Applications of Blockchain in Various Domains

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Chapter 1
Applications of Blockchain in Various Domains

Jishnu Bhardwaj, Raunak Negi, Preeti Nagrath, and Mamta Mittal

1.1 Introduction

Blockchain [1], mostly referred to as the foundation technology behind Bitcoin [2], is one of the emerging automations in the market luring a lot of recognition from firms, startups, and the media. Blockchain has the possibility to alter numerous industries and make procedures more democratic, safe, clear, and effective.

With huge amounts of data getting processed every day due to digitization of documents, it becomes very essential for every institution to efficiently command the security menaces and acquire significant cost efficiencies. Now this is the point where blockchain technology, with its promise of redistributed possession and unchangeable and cryptographic [3] security of evidence, is catching the eye of the C-suite directors. Financial people are the first ones to take advantage of this technology even though it is still at an early stage. A recent study published by the World Economic Forum [1] has predicted that banks and governments around the globe are at ease to examine and experiment numerous blockchain templates.

With as many as 90 central banks [4] involved in blockchain discussions all over the globe, around 2500 patents [4] have been filed over the last few years and around 80% of the banks have started the Distributed Ledger Technology (DLT) projects [5]. The blockchain technology is on its way to become the new dominant force in the world.

In this chapter, we explicate the uses and applications of blockchain [2] technology.

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1.2 Related Works

Blockchain technology is finding its applications in almost all-important areas of the industry, and hence it has been a center of attraction for a lot of R&D. Over the last few years, it has been observed that the blockchain ecosystem has been booming, and there have been a lot of key concepts in the field of blockchain, dispersive applications, and digital identity-based financial exchanges. The previous and ongoing researches focus on the key concepts of the aforementioned, such as decentralized applications, Ethereum, smart contracts, blockchain-based identities, and dispersive autonomous organizations, and the other applications are discussed below.

1.3 Introduction to Blockchain

1.3.1 Blocks and Hashes

"Blocks" are the digital containers in which blockchain transactions are stored. Each block that has been created is linked to its parent block via hashes which are also referred to as unique digital fingerprints. These hashes are imprinted in the form of a header at the topmost part of each block. The history of all the transactions that are contained on the blocks is then linked back to the "genesis" block. The data stored in these blocks are completely secure and cannot be tampered with even by the person who has created these blocks. This procedure is done by the non-dependent nodes that come to a dispersed agreement for every transaction that has been made [6] (Fig. 1.1).

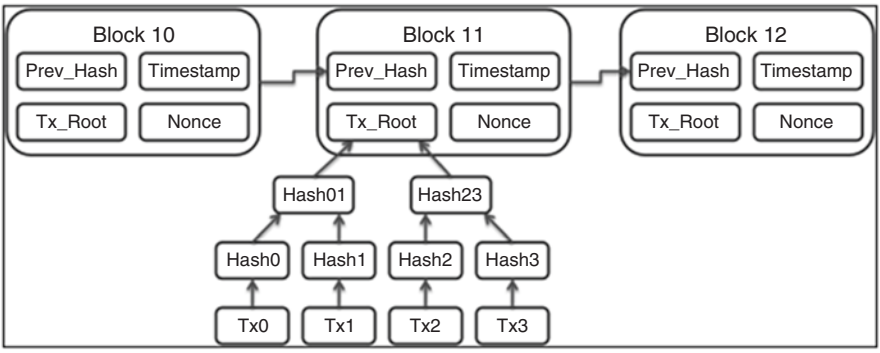

Fig. 1.1 Blockchain hashing algorithm [7]

1.3.2 Keys, Tokens, and Transactions

The prime concern of blockchain phenomenon is the strategy of ownership and its capacity of allocation of digital tokens to other users. The credit of this accomplishment is through an expertise called "public key cryptography." Here two keys are available – public and private keys. These keys are actually preserved in a convenient database called wallet. A publically exchangeable address for the user depicted by a unique string of numbers and letters is generated by public key. The public key is signed by a private key to produce a unique digital signature. Transaction on the network is done by the submission of this signature. The units of this account are the digital tokens and are used in keeping a track of blockchain [8]. Rules created by designers inspire different blockchain systems to have separate supply of tokens that function in accordance to its designs. Globally, companies charge for doing business on different digital tokens – either with each other or with governmental currencies. The innovative discovery of digital value exchange is its idea of reflection of two primary sources of weaknesses or susceptibility in traditional means of value exchanges:

1. Requiring an outside organization to confirm payments, verify contracts, and authorize settlements involving more than two parties [9]
2. Allowing different, and potentially conflicting, transaction records to be stored by the transacting parties and allowing for each record to be subject to alteration

The above mentioned problems/events are taken care by blockchain protocols and protected by advanced cryptographic features that are sometimes not valid through earlier protocols. Thus, prolonged decentralization and the use of distributed ledgers have affected advanced consensus mechanisms and created a huge system of availability, efficiency, and competency [10] (Fig. 1.2).

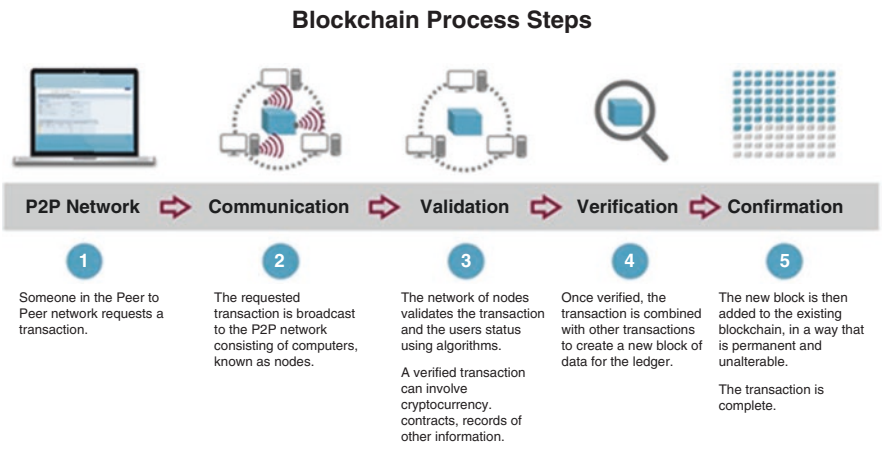

Fig. 1.2 Step-by-step transaction process [1]

1.4 Bitcoin: Introduction

The three largest cryptocurrencies in today's global market are Bitcoin, Ripple, and Ethereum. These cryptocurrencies are also the largest blockchain systems, since blockchain is the primary technology that allows them to function [11]. In this chapter, we will talk about the largest cryptocurrency of the three, that is, Bitcoin. The initial researches on Bitcoin began in the early 2008 and the first breakthrough was the publication of the white paper "Bitcoin: A Peer to-Peer Electronic Cash System" by an unknown person under the alias Satoshi Nakamoto [12]. He describes Bitcoin as the first "peer-to-peer version of digital cash" that allows payments to be sent in a cryptographic format from one person/organization to the other without the fear of it being hacked. More importantly, Nakamoto's idea represented the initial solution to the "Byzantine General's Problem" [13]. It was considered as a respected digital puzzle that was believed to be unsolvable before Bitcoin came into existence. It revolves around the fact that a group of non-trusted independent actors need to verify a given scenario.

Bitcoin is easily able to solve this issue by introducing the concept of "Proof-of-Work" (POW) chain which makes it necessary for third-party mediators to verify themselves and prove that they are solving difficult problems in a small amount of time. Computational power of each node determines the proof of work of the network. Transactions between two parties are verified without the intervention of a third party. In simpler words we can say that POW is a complex, expensive, and time-consuming task to incorporate but easy for others to verify. To understand this better let us use an example.

Previously it was stated that hashing the document consists of performing a daunting operation to the numbers, such as adding or multiplying. As long as the nodes on the network all verify, there is an agreement. If billions of nodes on the network show up, and one node produces the hash, that particular node would be altered as per the harmonious mechanism. So, it is next to impossible to tell what the original numbers were [14] (Fig. 1.3).

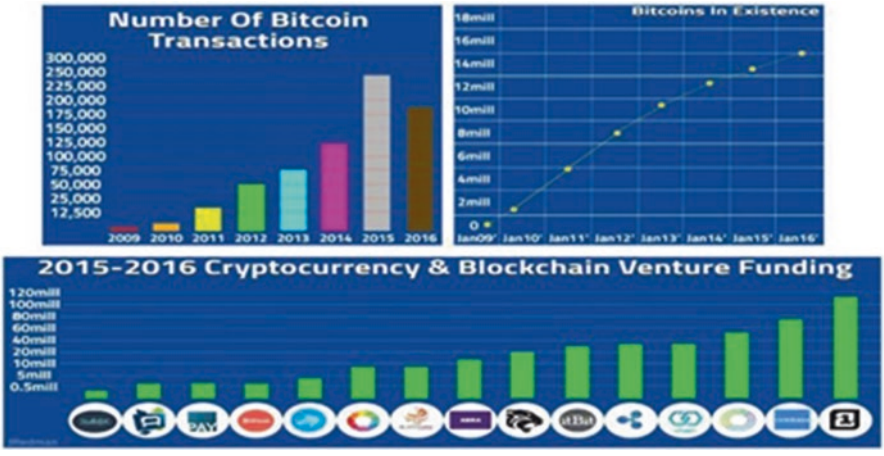

Fig. 1.3 Graphical representation of transactions made using Bitcoin [7]

1.5 Blockchain in Finance Services

In today's world, blockchain technology is of a very good use in looking after finance arrangements for the banks. Under this technology, all the important files such as a goods shipping bill and tax tally can be recorded in a concentrated depository where all the concerned parties involved can control the data in real time.

One great example of this is the Ethereum blockchain [15] which sanctions more comprehensive and secure business channels and well-organized processes and lessened costs in trading and finance. It enables digitalized [1] trade to take place within a less time period, at no extra cost, with greater levels of adaptation.

Its advantages are as follows:

- *Dependability*: Its varied planning removes the points of single failure and also gets rid of the need for data mediators such as transfer representatives and communication system employees. It also ensures to enable secure [2] application code which has been designated to be hack-proof against venomous third parties – which makes it nearly impossible to hack.
- *Lucidity*: It adopts high standards and agreements acting as the only shared origin of truth for system participants.
- *Reliability*: Its dependable archives make the job simpler for various parties in a business channel to cooperate and direct data.
- *Programmability*: It helps in the creation and implementation of computerized contracts – hack-proof, digital software [3] that helps the business logic – creating increased reliability and effectiveness.
- *Seclusion*: It provides tools that are leading in the market for granular data privacy across all the available softwares, allowing careful sharing of data in business communication channels. This dramatically improves dependability, reliability, and effectiveness while maintaining confidentiality.
- *Performance*: Its private channels are maneuvered to sustain many financial agreements per second and a time to time flow in network activity.
- *Extensibility*: It acts as a mediator between private and public chains [1] and offers each enterprise the global reach and high coherence.

1.5.1 Ethereum

Ethereum is a dispersive platform that allows us to implement extra Distributed Applications or DApps [7]. The DApps are written with smart contracts. The implementation of one or more intelligent contracts can form a DApp. An intelligent contract will run exactly as planned, without any pause, restriction, tampering, and interference by third parties.

Figure 1.4 represents the structure of Ethereum blockchain.

One of the most significant advantages of using Ethereum blockchain to run smart contracts is that it allows the interaction between two and more smart

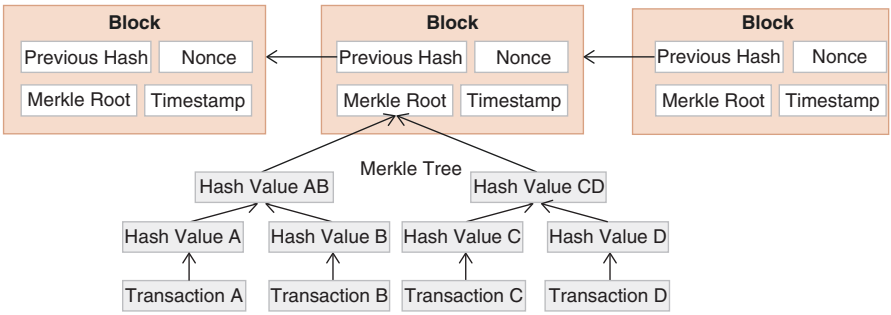

Fig. 1.4 Ethereum block structure. (From "Blockchain Platform for Industrial Internet of Things," Arshdeep Bahga, Vijay Madisetti, 2016)

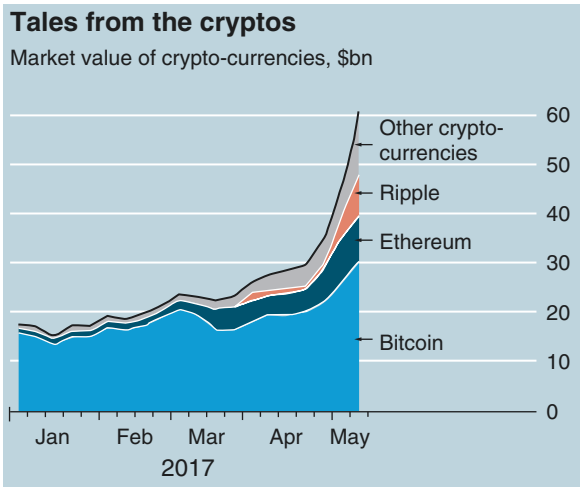

Fig. 1.5 Comparison between Ethereum and Bitcoin. (From CoinMarketCap, *The Economist*)

contracts. Integrating the agreement protocol and other things is already taken cared of beforehand, only the logic of the application needs to be written and executed, DApps cannot be created with Ethereum blockchain, and only those types of DApp can be created whose functions are supported by Ethereum. The internal currency of Ethereum is called Ether. To implement intelligent contracts, Ether is needed. The total market value observed for different types of cryptocurrencies along with Ethereum until May 2017 is presented in Fig. 1.5. Ethereum's total market value is about $35 billion as represented in the figure.

1.5.2 Smart Contract

A smart contract is a dependable entity as it carries out tasks accurately without any possibility of downtime, restrictions, trickery, and intrusion by third parties. A contract contains variables, functions, function modifiers, events, structures, and enumerations. They also support inheritance. Inheritance is implemented in a contract by copying the code at compile time. Some smart contracts also support polymorphism, i.e., "Serpent" or "solidity" is used to write a smart contract. Once the code is written, either Mist or Ethereum wallet (which was developed by the Ethereum Foundation) can be used to deploy it in blockchain. These smart contracts can store data, send and verify transactions, and interact with other contracts.

1.5.3 Decentralized Autonomous Organization

Blockchain technology along with Ethereum smart contract can together be deployed to unleash an immense variety of decentralized applications or DApps, such as a decentralized storage system, exclusive cryptocurrency, and Decentralized Autonomous Organization (DAO) [7]. Availability of exclusive version of cryptocurrency can essentially be deployed to address a variety of the internal functionalities of different companies. More than 30 decentralized human-less venture capital platforms are specially provided by DAO for investors who wish to invest. The investment is decentralized and distributed. Figure 1.6 describes the role of DAOs in the decentralized ecosystem. The DAO acts as a link between the blockchain, the

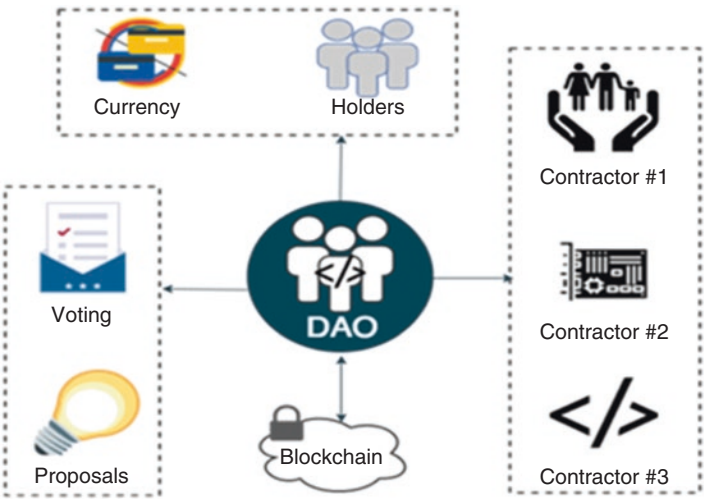

Fig. 1.6 Role of DAO in a decentralized system. (From https://blog.codecentric.de/en/2017/09/decentralized-autonomous-organization-blockchain/)

currency holders, the administrators with voting rights and proposals, and the contractors, as shown pictorially in the figure below.

Efficient hardware utilization is achieved using a file storage which has a decentralized structure, which promotes users to rent unused or stagnant data drives. WeiFund and uPort are examples of such platforms. WeiFund promotes crowdfunding in Ethereum and uses smart contracts to establish an open platform. uPort provides for users to exercise total control over their identity, and no institutions or authorities are involved.

1.6 Application of Financial Trade Services

1.6.1 Central Bank Digital Currency [16]

A Central Bank Digital Currency (CBDC) [16] is the digital form of money kept in a central bank, which is the legal compassionate created and backed by a central bank. CBDC is managed through a centralized archive [5], thus tripling the security of transactions between banks and individuals. A recent study that was conducted by the bank stated that more than 70% of organizations are actively developing proofs of concept for the CBDCs. Aspects that define a Central Bank Digital Currency are as follows:

- *Digital aid*: CBDCs are considered to be centralized digital assets and are considered as the only source of truth.
- *Central bank backed*: CBDC represents the public's claims legally.
- *Central bank operated*: The supply of CBDC is fully controlled by the central bank.

Some features of this digital currency are as follows: [17]

- *Trust*: A blockchain-based CBDC system enables central banks to control the flow of currency and at the same time protect the privacy of the CBDC's use to the end users.
- *Programmability*: CBDC is able to restrict third-party access to the information. This feature comes in handy while protecting the user's data.
- *Availability*: Distributed systems such as blockchains ensure that data is made available to its users in addition to developing trust and transparency around transactions. Ethereum has proven to be a good example in this case.
- *New Developments*: A blockchain-based CBDC benefits from the creative products and services that are being developed across the blockchain ecosystem, including unguarded wallets, no knowledge of cryptography, and dispersed transactions (Fig. 1.7).

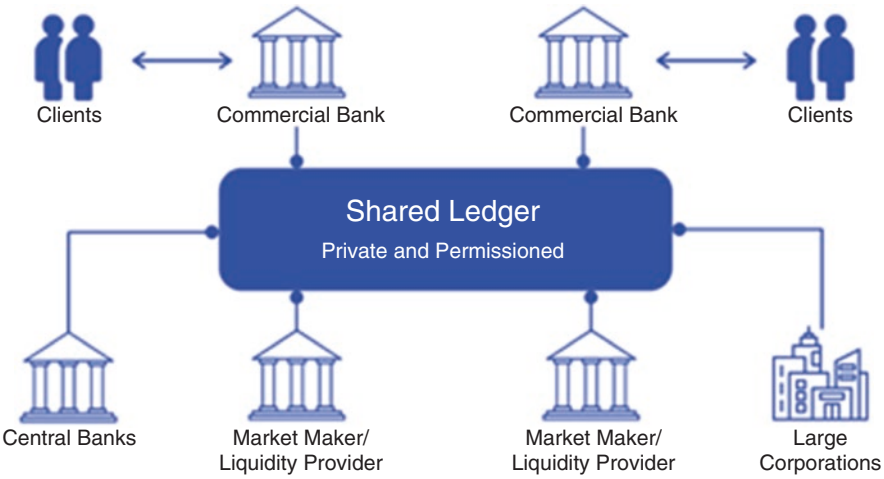

Fig. 1.7 Central Bank Digital Currency [18]]

1.6.2 Codefi Payments [19]

Codefi Payments offers a suite of blockchain-based payment solutions designed to make global transactions faster and more secure. It allows the businesses to easily accept cryptocurrency payments and also supports the commonly adopted payment structures that include invoicing, checkouts, etc.

1.6.2.1 Payment Plans

The product is registered with one or more subscription plans.

1.6.2.2 Automated Smart Contracts

Payments are accepted and tested using smart contracts directly from the Codefi Payments interface.

1.6.2.3 Integrate with the Software

A person needs to choose from three integration options:

Sending a payment link or email to the customers directing them to a Codefi-hosted payment page.
Install the Codefi pay widget and create a custom interface using API.

1.6.3 Trade Finance

Trade finance is the funding of the international business chain. The finance industry thrives on paper-based procedure which is more exposed to security threats. Single negotiations can take up to 90–120 days in order to process the letter of acknowledgment, substantiate documents, and demonstrate reliance among collaborators. Blockchain can digitize the entire trade finance cycle with increased security and effectiveness. It enables more clear administration, decreased clarifying times, low money requirements and decreased risks of trickery, human mistakes, and counterparty risk [20].

It allows the following:

- Digitized and genuine attestation and KYC/AML data with instantaneous verification of financial assets
- Digitization of assets enables quick settlements
- Production of more effective financial structures through secure systems and digitized processes
- Production of a harmonious financing vehicle for the entire trade cycle, which eliminates the legal practice of dealing with independent finance vehicles for each stage of the trade [21]

1.7 Blockchain in Healthcare

There has been a thorough and comprehensive study of blockchain ever since its introduction via Bitcoin [1]. It mainly focuses on the nonmonetary or nonfinancial cases, but it has been observed that healthcare and its services is one of the few industries on which blockchain is anticipated to have serious effects and consequences.

Research in this sector has been fairly recent but is rapidly increasing, leading to health informatics and researchers in the path of struggling, having difficulty to keep up with the speed of research progress in this sector. The approach here is based on the PRISMA policy [22] and guidelines along with an organized mapping study, where well-thought-out search protocols are used to explore scientific databases, for determining, extracting, and evaluating every relevant and suitable publication. Numerous studies have shown different applications of blockchain in the healthcare sector, but there is a shortage of sufficient model execution and research to describe, identify, and interpret the potency of these described cases. Growth of blockchain applications in healthcare, limitations they pose, and possible areas of growth have been discussed briefly in this section. Hence, more research is required in order to better comprehend, describe, and evaluate the usefulness of blockchain in the healthcare industry (Fig. 1.8).

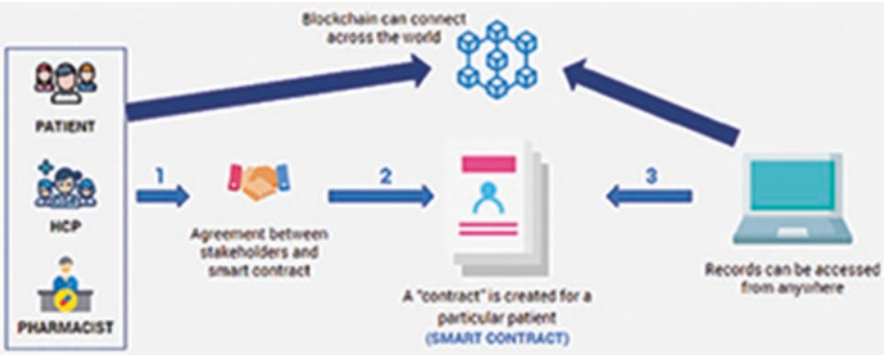

Fig. 1.8 Data flow in blockchain-powered healthcare systems [23]

Taking our first step in methodical mapping study, we circumscribe the given research questions in order to unscramble the cutting-edge research on blockchain technology in healthcare.

1.7.1 Applications and Real-World Cases of Blockchain

The essential question here is to grasp various parts and sections of healthcare that blockchain has been implementing. By reviewing and screening the relative articles from scientific databases, recognition of healthcare problems of blockchain with their possible solutions can be determined, which can be followed by isolating and dividing those problems that are resolved and settled better using other approaches, techniques, and means. An outline of problem territory in healthcare where blockchains are applicable helps the researchers, analysts, and professionals to emphasize their interests and theories to those bright areas of this technology's application.

1.7.2 Prepared Blockchain Models Based on Identified Real-World Applications

In the fields of scientific works and literature, there are several areas of application of blockchain. However, when talking about working prototypes, not all of these suggestions have been rendered and executed. It is, hence, important to comprehend the degree of usage scenarios of implementing blockchain-based healthcare applications. This helps us draw our attention to the sections and areas in which there exist research holes and the need to transform research focus to these affected zones and sections.

1.8 Applications in Healthcare

After screening and preliminary examination of some of the papers, one or more than one situation of some of the identified block use cases was addressed by the papers, we decided to discuss them [23].

Some of the major areas of discussion are as follows.

1.8.1 Electronic Medical Records

One popular real-world application of blockchain in the health department is the managing of Electronic Medical Records [24], abbreviated for EMR. EMRs, used exchangeably with Personal Health Records "PHRs" [25] or Electronic Health Records "EHRs" [26], are associated with electronic formation, warehousing, and administration of the user's (patient's) health, personal, or medical-related data.

The major properties and characteristics of blockchain, which include decentralization, constancy, dependability, sturdiness, data protection and secrecy, make it a hallmark for stocking, managing, and administrating patient's Electronic Medical Records or "EMR."

The European General Data Protection Regulation or "GDPR" [27] is a regulation in European Union, which forbids the access of delicate data of patients they explicitly give their permission. Blockchain is widely proposed as a doable technology too, since it is consistent with "GDPR" and gives the users full control and authority over their data.

1.8.2 Pharmaceutical Supply

Talking particularly about the pharmaceutical industry, another real-world application of blockchain is in health supply chain management [28]. Since delivery and supply of fraudulent and forged medicines can have ghastly conclusions for the patient, it is still a usual challenge faced by the drug industry.

To address this problem, blockchain has been found having the capability. There are some companies that are working detecting prescription drug deception via blockchain, as mentioned by Engelhardt [29], in his examination. Nuco and HealthChainRx are some of the mentioned companies [29]. The concept is recording all the transactions which are related to the drug prescriptions on a blockchain network, where all the interested parties such as producers, distributors, doctors, patients, etc are linked. In case of any modification or malicious adjustment of the prescription by stakeholder parties, it can be identified.

1.8.3 Biomedical Research and Education

In the case of the biomedical department, blockchain has a very intriguing application. Elimination of false data and exclusion of undesirable results in the research can be achieved by blockchain. The anonymity of users in blockchain, which is its inherent property, helps patients grant the authorization and approval for their data to be utilized for clinical studies and experiments. Moreover, the immutable property guarantees the data integrity.

This clear and open nature of blockchain technology makes it easier to replicate and reproduce research from the blockchain data. This is why it is expected that blockchain would surely revolutionize the biomedical research department.

1.8.4 Health Data Analytics or "HDA"

Blockchain technology offers an opportunity to utilize and exploit the emerging technologies. Accomplishing predictive analytics of data and progressing research in medicine is now achievable by powerful techniques of deep learning and transfer learning [30]. A research, conducted by Juneja and Marefat, looks for ways in which blockchain is used in a deep-learning architecture for arrhythmia classification [31].

1.8.5 Protecting and Ensuring Patient Data

One of the most important qualities and aspects of using blockchain technology in the health department is to keep our medical data safe and protected. Security has been a major issue in this industry. Between 2009 and 2017, more than 176 million patient records have been exposed in data infringement and leaks [32, 33]. The violators and hackers stole important information like credit card and banking details, along with health and genomic testing records.

Blockchain, with its ability and power to preserve a trustworthy, decentralized, and transparent log of patient data, proves itself as a powerful technology for security cases. In order to protect the delicate and sensitive medical data, blockchain masks out the identity of the individual user via complicated and secure codes, making it a powerful combination of being transparent and private. This noncentralized kind of the technology enables healthcare service providers, doctors, and patients to exchange the information efficiently and safely (Fig. 1.9).

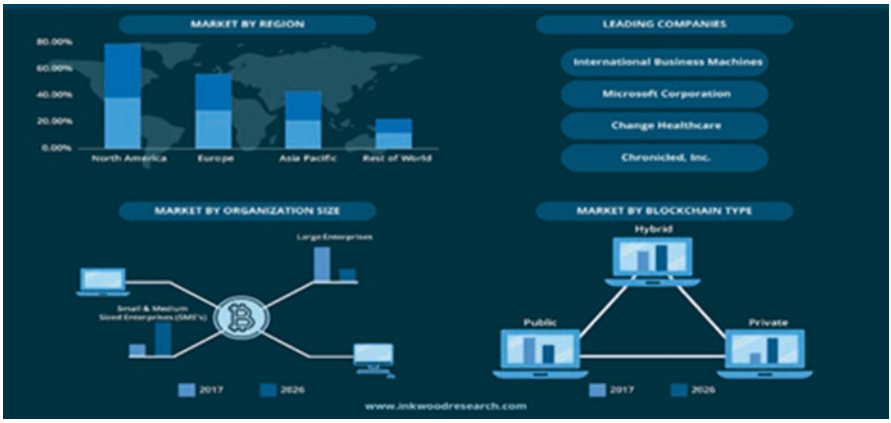

Fig. 1.9 Statistical forecast of blockchain in healthcare market [32]

1.9 Blockchain in Architecture

In the current scenario, construction engineering faces countless challenges and problems in regard to confidence, information sharing, and automation process to name some. We know blockchain is a decentralized operation and information management technology, gathering more and more interest from academic as well as industrial aspects [34]. Despite that, a large portion of the current research, practices, and usages are concentrated on blockchain itself (technical issues and limitations) or its applications in financial service sectors like Bitcoin [1] as discussed above.

The possibility and capacity of blockchain applications in the construction sector is our main aim in this section. Looking at the possibilities, the three types of applications that are enabled by blockchain are as follows:

1. Enhancing current processes of contract management
2. Management of supply chain
3. Leasing of equipments

The construction industry has been regarded as one of the world's most disconnected and high impact sectors. The infrastructure and framework projects all over the globe have highly fragmented, diffused, and sophisticated supply networks. Crossrail project [35], London, is a great example to represent this phenomenon.

In order to handle such an expanded supply chain, monitor of work in progress, schedule and register costs and payments, colossal action, and resources are necessary. Not limited to this, construction projects encounter various types of mistakes, blunders, postponement, and crashes at various levels and degrees. The lack of responsibility and accountability in this business has been a problem for ages, along with highly tight profit margins. Firms find ways to cut costs and try to dodge and shift blames, faults, and charges from the consequent failures. This is where blockchain can help us to make such procedures more competent, transparent, productive, and accountable.

Enhancing project management, providing a reliable database, computerizing of processes and documentation, and acting as a record book for legislative or regulatory concerns are some of the examples of main use cases of blockchain in the construction and building industry. Some of the possible blockchain applications have already been introduced and had an effect on the economy. A couple of these applications can be either straight away applied to the construction industry or serve as a basis for custom applications in capital construction [36, 37].

1.10 Applications in Architecture

1.10.1 Automated Ledger for Subcontractors

The usual step for acquisition of the building starts with a client, then its consultants, and the main contractor. The main contractor further undertakes subcontractors for carrying out all the specialized works, which generally vary from masonry to carpentry to painting. Several brokers and middlemen sit between the client and the final outcome.

Tracking of these middlemen and subordinates, with their tasks, has proven to be a hurdle. Regular checking and tracking of the amount of materials and equipment required, the clearance of access to the building, the deadlines, and checking of working hours of labor and other masonries are all tedious tasks.

An "automated ledger" [38] can potentially serve as a way to overcome all the obstacles mentioned above. This will make it easier to keep track of the construction and also to identify reliable subcontractors for a project, representing a subject-matter-of-the-contract relationship.

1.10.2 "Smart Contracts" to Initiate Milestones

One of blockchain's most well-known applications, "smart contract" [39], is being extended to different industries including construction. Automation of contractual operation and paperwork can be done by putting smart contracts in place, which saves money, frees up valuable resources, and makes project delivery efficient.

These contracts can be established at different levels and layers of the construction meshwork, from management of the building to the payment process. Clients and managers are able to track building processes and identify the people accountable for these processes because the contract is only activated when a task, set beforehand, is completed. It can also be used as a milestone-based payment network, which will generate computerized agreements, hence creating an verifiable record of operations.

1.10.3 Decentralizing Automated Organization

Groups of "smart contracts" can be utilized for creating a DAO [40], or "Decentralizing Automated Organization." It is a system which is run via rules encrypted as computer programs utilizing smart contracts. The integration of blockchain and the Building Automation System [41] (BAS) allows building's DAO, for example, to place an order for something like new fan fitting, accept the delivery and take responsibility for it, get some individual for its installation, and pay the supplier as well as the installer.

This DOA's wallet, which is linked to the wallets of those individuals who live in the building, is used for making payments. Collection of rents, corporate and enterprise fees, insurance installments, etc., are all within the reach and autonomously managed by the company's DAO.

Besides the code, the DAOs do not have a hierarchical framework and arrangement. For its construction phase, it requires human input to set the conditions and makes decisions to meet those requirements, which can include light fitting, paint color, maximum speed, etc. These requirements are met and decisions are made by starting a series of if/then that uses bundles of interlinked smart contracts carried out between customer and different members of the project personnel, main contractor, etc. [42]. DAOs are open source, hence transparent and incorruptible, in theory at least.

1.10.4 Life Cycle Ledger

In case of applications going beyond smart contracts, blockchain technology is particularly useful. It has the ability to work as a ledger to preserve a report of the construction process from one extreme to the other and record the blockchain information which can be cited back to when needed. For enterprise servicing, renovation, and regulatory conformity, it proves to be especially useful.

In a similar way, the ledger can store warranties and validations. Due to its nature, it can protect the construction process from tampering and fraud. This is because trials and outcomes can be stored, trailed, and traced on the blockchain, enabling easy comparison to building codes and requirements, along with streamlining audits throughout and following the construction period. In the post-construction phase, ledgers can be used for keeping records of developments in the life cycle of the building. It is a potent tool for enhancing operations and optimizing institute capacity to pinpoint and exchange (occasionally huge amounts) data with the individuals and agencies.

1.10.5 The Management of Data

Blockchain as a service can be of special importance, in situations where the technology provides a communication podium between different users, enabling them to manage the performance of their tasks in an efficient manner. It has the ability to permit tracing of data, boost decision-making procedures, and cut down the waiting time in transmission [43, 44].

1.11 Voting

Recently, many countries have begun using electronic voting systems or EVS. The first attempt in the world was made by Estonia [45] for voting in its national elections [46]. The voting was done via the Internet and a national identification card. This card is utilized for authentication, encryption, and signatures. Using the given electronic ID for verification, the voter downloads the voting application, and if eligible, a series of candidates would appear on user's screen and the vote was casted. This was followed by Switzerland adopting the same strategy for its state polls. In order to compete against conventional and customary ballot systems, the electronic voting had to have some support by being safe, reliable, and anonymous in nature. The security in this system had to be tight and impervious to protect the voters from any external interference and prevent any alteration or recasting of the given vote. Tor is one such browser, often used for deep-web services, to hide the security and implement the anonymity of the voters.

However, there are several drawbacks:

1. Politics in manufacturing: Taking into account the given political scenario, companies which produce these electronic voting machines could have manufactured them to "favor" the current ruling party. High scrutiny and quality checks will be required to overcome this.
2. Accuracy in recording intended votes: In case of breaking or misalignment of the touchscreen voting systems while its transportation or loading/unloading, the machines might misread or misinterpret the voter's purpose. For example, a user who wanted to vote for candidate B might vote for candidate A due to described problems. Such discrepancies on a large scale can lead to unfortunate and terrible outcomes.
3. Fraud: In all the major countries, there are countless claims and proclamations of fraud by the losing parties, in different levels and increments. Millions of votes can be easily nullified or falsified, if the voting machine created and dispersed by one vendor to different polling booths turns out to be dishonest and malicious in nature [47].
4. Hacking: The machine manufacturers and election jurisdictions usually claim to not broadcast and relay the poll results from different precincts via the Internet,

but this does not stop them from transmitting results via direct LAN connection, via VPN [48] (Virtual Private Network) or by other similar means.

Hence, in order to overcome all these drawbacks, the idea in BEV, or "Blockchain-Enabled Voting," is simple. Explaining this structure in terms of current currency analogy, each user or "voter" is given a one vote or "coin." The credentials and other related information of the user are stored in the "wallet." When a user votes for a certain candidate, this coin is transferred from the user's wallet to the candidate's wallet. The coin is issued only once to prevent repetition of votes. However, the users are given the choice to modify their casted vote before a defined deadline [49].

Therefore, we can imagine that this way blockchain addresses two of the most universal concerns in voting today: voter access and voter fraud.

By using a smartphone or desktop/laptop, blockchain provides an encoded key and immutable personal IDs, which entitles voters to vote anonymously. A mobile-based Boston startup, Voatz [50], is an e-voting platform which employs instant verification and biometrics. An everlasting, unbending record is established when the public ledger binds an individual user, or in this case, voter, to each ballot. With the peer-to-peer network, no one can engage in nefarious activities, and if they do so, they are corrected or evident on the ledger. Hackers would need to hack the blocks where the transaction records are stored, before the introduction of any new blocks.

In order to provide permanence and prevent illegal or false addition, all the given votes are controlled, verified, and monitored by blockchain. The mobile phone version of this startup was tested during events such as student government elections, church group, non-profit organization, union voting, and subnational political party events. For town meetings in Massachusetts, this system was also used. Russia is another example of blockchain voting. The city of Moscow's Active Citizen program [51] was launched in 2014 and has more than two million users (Fig. 1.10).

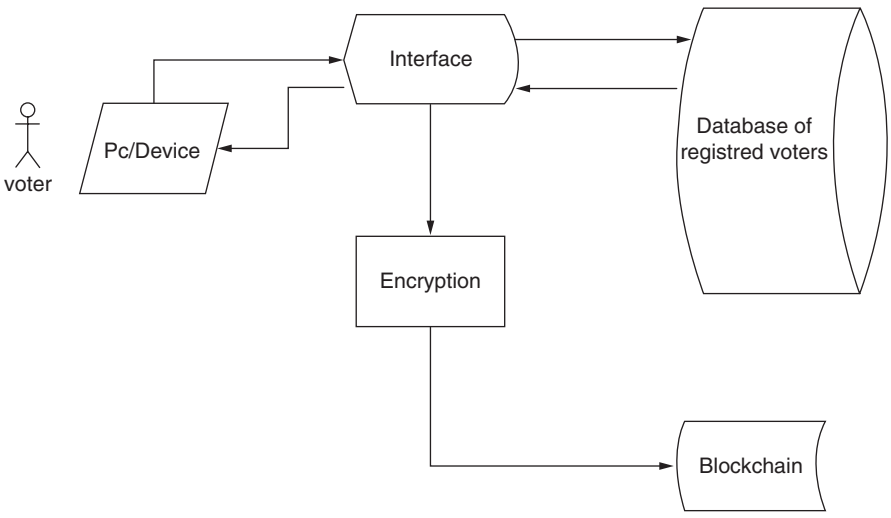

Fig. 1.10 Representation of the e-voting system [51, 52]

1.11.1 Opportunities and Benefits

1. The voting records generated by blockchains are encrypted in nature in order to address falsification of votes. The manipulation of the votes becomes impossible, since they are recorded securely, transparently, and permanently. This allows open scrutiny and public review of the votes while maintaining participant's anonymity. Even though it is said that nothing is secure, hacking into these records is nearly impossible and unfeasible.
2. Participation and access to voting is likely to increase with the help of improved identity verification by BEV. BEV is shown to improve the situation, as Voatz can accept the state IDs, passports, driver license, and seven other official documents for authorization and verification of the identity of voter [50].
3. Wiping out of any ambiguities is another benefit with BEV. With greater focus on promoting greater transparency and clarity to voters, it helps in reducing any likelihood of ambiguities. For some, the current online voting procedure might seem complex. Moreover, it is difficult to figure out whether the casted vote was intended or it was counted when casted. As we have discussed above, the public and open nature of blockchain makes it auditable.
4. Processing time of the current machines is high. Since the voting machines are in different areas at the time of polling, gathering them together is a difficult and time-consuming task. This reduces the efficiency of the counting, leading to monetary issues. Introduction of blockchain can metamorphose the entire process and time consumed. The outcome of the polls can be found instantly, after the voter finishes off voting. There would not be any need for long lines and manual labor of collecting the machines.

1.11.2 Challenges

The above discussion would sound wonderful, but only in theory. In order to implement the given ideas, many hurdles need to be conquered by the institutions and stakeholders. Public confidence in the security and accuracy of this technology is another key aspect for success. The complex blockchain's model and procedures might be a hindrance to the mainstream public. Moreover, the skills of the digital user is also a concern.

The political leaders might block the introduction of blockchain, as it takes away the central authority of the electoral commissions and agencies. Transparent being in the fiber of blockchain might cause the power shift from the authorities to the public, which in the current scenario is what they will try to stop.

The software and the technology is not up to the mark in order to efficiently implement the encryption and chaining. Since encryption is an extensive method, it is time-consuming for general smartphones and computers. Feasibility and power consumption will be the prime areas to tackle in terms of hardware shortcomings.

Estimates have suggested that, on average, there are 25–50 defects per 1000 LOC. For Ethereum [53], a blockchain-based platform for distribution, used by the Active Citizen program of Moscow, the numbers are nearly double. With the scale of hacking in modern technology, it has been found that Ethereum contracts are a "piece of cake" for them [54]. Moreover, sufficient observations have not yet been collected and processed to establish the scalability and extension of blockchain-enabled voting.

There have not been enough ledger technology and blockchain-based working models to accurately judge this technology in regard to present polling systems [55]. Full and complete execution of BEV for a domestic election has not yet occurred, though it has the ability to transform the voting in the coming future.

Politics-related violence during, before, and after elections is common in Africa and other developing countries [56]. The safety and transparency, with the reduction of electoral violence, can be ensured by BEV. More accurate and honest results can be predicted. All the voting-related expenditures would decrease, as it does not involve management and maintenance from any central authority. Finally, reduction in cost of paper-based elections and increment in participation of voters is expected after total implementation of this technology.

1.12 Music

The music industry consists of many entities, ranging from artists, labels, or record companies to retailers and streaming digital service providers [57]. The birth of streaming services has given a major boost to the music industry. There has been a shift from ownership to access, and the conventional revenue route has been disrupted. Many major record labels have witnessed huge drops in sales.

Blockchain has a massive potential to alter the supply chain, even though it is still in its early days. Open Music Initiative [58], OMI, is one of the many organizations which tries to bring the industry together to clarify and elucidate the benefits of investing in this technology. It assures to return the power back to creators via a fair distribution network. Freedom for accessing the transactional information and being paid more effectively is the idea. Introduction to original and creative models by the stakeholders or creators themselves is another potential opened up via this network. This would reduce the role of brokers and middlemen, like labels and publishers, and they might have to adapt themselves in the new environment according to the power balance.

Blockchain being transparent in its process allows the musicians and creators to see exactly where their money went and how much they are owed. With the current scenario, the artists are the last person to see how much profit they have made, even though they are the first one to put any work into it. Many of them are in the dark on how their profits are calculated, in which direction the money is flowing, and how people are listening to their music. It also makes it clear who the original copyright holder is, who was involved with their content.

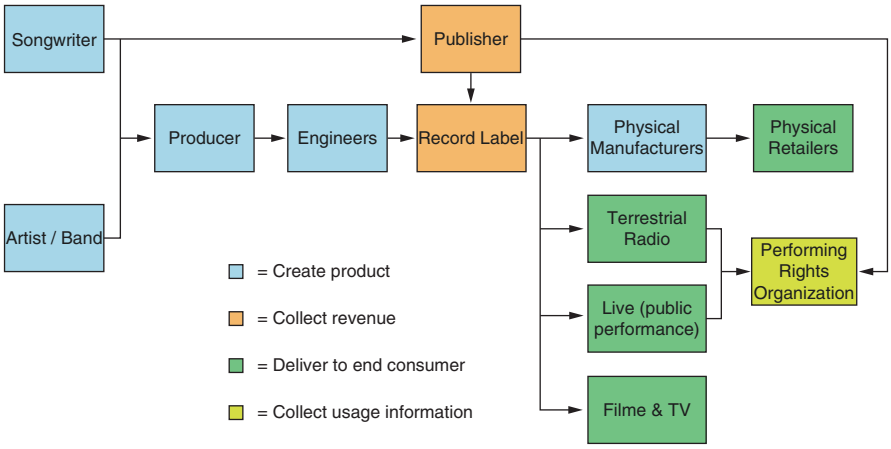

Fig. 1.11 Music supply chain before digital media [59]

No matter how excessive and bold these claims may seem to be, the power of blockchain can indeed cause a storm in the music industry. The major transformation it brings is removal of royalty payments to the middlemen and intermediaries. The establishment of a peer-to-peer network gives most of the power to the creators itself, and they are able to get the fair remuneration which they deserve (Fig. 1.11).

1.12.1 Applications

1.12.1.1 Maintaining Record

For the production of every song, the team behind it consists of lyricists, producers, engineers, and other members of the technical staff. Identification and payment process of these stakeholders for their IP usage is currently out of date. Imogen Heap [60], a London-born English songwriter, has stated, "One of the biggest problems in the industry right now is that there's no verified global registry of music creatives and their works. Attempts to build one have failed to the tune of millions of dollars over the years […]. This has become a real issue, as evidenced by the $150 million class action lawsuit that Spotify is currently wrestling with."

Just like WAV and MP3 formats, dot blockchain or ".bc" [61] was presented as a dynamic format for music files. Its main purpose was to manage the rights of the media around the world. Data like the ownership rights, payment rights, and related information was to be incorporated inside this file format. Once the creation is done, it is made available to the users after adding it to the network. Dot Blockchain Media (now known as Verifi Media) is an organization whose goal is to deliver and

provide the arrangement and structure to the artists, songwriters, melodists, audio engineers. and people in the music industry and its related fields, through open-source rules and licenses.

1.12.1.2 Smart Contracts

Using smart contracts can be game-changing to the musical industry, because of the automatic compensation to the creators and artists. Whenever a user streams or downloads a song, the payment generated is automatically sent to the stakeholder, whose information is located within these chains of network. Hence, no third-party app is required. Instant and spontaneous payment will be received by the artists as soon as they release and license their song. The information regarding the transactions will also be available for auditing and cross-processing. This information can be used for further analysis and in the field of "Data Mining" [62].

It is believed that this process is not suitable for high-frequency low-cost transactions, which is the case of streaming and music. But there are platforms that are using this method, charging the user's with cryptocurrency. The first track to generate and automatically circulate payments through smart contracts for all the involved parties was Tiny Human, composed by Imogen Heap. This song was accessible in Mycelia, which is run via Ethereum network. The currency used for transactions was Ether, which is an Ethereum cryptocurrency [63]. Even though the revenue generated at that time was not much, because of the unpopularity of blockchain applications in the general public, the fans were keen on trying out new things. This process displayed high potential in today's market.

1.12.1.3 Analysis and Model Innovation

With the information being available publicly, not only transparency increases but also allows the artists and creators to utilize this information to generate better and more robust business models. The demographics and geographic reach, preferences of the purchase of users, etc. can be easily studied and accessed by means of data mining. One such example is the popular streaming company Netflix [64], which examines and reviews millions of data generated real time by the users. This is one of the key reasons for the great success of the company. This comes under the "big-data" [65] analytics.

1.12.1.4 Revenue Management

Music, like many other industries, is a stockable good. The price of any song is variable, depending on the number of times it was streamed or downloaded in a day, the region-wise distribution it achieves, streams per person, etc. Such fluctuations and swings can vary the song value and usually increase the revenue captured by the creators.

For example, after examining the records, if one track is played more in an identified amount of time, then its price can be increased for that period of time and little less in other intervals. This allows users to either stream the song in the discount period, or other users that are not affected can still stream it at the costlier period. It helps to increase the range of the time when the song is played. Also, cuts and discounts could be given to those users who stream the given music for a given number of times. The theory of super-members and fans can be created, which would allow the users of such groups to pay less or not even pay after a given number of times.

1.12.2 Current State

Many organizations and companies can be found investing in research and the required platforms that enable appropriate and suitable functionality of blockchain. The Open Music Initiative (OMI), one of the discussed organizations, is in the works of preparing a protocol for music rights of holders and creators. The purpose is to create an API system in order to support other interested parties for designing and improvement of their own system, rather than building a database to provide a collection of such records.

Other agencies like Bittunes, Peertracks, and Voise are creating indigenous systems to allow their users to download and stream music via blockchain. For royalty payments and related stuff, companies like Revelator and Blokur are providing services in order to increase the profit and efficiency by data analysis. The given list of platforms are themselves providing streaming and downloading services, though they are in beta version.

- Musicoin
- This is a blockchain platform that enables customers to stream ad-free music from a list of standalone artists. Promising no middlemen, transparent contracts, and equitable remuneration, the platform uses Universal Basic Income or UBI model to guarantee fair compensation according to their contribution. Musicoin cryptocurrency is used for transaction of money and payments through smart contracts. Moreover, it is encouraged to tip the musicians through musicoin. The platform has plans to distribute merchandise and subscriptions to the super fans to increase the popularity and power of currency, and to connect better with its audience.
- Resonate
- Resonate is a music streaming platform with bold claims of being more affordable to its listeners in comparison to direct competitors like Spotify and Apple Music. The cooperative has a number of independent artists and labels, and its goal is to increase its popularity with the market and the users. Smart contracts are used to pay the musicians, and upon joining, musicians are paid directly through smart contracts and, consumers, as new subscribers, are given 3 hours of free streaming, after which they follow the pay-per-listen model.

- Ujo Music
- Like the discussed platforms, Ujo platform also uses cryptocurrency and smart contracts to pay their artists in accordance with "paid per song." The platform uses Ethereum for their payment system and provides free and paid streaming services.

1.13 Businesses in Blockchain

Businesses can grasp blockchains in different ways so as to gain an advantage over their rivals. They can modernize their core, eliminate extra costs, and make psychological property ownership and transactions crystal clear and automated. Companies consider applying blockchain technology in four aspects:

1.13.1 Accounting Settlement and Crowdfunding

Bitcoins can help businesses solve their problems which are related to funding. For instance, cryptocurrencies were created to fund companies who wish to implement digital payments and accounting settlements. The automation of electronic transaction management enhances the level of control of financial business execution, both internally and externally. In addition to this, blockchain technology represents an upcoming source of capital crowdfunding. The investors of major enterprises can obtain alternative entrepreneurial finance via token sales or initial coin offerings. Companies would be able to handle finance-related issues more flexibly by dealing in digital currencies that are based on blockchain technology.

1.13.2 Information Sharing

Data is the most valuable resource and it plays a vital role in every enterprise. Blockchain provides reliable storage facilities and efficient usage of data. As a dispersed and secure ledger, this technology can be used to tackle digital assets for several companies in different capacities. Decentralized data storage refers to the fact that data is not given to a centralized agency but instead to people across the globe because they would be able to tamper with the data. At the same time, blockchain also supports data sharing.

1.13.3 Supply Chain Management

The desire to significantly improve the supply chain management can be achieved by blockchain technology. Recent advancements of the Internet of Things and blockchain technologies support much better supply-chain transactions. When the product is passed on from the manufacturer to the customer, the important data files are recorded in blockchain. Companies are now able to trace products and raw materials to improve their product quality.

1.13.4 Smart Transactions

Businesses are now able to establish smart contracts on blockchain, and these smart contracts are widely used to implement business collaborations in general and international business processes. Enterprises are now able to automate transactions based on smart contracts on block chains without manual confirmation.

1.14 Blockchain in Smart Cities

The rapid rate of increasing urbanization has given us considerable development in preparing long-term capable and productive solutions. Many cities have been plagued with management and maintenance of energy, waste, and several other government services. Blockchain can provide solutions to these problems. Technologies like machine learning, deep learning, Internet of Services, artificial intelligence, etc. are being utilized to convert cities into smart cities [66]. The main goal of such cities is to ease the living condition by utilizing the given resources to its best and minimizing the expense for the same. Blockchain can provide transparent and secure answers to the communication, financial, and healthcare sectors, which are key for the idea of smart cities.

1.14.1 Uses of Blockchain in Smart Cities

Blockchain for Cities [67], a United Nations initiative, is a program to bring together many technologies like BIM (Building Information Modeling), the GIS (Geographical Information Systems), and UPIS to inspire cities. This assists them to convert these cities into smart cities.

According to the researchers, some of the areas where smart cities utilize blockchain are as follows:

Security
Blockchain has proven to be a secure and safe medium for many tasks. The decentralized ledgers and hashing guards the data given by the users.

Energy
Using smart contracts has allowed renewable resources enormous development, along with financial support and energy policies [48]. For example, households with solar power can easily distribute any surplus energy with members of their grid.

Mobility
Since the privacy of the users is maintained, state departments can have an idea of the number of citizens who use travel in trains, cars, and buses and allocate the resources accordingly. The payment concerned with these transports can be done via blockchain-powered payment apps, to increase the overall efficiency of the system.

Waste
The waste produced can be tracked by blockchain technologies. Citizens who dispose of garbage correctly can be provided incentives and discounts to motivate other citizens. An efficient chain of collection, transportation, and disposal at landfills can be created, which will improve the recycling of waste, since the garbage at its origin will already be separated by the people themselves.

1.15 Issues and Constraints in Blockchain Application

This topic aims to grasp the challenges faced during the implementation of applications discussed above. We try to seek and rectify what problems and limitations are awaiting us in our future goals of solving healthcare-, architecture-, finance-, etc.,-related issues, on the basis of current prototypes and applications we have at our disposal.

Since most of the data in blockchain is immutable, backtracking and changing the data is a lot of work, hard forks are generally required for such transactions. The storing of these blockchain chains requires a massive amount of disk space. With this ever-growing size, users would not be able to download these chains, keeping in mind the load that would be required by networks to control the flow of data.

Since blockchain is a technology with ever-increasing efficiency, more research is required to open more doors for its applications in the sectors discussed. But before we work on the given application's real-world implementation, there are lots of legal and accountability issues to examine and review. The steep work put into project direction, data entry and monitoring, and billing and invoicing approaches has been found ancient and old-fashioned for the present age. Even with industry being conservative and intricate, it is time to modify the practices and habits. The

acceptance of blockchain might prove to be an obstacle, but there is evidence that the advantages and gains connected are massive [68].

1.16 What the Future Holds for Blockchain

Blockchain is still in an early stage of development, so it still has mixed predictions about its future and potential.

A study conducted by the analytical firm Gartner concluded that:

- It is estimated that only 10% of the companies would have achieved complete transformation by the year 2022.
- Businesses would be worth $10 billion by the year 2023.
- It is estimated that by 2026, the business value added by blockchain would be around $360 billion, and by 2030, the amount will shoot up to $3.1 trillion.

Cybersecurity is the most promising area of growth for blockchain technology. The most significant challenge that businesses face is hacking or data tampering. By the use of blockchain technology, hacking can be prevented and it allows the participants to verify the file's originality.

The International Data Corporation (IDC) has reported that many IoT corporations have considered the execution of blockchain technology in their solutions.

This is due to the fact that blockchain technology provides the most secure foundation for communication between different IoT devices. Many existing protocols have failed when they have been applied to IoT devices; thus blockchain technology has proven to be effective.

The idea of the distributed ledger is very efficient for government agencies that have to govern huge amounts of data. At present all the agencies have separate databases so in order to gain information about residents, they have to constantly contact each other.

However, after the execution of blockchain technologies, the functioning of such agencies will improve and they will produce larger outputs.

Estonia has already started using blockchain technology on the governmental level. It is believed that all the public services in Estonia have access to X-Road, a dispersed digital ledger that has all the information about its residents. This technology is a very high-level encryption technology that includes two-factor authentication, and this enables the people to control their own data and be sure of its security.

In the future, blockchain will completely change the complexion of trade processes in many industries, but adopting/implementing it will require a lot of time. We can expect that governments around the world will finally accept the benefits of blockchain technology and will start using it for improving financial and public services. Though many blockchain startups will fail as well, people will get more experience and knowledge on how to implement this technology. Blockchain will encourage people to adopt new skills, whereas traditional businesses will have to completely rethink their policies [69].

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