology developers and innovators must present solid use cases by justifying how the distributed ledger will have a great and positive impact to the industry as well as to the clients [21].
- ***To understand the current status and the future impact***: Interested adopters or developers of blockchain have to understand the current situations with the current technological solutions and analyze the challenges, costs and benefits from adopting blockchain in the organization [21].
- ***New technology needs more time for success***: It is understandable that sometimes new technologies might not achieve their potentials fast, thus, innovators, developers and adopters need to continue driving the change in the industry by more engagement and collaboration [21].
- ***Mature and successful products need more time***: Technological innovations don't achieve success from the first versions, thus, it is important to consider those early versions as prototypes that help in uncovering the areas that need improvement [21].
- ***The importance of bridging the gap between technology and industry***: It is important to fully understand the domain knowledge that will be used to develop the new technology, and not to separate the development process from the business expertise [21].
- ***The important role of the regulators***: Technology development should be in full accordance with authorities' standards and roles. It is important to keep briefing these authoritative stakeholders about the development process in order to address their concerns regarding security, privacy and legal measures [21].
- ***Scalability of the Technology***: It is important for new technologies like blockchain to be able to handle large financial markets datasets while considering concerns related to security, robustness and performance [21]. This issue is especially important in order to manage the operational risks of the transition to the new technology during implementation.
- ***Agreement on common standards***: Industries need to have an agreement on the design issues of blockchain such as its openness (open or permissioned-base access systems). Moreover, they need to have common grounds on how to operate and manage blockchain infrastructure, which includes its governance, updates and responsibilities.

2.8 Case Studies

In this section we investigate two case studies showing the implementation of blockchain at work environment and we provide explanation about its role for the business success. However, because the business world is still discovering the hype and the potentials of a nascent technology like blockchain, the following use cases are still developing.

The first case study is about a futuristic plan or vision called "Energy union" set by the European Commission Energy Union Framework Strategy in 2014 [22]. This plan aims to give the power for the EU citizens to embrace the energy transition in order to reduce their bills, have more choices, actively participate in the energy market, and most importantly to protect the consumers [22]. However, such vision requires dealing with many critical issues. These are:

- *Delivering accurate information* regarding incurred costs and power consumption in order for the customers to realize possible opportunities in such fully-integrated continental energy market.
- *Appropriate ways to reward active participants* such as switching between contracts as well as managing demand and response according to current prices.
- *Ensuring interoperability* in the market while considering various aspects such as residential energy service providers and available options for the consumers as well as embracing possible gains from self and micro power generation.

These factors make it necessary for the European commission to invest in new technologies that can meet their expectations. Hence, the interest in blockchain and its distributed ledger as the technology that can improve the level of integration and development of the energy retail market. Thus, a European Commission called Joint Research Centre (JRC) for science and knowledge service, which provides scientific advice to EU policy, is practically investigating the applications for blockchain, such as micro-generation energy market and energy contract ledger. The first one is about consumers that are capable to produce energy locally and trade it with other local markets. Distributed ledgers and smart-metering can enable local energy generators to access the energy market, which until now remains a privilege for only the major energy suppliers. The later case, energy contract ledger, is another application context where distributed ledger can enable better management of the administrative complexities associated with changing the energy supplier such as closing the current contract, opening a new one with new supplier, and discussing new terms. Distributed ledgers can improve this process by allowing consumers to finalize the transition easily on the internet. Additionally, energy providers can save costs required for the administrative operations [22].

Point of Attention This case study shows how distributed ledgers (blockchain) can be utilized to develop more competitive energy retail market by empowering the consumers with more information that can enable them to have wide choice of action. The benefits of such vision are so promising, hence, that further investigation is required. However, there are still questions about the scalability, security and stability of such applications that need to be addressed.

The second case study discusses the use of Distributed Ledger Technologies (DLTs) in contexts different from its original purpose, Bitcoin, since the concepts and structures developed for distributed ledgers is extremely portable and extensible to other areas of economic and social interactions. It is about the ability of governments to use distributed ledgers for information sharing between economic entities, which helps to reduce market friction and would enable new forms of innovation to emerge. Consequently, SMEs can benefit from the reduction in transactions' costs to be able to move more freely within the market, which helps to lower overall operating expenditures. Additionally, by using DLTs to register companies' patents and Intellectual Property (IP), it is possible to reduce the overall number of contract disputes. These disputes make up 57% of all litigation in the UK, more than any other category of legal action [22].

Point of Attention This case study shows how distributed ledgers can help reduce transaction costs for SMEs and streamline cost of operations for local and national government. Additionally, having a trustworthy proof of ownership for digital assets such as IP will reduce the options for litigation, providing an overall social benefit for UK society.

DLTs can be used to register contracts and assets, which provide a robust and trustworthy method to prove the businesses ownership of the properties including Intellectual Properties (IPs) as well as patents. Moreover, they can handle micropayments, decentralized value exchange and transfer, token earning and spending. Thus, DLTs can help governments to improve the way businesses work in various ways. These include:

- Business licensing.
- Registration (e.g. properties, wills, intellectual properties, notary services, health data, etc.).
- Insurance transactions.
- Taxation management at different municipal and regularity levels.
- Pension related data.

Distributed ledgers provide opportunities for government to reduce operating costs, fraud, error and the costs of delivering services to underserved users. This can benefit SMEs by reducing the costs of the transactions.

2.9 Summary

Blockchain is a technology that is highly likely to change the way businesses will work in the near future, just like what the Internet did in the 1990s. It is a nascent technology, and the realization of its potentials to overcome the existing issues in the way businesses transact among each other as well as to improve current business practices encouraged large organizations such as IBM and major banks to greatly invest in it. Blockchain adopters, however, have to face several concerns such as the regulations that govern how it works, security and privacy issues, integration concerns and cultural acceptance. If these concerns are addressed properly, then, blockchain will successfully match its potentials as a value system and the possible advantages of shifting to blockchain technology will be promising for the adopting organizations.

In this chapter, comprehensive descriptions for blockchain and its features have been provided. Moreover, explanations for blockchain applications in several industrial sectors have been discussed. The discussion has proved the importance of blockchain technology in vital domains such as scientific research and healthcare. Additionally, it demonstrated the variety of implementation areas in the financial sector. Nevertheless, proper research, management and experience are required to successfully understand the business domain as well as how blockchain technology can fit and meet business requirements. Finally, the chapter has discussed two developing case studies, highlighting the significance and benefits associated with the adoption of blockchain in order to have more efficient businesses.

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Blockchain Governance

3

Abstract

Blockchain governance is the provision of services in a potentially more efficient and decentralized way, without having to necessary rely on the state or government bureaucracy. In this chapter, the societal impact of decentralized Blockchain governance is discussed, describing their associated challenges. We further explain how banks are adopting Blockchain to improve upon their existing products and services with specific examples of some European-based banks. In addition, the impact of Blockchain governance on non-banking sectors such as financial institutions are well presented as well as techniques needed for adoption. The chapter concludes by an articulate summary on overall issues addressed, the risks Blockchain-based governance may produce and highlights a few methods to cope with such a huge technological disruption.

3.1 Introduction

Blockchain governance is the provision of services in a potentially more efficient and decentralized way, without having to necessary rely on the state or government bureaucracy [1]. This provides a more distributed diffusion of authority, in which the sources of authenticity are individuals themselves. Using the Blockchain as a permanent, encryption-secured public record storehouse, human agents as representatives can be replaced by smart contracts and decentralized autonomous Corporations [2].

Existing legal systems currently involves the invocation of various state-appointed mediators to improve the enforceability of contracts. Some contracts need to be notarized to prove that the parties really did sign the contract in the presence of a legislative officer, while others have to be registered in order for the transaction to be stored in the public records. When all contracts are put into a

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Blockchain, a technological solution can be developed that does away with the need for human intermediation and establishes provenance [3].

With such a technological solution, Lawyers will no longer draft lengthy paper documents but will instead prepare self-executing legal documents that activate payments when certain pre-defined situations occur. The ownership of intellectual property rights would be easily demonstrated by referencing their time-stamped locations on the Blockchain [4]. In addition, many government operations can also be replaced by Blockchain equivalents. A Blockchain database of public records will ensure that birth certificates, land records, other records are automatically recorded in a format that is publicly verifiable. This would consequently diminish our investment in governance and offer greater accountability in the provision of public services. As noted above, record keeping is considered as an important function and feature of the blockchain technology. It enables easier and more trusted value transfer among individuals in both of its forms, short-term transfer such as money transfers, as well as long-term records retention such as land transfers. Considering the implications of having frauds committed in both of these use cases, however, it is important to understand the two dimensions—record retention requirements and evidential requirements—that characterize the different blockchain technology applications [5]. Figure 3.1 provides an illustration of the blockchain use cases considering these two dimensions.

It can be noticed from Fig. 3.1 that when both retention requirements and evidential requirements are low the use cases are most suitable for blockchain-based solutions. In contrast, when both retention requirements and evidential requirements are high, then the aforementioned technology is not suitable for such applications unless blockchain governance is well structured and can prevent fraud incidents [4].

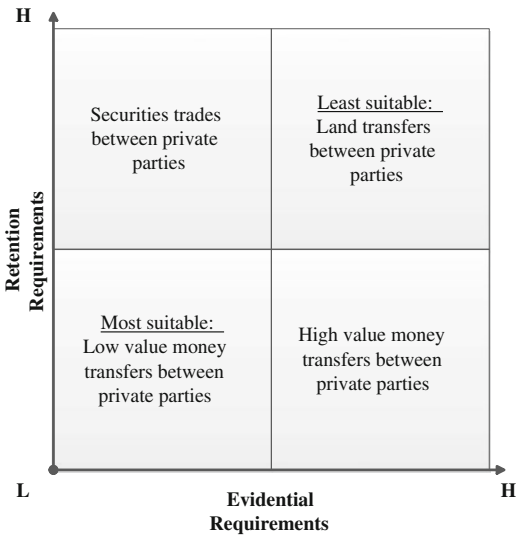

Fig. 3.1 Heuristic for thinking about the suitability of blockchain solutions for recordkeeping. Adapted from [4]