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# Blockchain in Data Analytics

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Edited by

Mohiuddin Ahmed

Cambridge Scholars Publishing

Blockchain in Data Analytics

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Dedicated To

*"My Loving Parents & Wife"*

***—Mohiuddin Ahmed***

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I am grateful to the Almighty Allah for blessing me with the opportunity to work on this book. It is my second time as book editor and my sincere gratitude to the publisher for facilitating the process. This book editing journey enhanced my patience, communication and tenacity. I am thankful to all the contributors, critics and publishing team. Last but not least, my very best wishes for my family members whose support and encouragement contributed significantly to complete this book.

—Mohiuddin Ahmed
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# PREFACE

## Introduction

Blockchain is a public ledger where transactions are nearly impossible to amend. A decentralized database where business is transparent without any involvement of the middleman. The first use of blockchain technology was the digital currency (bitcoin). However, other potential uses of this technology are yet to be explored. It is expected to have an impact on cyber security, internet of things, supply chain management, market prediction, governance, information management, financial transactions and more application domains. Till today, blockchain has redesigned the way people deal with their money due to its effectiveness, especially in terms of security. Therefore, from the data analytics point of view, investigation of blockchain technology in a wide range of applications domain is crucial. In this context, this book will provide a broader picture on the concepts, techniques, applications, and open research directions in this area. In addition, the publication is expected to serve as a single source of reference for acquiring the knowledge on this emerging technology.

## Objective of the Book

This book is about compiling the latest trends and issues about emerging technologies, concepts and applications which are based on Blockchain. It is written for graduate students in universities, researchers, academics, and industry practitioners working in the area of Cyber Security, Data Science and Machine Learning.

## Target Audience and Content

The target audience of this book is composed of graduate students, professionals, and researchers working in the field of data analytics and cyber security in multi-disciplinary applications. The chapters are written in tutorial style so that the general readers can be able to easily grasp some of the ideas in the relevant areas.

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Chapter One: Introduction to Blockchain

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The first section includes an introductory chapter to discuss blockchain. The second section has four chapters which reflect on the different concepts of blocckchain for data analytics such as Internet of things, Industry 4.0, fog computing and project management. These topics are considered as emerging trends for blockchain data analytics. The third section is dedicated for the applications of blockchain for data analytics in different domains such as privacy, healthcare, finance, e-commerce, agriculture etc.

Editor
Mohiuddin Ahmed

# CHAPTER ONE

# INTRODUCTION TO BLOCKCHAIN

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## Abstract

Blockchain is one of the most-hyped topics of the computing world recently, as well as in the financial technology (FinTech) industry. Experts say that the future of monetary transactions, and secure information exchange rests on the shoulders of blockchain. Blockchain provides the potential to change how the world moves forward. For example, if you want to buy any asset, such as a house, vehicle, or any other tangible or intangible property, you currently need to go through a lot of paperwork and labor-intensive effort. However, blockchain makes life easier, and accomplishes these cumbersome functions within a short period of time. Blockchain can be defined as a simple block of transparent digital information which is highly secured and shareable, but immutable. Transparent digital information means the data exploited is traceable and identifiable. In this chapter, we present briefly what blockchain is, how it works, and what the major application areas in the real world are.

**Keywords**: Big Data, Blockchain, Cryptography, Data Analytics, Digital Currency, Information Security, Internet of Things, Private Key, Public Key, Transaction.

# 1. Introduction

Blockchain is one of the most recent technologies in the domain of security, tractability, and transparency, for managing any digital asset transaction, as well as for physical assets and agreements.

In this chapter, we will learn about blockchain, how it works, and what the benefits and limitations of blockchain are, as well as the area of blockchain implementation, from which we can gain the advantages of blockchain. Section 1 describes the basic idea of blockchain, and later, in section 2, the history and evolution of blockchain are depicted. Section 3 covers the types of blockchain, followed by Section 4, which describes the basic mechanisms of blockchain and transaction. Section 5 focuses on the importance of blockchain, Section 6 presents the applications of blockchain, and finally, Section 7 provides the challenges and opportunities of blockchain.

We have the conception that blockchain is the technology that powers bitcoin, and although this was its original purpose, blockchain is capable of so much more. Let's see what blockchain is.

Blockchain is shorthand for a suite of distributed ledger technologies that can be programmed to record and track anything of value, such as financial transactions, medical records, land titles, and so on. Blockchain technology is based on the centuries-old method of the general financial ledger. In simplified language, it is a digital ledger which holds the records of all sorts of transactions that happen in a peer-to-peer network. This technology is assumed to 'cut out the middleman' from any sort of transaction or transfer of digital assets. This is a much more secure and decentralized medium. Financial institutions are exploring the possibilities of using this technology to ensure secure transactions.

Blockchain works like a digital ledger, with some particular characteristics, such as:

- Blocks can only be appended;
- No block can be edited;

- The validity of any transaction depends on the previous transaction, so that no fraud can happen;
- Transaction happens only after full verification.

The working mechanism of blockchain will be described later in this chapter.

## 2. History and Evolution of Blockchain

The history of blockchain is not that old. The first step of blockchain was initiated in 1991 by Stuart Haber and W. Scott Stornetta, with their work on a cryptographically-secured chain of blocks, where no one could tamper with the time stamps of documents. In 1992, they upgraded their system to incorporate Merkle trees, to allow the system to accept more documents in a single block. [1] However, the blockchain that we know today was introduced by Satoshi Nakamoto in 2008. He is known as the brain behind blockchain technology. Many people believe that he could be the person, or one of a group of people, who worked on bitcoin for the first publicly-known application of digital ledger technology (DLT). [2][3] Satoshi released a white paper on blockchain, explaining all the details of the technology in 2009, and from there, the development of blockchain has gone far, with many implementations.

**Evolution:**

The evolution of blockchain can be divided into three different phases: Phase 1, Transactions; Phase 2, Contracts; and Phase 3, Application. [1] Figure 1 briefly presents the timeline of the evolution of blockchain.

**Phase 1: Transactions (Blockchain 1.0 and Bitcoin):**

The timeline of this phase is from 2008 to 2013. During this time, Blockchain 1.0 was in practice, where the main goal was to carry out peer-to-peer transactions. During this phase, bitcoin was the popular implementation of blockchain technology, and everyone was busy with bitcoin transactions and bitcoin mining.

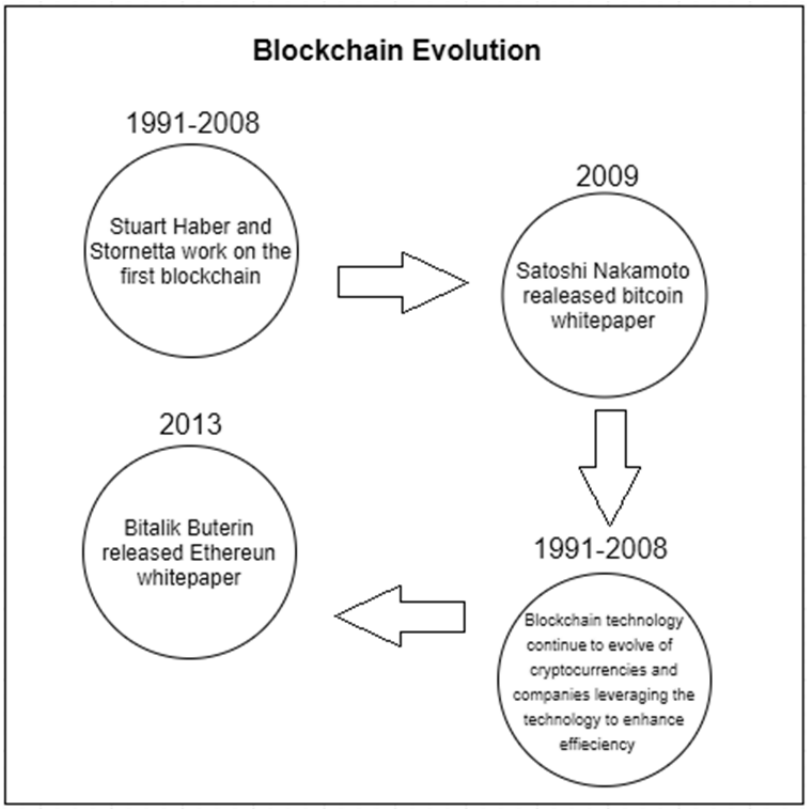


Figure 1: Evolution of Blockchain

**Phase 2: Contracts (Blockchain 2.0 and Ethereum):**

The timeline for the phase of contracts actually appears between the years of 2013 and 2015. In this phase, another potential of blockchain technology was noticed. Decentralization was the key feature of this phase. While in the transaction phase, the communication was mostly on a peer-to-peer basis, but here, it was used in a distributed fashion, and the technology of smart contracts was widely used. Smart contracts expanded blockchain from being used as a cryptocurrency to a platform of decentralized applications.

Vitalik Buterin was one of the developers who figured this out. He started building a new public blockchain network, named Ethereum, which can perform various functions in addition to being a peer-to-peer network. This version of blockchain technology can be named Blockchain 2.0. The Ethereum blockchain evolved to become one of the biggest applications of blockchain technology during this phase.

**Phase 3: Applications (Blockchain 3.0 and the Future)**

The history of blockchain does not stop with bitcoin and Ethereum. In recent years, a number of projects have come up with new features for blockchain. Phase 3 started from 2018, where different applications began to be integrated with blockchain technology, and blockchain was being secured with biometric complementation, such as facial recognition, voice matching, and fingerprints. The network of connected devices known as the internet of things (IoT) is being aggregated to blockchain platforms, and more new platforms and applications have started using blockchain in their daily operations.

## 3. Types of Blockchain

There are three types of blockchain, known as public blockchain, private blockchain, and consortium blockchain [6].

- **Public Blockchain**

  The public blockchain network is open access. The network imposes no restriction to access its premises. Anyone can send a transaction to this network, and anyone can become a transaction validator. [6] Usually, the public blockchain network offers economic incentives for the people who secure them, and utilizes some sort of proof of stake, or proof of work, algorithm, to general people. This is known as cryptocurrency mining. Some of the largest and best known public blockchains are bitcoin and Ethereum.

- **Private Blockchain**

  Unlike the public blockchain network, private blockchain networks are permissioned, which means no one can join the network until they are invited by the network administrator [4]. Both participants' and validators' access are restricted without any invitation to participate. This sort of blockchain network is used by companies who want to

secure their data without sacrificing autonomy or taking the risk of exposing data to the public internet.

- **Consortium Blockchain**

Similar to the private blockchain network consortium, the blockchain network is also permissioned and semi-decentralized, but instead of a single organization controlling the network, a number of companies might each operate a node on such a network [5][6].

## 4. How Blockchain Works

In order to understand how a blockchain chain works, let us discuss a common scenario where it can be operational, and some of its key attributes. The main purpose of blockchain is to provide security, and banking transactions are the most suitable candidates to use blockchain. Let us consider that a financial transaction in the form of a money transfer is taking place between an account named 'A' and another named 'B'. It is essential that both the accounts are updated after the transaction is completed. This is the place where intruders may interfere and cause changes to the entries that are made on both the accounts while updates are performed, leading to the possibilities of a tampered-with transaction. In order to address this situation with a feasible solution, blockchain is used. Some of the following paragraphs will describe in detail about how the solution can be achieved, relying on the fact that it is a collection of blocks linked with each other in chronological order, and each block contains a set of data. However, let us take a closer look at how blockchain is better than traditional processes, in order to understand its operation. This can be explained based on some key attributes which are as follows:

- Peer-to-peer – There is no central authority who has control of the entire data. All participants within the network are allowed to communicate with each other directly;
- Distributed – All the blocks are distributed over the entire network, which makes it difficult for intruders to tamper with the data;
- Add-Only - Data can only be added in the blockchain in time-sequential order. This property implies that once data is added to the blockchain, it is almost impossible to change that data, and it can be considered practically immutable;
- Consensus – This is the most important attribute of all. It gives blockchain the ability to update its data via consensus. In this way,

> no central authority has control over the data. Any kind of update has to be made following strict protocols, and will be only added when a consensus has been reached among the peers in a network.

Blockchain is made up of several sets of data blocks which hold the records of each transaction. Every block is connected with every other. Blockchain can be either private or public. In a private blockchain, only members are allowed to access the network. Anyone can use a public blockchain network, like the internet. Blockchain uses cryptographic technology to secure the transactions, and cryptography is a mathematical method which keeps data secure by proving its identity mathematically. Blockchain uses two keys for this purpose. The first one ensures only a valid user can enter a transaction block to the existing blockchain, and another key will let someone else authenticate whether a valid user has made this block or not.

Another important mechanism that is used in blockchain is immutability. That is, no tampering or editing of previously made blocks is possible in blockchain. It is controlled by a cryptographic concept known as hash. Hashing makes data secure by altering data into something else, using mathematical functions. For example, the hash of the sentence "the quick brown fox" is "9ECB36561341D18EB65484E833EFEA61EDC74B84CF 5E6AE1B81C63533E25FC8F" using SHA-256 encoding. If only one letter of the alphabet is changed in the previous sentence, then the hash will turn into something completely different from this one. In the blockchain, any minute change is detected, as hashes are linked to each other. A new block must have the previous block's hash linked to it. As a result, though it is public, it is very secure. Working Mechanism of a Blockchain Transaction is listed below:

1. When a transaction is carried out, it is linked to the blockchain as a block, protected by cryptographical encoding. All the blocks created within a certain time are sent to the other members of the network. In bitcoin, all transactions are sent within 10 minutes.
2. Members of the network with high computing-power-enabled devices, or computers, compete with each other to validate the transaction, by solving a complex problem. Any member who solves the problem first, receives a transaction fee, or another reward. For example, in bitcoin's blockchain, members receive bitcoins.

3. Any block which is validated is first time stamped, and is then added in order. Newly validated blocks are added to the previously validated blocks.
4. The entire chain of such blocks is called blockchain, which keeps updating with newly added blocks. Figure 2 describes step-by-step how blockchain makes a transaction.

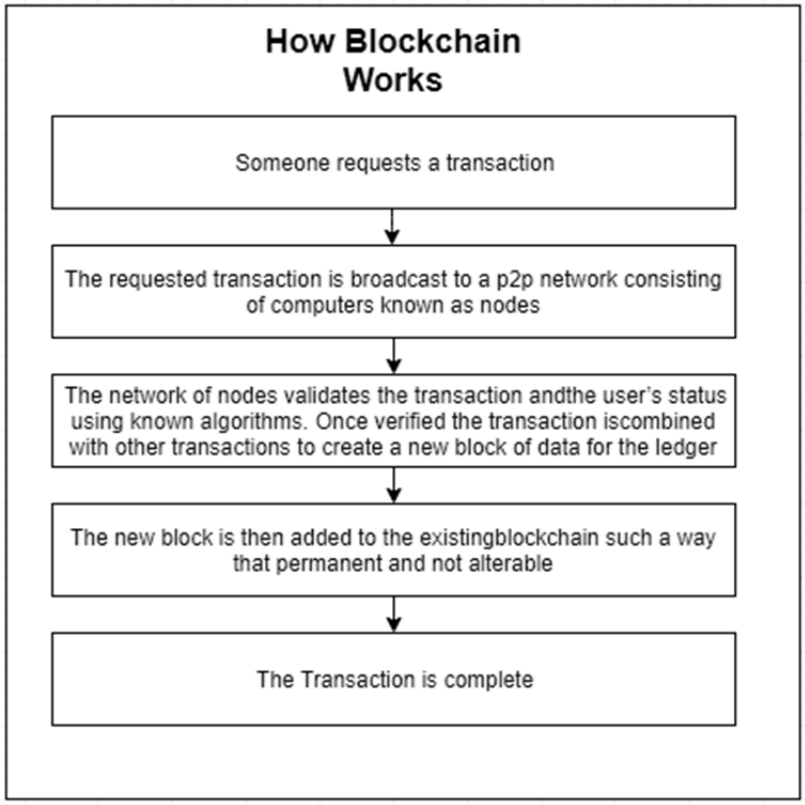


Figure 2: How a blockchain transaction works

## 5. The Importance of Blockchain

The importance of blockchain relies on its primary features, which are trust, integrity of content, smart contract, and bypassing the intermediary, in any sort of transaction. Blockchain technology is changing industry

drastically, especially industries which are related to financial technologies (FinTech). Besides FinTech industries, blockchain has brought changes to healthcare industries, e-governance systems, and data analytic-based industries. The importance of blockchain is not easy to describe in words, except by experiencing it first-hand.

Let's look at some real-world problems and scenarios which can be solved by using blockchain technology. The Australian Securities Exchange recently scrapped their old CHESS transaction system for managing the stock exchange market, for distributed ledger technology (DLT). [8] The Government of Andhra Pradesh in India plans to deploy blockchain technology across the administration. They have piloted two projects - managing land records, and streamlining vehicle registrations, using blockchain. [7] These are just examples; many others are switching to blockchain technology for solving different sorts of problems, and many are on their way to embracing it. The healthcare industry is another example where blockchain is being used for efficient and secured data management problems which are shared across different healthcare providers.

The electoral process is also a beneficiary of blockchain technology, which can provide an extra layer of security that the current manual system cannot provide. Blockchain is also being tested in the management of supply chains, insurances, peer-to-peer lending, energy sharing systems, gaming and streaming systems, and so on. Blockchains are also being used to solve daily life problems; for example HelloTickets is a platform which publishes tickets for events. Using blockchain guarantees each ticket's authenticity, removing the necessity of a third party to authenticate the tickets. The possibilities of blockchain are so huge that many governments are taking interest in it. For example, Spain's Securities Regulator has undertaken a pilot project, the President of Uzbekistan has signed a decree on blockchain integration, and the Maltese parliament has passed laws which set a regulatory framework for blockchain, cryptocurrencies, and DLT [9].

What if there was no blockchain? What would be the consequences of that? We might possibly face a lack of trust in any sort of online transaction, more fraudulent activities in asset management, especially in land titles, and a fear of not getting original and authentic data. We might also face a lack of efficiency in large transactions and service delivery systems.

Cheng et al. proposed a business model for the decentralized electricity market, based on blockchain, in order to reduce the high cost of achieving a digital centralized solution for construction, management, and maintenance [17]. Since the management of data which is produced in large quantity is difficult and costly, blockchain was used as a solution, in order to achieve peer-to-peer transactions in the power system.

Metler demonstrated the use of blockchain in the healthcare industry, [18] stating that it can add significant value to the treatment of older people, or of chronic diseases. A startup in the USA, called Gem, has used Ethereum blockchain to create a health network [19]. This will allow healthcare specialists to be present in a large distributed network system, where it is possible to share multiple copies of different kinds of information with each other. It will help to combine business, individuals, and experts, at the same time, which has the potential to increase patient care. This also means that the records of individual patients, and their interactions with doctors, will be present in the network for others to see when needed. This means that patients will be exposed to a reliable healthcare environment. In another attempt, Estonia collaborated with Guardtime to digitalize its healthcare system, where all the medical records of citizens were available [20]. The entire system was developed using blockchain, which helped to retrieve medical information when required by any individuals, especially in the case of insurance.

When more and more people are implementing systems within systems, more and more data is emerging which can be used for various types of research. Healthbook is a Swiss digital system that efficiently stores and manages health data [21]. This has led to the availability of numerous health data, based on which, different medical research were performed. Blockchain also has wide application in the pharmaceuticals industry. For the production of any kind of drugs, the final product must maintain the required quality in order to be used commercially. For this process, data can be used to monitor the production of drugs to ensure quality.

According to the World Health Organization (WHO) the amount of counterfeit drugs has risen by up to 30% in developed countries. Some of these drugs are also used for cancer, antibiotics, painkillers, contraception, and other diseases. As a result people are badly affected. Hyperledger, which is a research network across industries, launched the Counterfeit Medicine Project, [24] which uses blockchain to detect such counterfeit

drugs. Apart from healthcare, there are other sectors where there are influences of blockchain.

Tam Vo et al. proposed a system that will transparently manage and analyze data for car drivers in developing countries, in order to introduce a 'pay-as-you-go' insurance service [22]. The reason for proposing this system was that drivers have to pay a large amount of insurance, independent of mileage, and driving behavior and patterns.

Nguyen provided a study using blockchain for economic growth [25]. He derived that blockchain can contribute to journalism, since the contents can be made available online, and interested persons can buy the contents by paying a few cents. This, in turn, encourages publishers and writers to create more content maintaining proper writing quality, as people have so many options to choose from. So a new source of earning is being created, and writers are discouraged from providing fake information, as the contents are available to everyone. In addition to writers, with its wide spread of data all over the network, blockchain can provide anyone with a platform to earn, from artists to game producers. Nguyen also adds that the use of blockchain also promotes new forms of media, such as crowd-made RPGs (real-life prediction games), online interactive drama, and novels, as well as new ways of combining art, music, and storytelling. He also concluded that the monopoly of the cable TV companies can be broken, as content is available online, and users usually have to pay only a little to view it.

Hou discussed the importance of blockchain for e-governance in China [26]. He concluded that, along with the help of blockchain, e-governance will help with the quality and quantity of government services, government information will be transparent and available to the citizen, different government organizations can easily share information between themselves, and China will get help to build its own credit system.

Who does *not* need blockchain? The answer to this common question is that if any application does not need to store the state, there is no involvement of multiple parties, and no need of public verifiability, then the application is not meant to use blockchain technology. The flowchart provided below will come in handy to understand the scenarios where blockchain is not needed. [10]

## 6. Applications of Blockchain

There are numerous fields where we can use blockchain, but for now we will be limited to the following fields, and all of them will be elaborated in different chapters of this book.

### 6.1 Data Analytics

Data analytics (DA) is the process of examining sets of data to draw conclusions about the information they contain. This means finding actionable information from large data sets. Recently, data is being transformed into currency, and data analytics is at the root of this shift. [11] Data analytics are used for future prediction, and are being used by companies from financial management to marketing. But using data in such a way to extract trends and information comes with high barriers, such as trained specialists and pricey equipment. With the use of blockchain, these can be lowered to the least cost. Blockchain is the way to minimize the data analysis cost for large data sets, with distributed networks of different machines and algorithms.

### 6.2 Big Data

Big data refers to data sets that are too large or complex for traditional data processing application software to deal with efficiently. So far, we are familiar with data analytics, and data analytics also deals with big data. While using blockchain for data analytics, it adds another data layer to the big data analytics process. This data layer provides two additional values to big data, [12] and those are:

1. Blockchain-generated big data is secure, as it cannot be forged due to the network architecture;
2. Blockchain-based big data is structured and complete, which makes it perfect for further analysis.

Big data, combined with blockchain, can lead to lot more efficient analytics. There are three reasons for this. [33] These are as follows:

- Security – Every single record inside a block in a blockchain is highly secured, which makes it very difficult for any data to be tampered with;
- Transparency – The data can be traced back to its point of origin;

- Flexibility – Blockchain can store both structured and unstructured data.

The main facts about combining big data with blockchain are the quick transfer of data, and the overall improvement of the stored data. Blockchains will allow businesses to confidently identify the integrity of the data being generated. Consensus-driven timestamping, proper audit trails, and immutable entries, will all become better, as blockchain starts becoming more mainstream. Healthcare is one of the sectors which is supposed to receive a considerable number of benefits. Healthcare providers can share information with patients, their physicians, insurance providers, justice departments, employers, etc., easily and securely. This can lead to:

- Following up the patients properly;
- Ever-available medical records that cannot be altered;
- Ever-available, secure, patient history.

## 6.3 Information Security

The future of information security, or cyber security, relies on blockchain technology. As blockchain technology allows the blocks to be decentralized with data integrity, it can be used to prevent any type of data breach, identity theft, cyber-attack, or any other fraudulent activity in any transaction. What can be done by using blockchain in information security is listed below: [13]

1. Protected edge computing with authentication;
2. Advanced confidentiality and data integrity;
3. Secured private messaging;
4. Improvement of public key infrastructure;
5. Intact domain name system;
6. Diminished DDoS attacks.

More information can be found in the relevant chapters of this book.

## 6.4 The Internet of Things (IoT)

Traditional IoT systems are based on centralized architecture, where information is sent to the cloud from devices, and after processing, sent back to devices again. With billions of devices, this architecture is not

scalable while maintaining the security of data, and with the provision of third parties to authenticate data on each transaction, the system will be incredibly slow.

Blockchain is, by default, a cryptographically secured distributed ledger system which allows a secure data transaction system between different parties. Smart contracts in the blockchain network will allow devices to function securely and autonomously. It not only allows greater automation, scalability, and cheaper transfer (as there is no third party), but can also prevent data tampering by individuals who want to use the data for their own benefit. The architecture is also decentralized and cryptographically secure [14]. Moreover, with a centralized network, the risk of a single point of failure is also mitigated in the blockchain-enabled network. IOTA is an example of a blockchain-based IoT platform.

## 6.5 Cyber Physical System/Smart Grid

A cyber physical system (CPS) is a mechanism that is controlled or monitored by a computer-based algorithm, and tightly integrated with the internet and its users. As an example, we can mention any autonomous industrial production system. In such a system, the hardware, users, and software, are tightly bonded, and the following challenges are faced over time: [15]

1. Heterogeneity in devices and resources;
2. Multiple attack surface;
3. Scalability;
4. Centralization;
5. Lack of control over data sharing and lack of auditability;
6. Complex interaction of different OS, software stacks, and hardware;
7. Different implementation of security or privacy mechanism.

By integrating the great features of blockchain technology, we can provide solutions to the above-mentioned problems of any cyber physical system. The features we would like to use to solve these problems are, the distributed nature of blockchain, chronological and time stamped records, immutability, auditability, and cryptographically sealed data transfer.

## 6.6 E-governance

There is particular interest in many countries in using blockchain for e-governance, in order to reduce infrastructural and communication costs, and also to build a reliable and transparent governing system [27]. For a country where the government is trying to digitize its services, blockchain can be the most suitable option. If implemented properly, e-government can allow the citizens, organizations, and enterprises, to carry out their task properly and with a lower cost. When the government is trying to introduce new services for food or healthcare or any other sectors, the use of a blockchain is always imminent for its distributed architecture, encryption, data immutability and transparency.

Some countries face continuous threats from counterfeit drugs. The most significant reason is the lack of regulation. The drug might not be properly packaged, or it is illegally sold in independent corner markets. In such cases it is also difficult to find out whether a drug is real or counterfeit. One current solution that is being tested is government working with the pharmaceutical companies to code drug packages in such a way so that consumers can later use this code to verify whether the drug is legitimate by using text [27]. Blockchain was used to build the network for this communication.

Kenya and Ghana are trying to apply blockchain to keep trace of their land records. Another land record keeping system has been implemented successfully in Georgia. Estonia has applied blockchain technology for business registration, e-health records, and other applications. Dubai has three pillars of government efficiency, industry creation, and international blockchain leadership, as part of its Smart Dubai initiative, and recently incorporated blockchain as part of its online payment portal, DubaiPay.

## 6.7 Education

It is a common belief that blockchain is only associated with providing security to any particular network. However, now we have explored other fields which can also utilize the benefits of this technology. Education is an equally important sector, comparable to the others discussed, which also uses blockchain. Editech is quickly growing, with the expectation of reaching a net worth of $93.76 billion by 2020. [28] Blockchain technology can formulate an entire transcript for a student. [30]

Duan et al. proposed a blockchain technology based on learning outcomes. [29] This technology is dependent on the graduation requirement index of the university with professional certification, and uses automated evaluation software as a tool. The records of each block are: the learning outcome, value, qualitative and quantitative combination of grades, process and evidence, the course name, the learning outcome name, and the weight of the course. Later, these records are used to convert the result of the students, according to the traditional grading system, into a capability index evaluation result. The University of Nicosia uses blockchain to manage all student certificates received from MOOC platforms [31].

Sony Global Education created a global platform to store information related to different degrees in one place [32]. One other most important application of blockchain is to store the information of students who have passed, carefully. Since it provides a large repository data along with efficient security, data can be saved and retrieved whenever required.

## 6.8 Crowd funding

Projects like Weifund are looking for ways to implement a crowd funding system using blockchain [34]. The main idea is that the decentralized nature of blockchain allows for the creation of multiple smart contract templates for launching individual contracts. Users can also create their own campaigns. By using smart contracts, two communicating parties can securely and easily transfer information and money amongst each other, without the involvement of any third parties.

## 6.9 Sports

In Sam Mire, "Blockchain for the Sports Industry: 11 Possible Use Cases"(2019), [36] some statistics are given. These suggest that, in 2018, attendance at major baseball games dropped by 8.6% of the rate achieved in 2017. The national football league also faced a 2% decline in annual attendance and a 10% decline in ratings. However, there was sharp increase in e-sport, where humans compete through digital, video, or game representation. An annual increase of 124 million viewers is expected between 2016 and 2020. This is a clear indication of generational differences, and decision makers for the traditional sports market must find ways to make clubs, athletes, leagues, and individual match outcomes, more attractive, keeping the venue experience affordable. Blockchain can

be one possible solution, through live sports betting and fantasy sports platforms. Other uses of blockchain include transparent reputation management for teams, leagues, and individual athletes, and a general reduction in middlemen, through automation, to make match attendance more affordable. Some applications are as follows:

- Tokenizing athletes – Through this technique, blockchain is used to invest in low-earning baseball players who agree to share an amount of their future earnings with the investors. This technique was introduced through the Big League advance, by Michael Schwime [36].

- Smart tickets to end scalping – The increase of e-ticketing systems has shown an increase in the number of online ticket vendors. This led to the selling of fake tickets. As a solution to this, blockchain was introduced, to bring all the authentic ticket-selling vendors together in one place, so that users can easily buy tickets from trusted sources.
- Decentralizing ticket resale/sharing – There are policies to return 100% of the money used to buy tickets, if someone does not receive them in time. However this will not alter the experience of watching a live game. Reasons for the tickets failing to reach the buyer on time can be transportation delays, or the purchase of tickets just a few days before the game. As a solution to this, blockchain can be used to deliver copies of smart tickets whenever they are bought.

- Recording and sharing performance data properly – Since blockchain is a reserve of data, it can be used to record data from different matches, which can later be used to provide various insights. These insights can be how a player performed in a match, and, based on other factors, what improvements can be made to performance. Also what the possible playing strategy might be to help a team win a match.

- Decentralizing the payment procedure of Fantasy Sport participants – Since this requires an online transaction, providing security is a difficult task. As Sam Mire notes, “The industry is pegged at roughly $7.22 billion in total, including money spent on ancillary activities, such as draft parties, food deliveries, fantasy-related memorabilia, etc. Offices, schoolyards, and group chats have all

become the domain of fantasy sports players, who enjoy the competition amongst friends, and the ability to make virtually every game more interesting" [36]. As a result, providing security for transactions is important, and blockchain can be used as a solution.

## 7. Opportunities and Challenges

Blockchain technology has a lot of opportunities and potential in every service which involves data and transactions of data. This is not limited to FinTech industries, banks, E-commerce, mobile commerce, cloud data services, end-to-end messaging services, data analytics, the internet of things, healthcare industries, medical data sharing infrastructures, and cyber physical systems. Besides these mentioned fields, we have witnessed other, different, implementations of blockchain technology. Blockchain also creates several new employment positions in industry, as follows:

- Blockchain Developer – The responsibilities are mainly comprised of designing, implementing and supporting a network that will be developed using blockchain through the various stages of production and development. There will also be other tasks that will include analysis of requirements, blockchain technology design around a certain business model, researching new technical solutions and protocols, creating and automating blockchain development workflows, implementing test-driven development practices, and building and launching a blockchain network.

- Blockchain Engineer – The blockchain engineer works on creating blockchain infrastructure, building end products on top of it, and developing meta transaction infrastructure using mobile applications, as well as development around document-signing frameworks and associated infrastructure, and development of APIs that interface with the blockchain.

- Blockchain Platform Engineer – The blockchain platform engineer provides expertise and development support to blockchain initiatives throughout the company, and develops subject matter expertise on blockchain network platforms, architectures, and administrative/operational requirements. He/she designs and builds