A Review of Blockchain-Based Solutions for Intellectual Property Rights Protection and Management

Sajjad Abdulkareem Mohsin[1], **Raad A. Muhajjar**[1]
[1,2] Department of Computer Science, Basra University, Basra, Iraq

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ABSTRACT

The fast and unbridled growth of digital content presents enormous difficulties for intellectual property (IP) rights management. Conventional systems find it difficult with the natural digital complexity, simplicity of replication, and broad illegal use. This paper uses a methodical literature review and an analysis of more than 39 research publications released between 2018 and 2024 to handle this. These were assembled using especially pertinent keywords taken from main scholarly databases. Our study of these published works reveals that the IP recording and verification process is much enhanced by blockchain's distributed, open, immutable architecture. Smart contracts automate agreements; non-fungible tokens (NFTs) offer special ownership proof and the Interplanetary File System (IPFS) guarantees consistent, distributed storage for digital assets. Still, this paper emphasizes continuing problems including user adoption, legal uncertainty, and scalability constraints. Future studies have to aggressively close these gaps by creating scalable, legally strong, and easily Blockchain solutions. Moreover, incorporating artificial intelligence will be crucial for their widespread and efficient application.

Corresponding Author:

Sajjad Abdulkareem Mohsin
Department of Computer Science, Basra University, Basra, Iraq
Email: sajjadkareem61@gmail.com

1. INTRODUCTION

Intellectual property (IP) is the term used to describe the intangible creativity of individuals or collective intellect, such as intangible knowledge, ideas, or crafts. In general, most countries around the world accept copyrights, patents, and other forms of intellectual property protection Compared to traditional assets like money, real estate, and goods, intellectual property (IP) is more difficult to protect due to its intangible nature in today's digital and globalized economy[1]. In our increasingly digital, globalized, and interconnected world, intellectual property management, protection, enforcement, and monetization are more important and difficult than ever. It is challenging because, especially when it comes to digital content, intellectual property is easily stolen, shared, copied, and misused [2]. Because they mainly rely on a central authority, current IP protection strategies, such as data preservation, have disadvantages like high costs, low transparency, and centralization [3].The decentralization, tamper-resistance, and transaction anonymity of blockchain technology can effectively address traditional intellectual property issues, such as the difficulty of obtaining it electronically as evidence and the high cost and low compensation of copyright protection [4]. Some features of blockchain technology, such as decentralized public records, transparency, trust, scarcity, and smart contracts, seem to be compatible with copyright principles.Authors can publish their works on the blockchain to create an almost immutable record of original ownership. Additionally, they are able to grant licenses for the use of their works by encoding "smart" contracts [5]. Using blockchain technology as a distributed computing platform, users can publish software components (called smart contracts) for a range of next-generation decentralised applications without the help of a trustworthy third party [6]. These contracts consist of code that, in the absence of a central authority, runs on its own when specific requirements and conditions are met.The result of smart contracts handling copyright information and purchase transactions is a system that can protect digital content [7]. Since large files, such as audio and video, cannot be stored directly on the blockchain, IPFS technology has been used as a data expansion system for the Ethereum platform's data storage layer. The Interplanetary File System (IPFS) is a peer-to-peer distributed file system that provides a high-throughput block storage format [8],[9]. Currently, blockchain technology is used to store ownership information of non-fungible digital assets (NFTs), which have unique and different properties from one another NFTs are among the most important future applications of smart contracts [10],[11].

2. RELATED WORKS

Peng et al. [12] have developed a public chain-based secure digital copyright management system. Initially, the system was built using Ethereum smart contracts and the Interplanetary File System (IPFS). The chain recodes transaction and copyright data, allowing users and copyright owners to transact directly without the need for centralised managers. Secondly, the transaction information is added to the image's watermark data to show that it was pirated. The system also uses a better ELGamal encryption algorithm, which makes the process of generating a temporary shared key more effective.

A new scheme based on digital watermarking and its information is created by Meng et al. [13] in their new copyright management system design by combining digital watermarking, blockchain, perceptual hash function, Quick Response (QR) code, and InterPlanetary File System (IPFS). In addition to providing timestamp authentication for multiple watermarks (multiple copyrights) to confirm the order of creation, blockchain technology securely stores watermark data.

The original artist has complete control over their work thanks to the system proposed by Sharma et al. [14], who uploaded their published work to the IPFS is a distributed file storage system built on blockchain technology, which means that multiple copies of the same published digital content cannot be created. In addition, this guarantees the integrity of the published digital material.

The InterPlanetary File System (IPFS) is a distributed database that can be used to store photographs in order to achieve decentralisation. Poudel et al. [15]. Only after it has been verified that no other image of the same type already exists on the system is the image saved in IPFS. The existence of a duplicate image is ascertained using the dHash algorithm and hamming distance. Peer-to-peer communication between the user and the owner of the photo is made possible by the Ethereum blockchain's Whisper protocol. On the basis of the Ethereum test chain.

Mehta et al. [16] proposed a decentralised peer-to-peer photo sharing marketplace and demonstrated its feasibility, dependability, and equity. A decentralised application automatically detects and rejects tampered images that visually resemble those that are already available for purchase by utilising Ethereum's robust smart contracts and perceptual hashes.

Wang et al. [17] look into the zero watermark algorithm's function in image security as well as the system's overall authentication and storage. They then build a system in line with their recommended secure blockchain-based framework for image copyright protection.To solve the problem of blockchain data scalability, this framework combines blockchain technology with zero watermark technology and makes use of the interplanetary file system.

Ma et al. [18] proposed DRMChain, a blockchain-based digital rights management system. For serving infringing content, it can provide conditional traceability in addition to reliable, high-level content protection. Additionally, it supports appropriate content and provides appropriate user service.

Xu et al. [19] proposed a new zero-watermark algorithm based on blockchain To generate a dependable watermark-free remote sensing image while taking into consideration the image's multi-scale features, the algorithm uses the K-L transform, NSCT transform, SVD, and other technical techniques. Using IPFS and Hyperledger Fabric, a watermark-free recording system saves the zero-watermark on the blockchain.

O. B. O. Agyekum et al. [20] proposed a system that primarily consists of digital fingerprint technology, IPFS, and blockchain (Fabric) to improve standard practices, protect digital media copyright, and ensure full ownership. This guarantees that authors or copyright holders are informed about the use of their data and removes the need for them to rely on any third party.

The individual research papers that were reviewed are succinctly summarised in Table 1, which also lists the main limitations, important technologies used, and their main contributions. This summary provides a fundamental understanding of the various initiatives aimed at implementing blockchain technology for intellectual property protection.

Table 1. Summarized related works.

Ref.	Problem Addressed	Key Technologies	Core Solution	Key Strengths	Main Limitations / Challenges
[12]	Digital copyright/image piracy.	Ethereum, Smart Contracts, IPFS, ELGamal, Watermarking.	Secure Blockchain system: improved ELGamal & transaction watermarking.	P2P transactions, effective piracy detection.	No full public Blockchain simulation.
[13]	Watermark gen/storage oversight.	Digital Watermarking, Blockchain, Perceptual Hashes, QR, IPFS.	Combines watermarking & Blockchain for secure storage & multi-timestamp auth.	Multi-timestamp auth.; secure watermark storage.	Prior research ignored watermark gen/storage.
[14]	Image integrity/provenance; Trusted Third-Party (TTP) reliance.	Blockchain.	Framework for creator control over image origin/access.	Full creator control, immutability.	Lacks content integrity/provenance support.
[15]	Unauthorized photo use slow/costly auth.	Ethereum test chain, IPFS, Smart Contracts, dHash, Whisper.	Integrates Blockchain, IPFS, P2P for photo ownership & authorization.	Decentralized ownership, effective duplicate detection.	Incomplete decentralization; test chain only.
[16]	Incorrect image attribution/tampering.	Ethereum test chain, Smart Contracts, Perceptual Hashes.	Decentralized P2P photo sharing for attribution & tamper detection.	Feasibility, reliability, automated detection.	Test chain (not prod-ready), scalability concerns.
[17]	Traditional watermarking needs Trusted Third Parties (TTPs)/data loss; scalability.	Blockchain, Zero Watermark, IPFS.	Blockchain system for secure image protection via zero-watermarking & IPFS.	Enhanced security, efficient storage, addresses Blockchain scalability.	Needs TTPs/data loss with existing watermarking.
[18]	DRM challenges; free consumption/spreading.	Blockchain.	DRMChain: New trusted Blockchain model for DRM with conditional traceability.	Reliable high-level protection, conditional traceability.	General DRM problems with Blockchain not fully solved.
[19]	Zero-watermark relies on Trusted Third Parties (TTPs) for remote sensing image copyright.	Blockchain, Zero-Watermark (K-L, NSCT, SVD), IPFS, Hyperledger Fabric.	Novel zero-watermark algorithm for remote sensing images via Hyperledger Fabric.	Robust images, multi-scale features, secure Blockchain recording.	Existing zero-watermark heavily relies on TTPs.
[20]	Traditional copyright processes offline/time-consuming.	Digital Fingerprint, IPFS, Fabric Alliance Blockchain.	Digital system using IPFS & Fabric Blockchain to optimize traditional media copyright.	Improved efficiency, full ownership protection.	Processes are offline/time-consuming.

A comparative analysis of the performance and important findings from the reviewed studies is presented in Table 2. It emphasises the type of results (qualitative or quantitative) and highlights similarities or differences between methods, particularly for projects that use related technologies or deal with related issues.

Table 2. Comparative analysis and results of related works.

Compared Papers (Ref.)	Shared Technologies / Focus	Key Comparative Result / Insight (Qualitative/Quantitative)	Common/Differentiating Aspects
[12] , [16]	Ethereum-based image IP.	Both feasible. [12] improved encryption; [16] focused tamper detection.	Both use Ethereum for image IP, but focus differs.
[15] , [16]	Ethereum Test Chain & IPFS for P2P photo management.	Both demonstrated effective P2P image proof-of-concepts.	Both make use of IPFS, test chains, and comparable stages of development.
[17] , [19]	Zero-Watermarking with Blockchain & IPFS.	Both address TTPs/integrity. [19] specific Hyperledger Fabric algorithm; [17] general framework.	Similar core tech for TTP/integrity. [19] more specific, [17] broader.
[19] , [20]	Hyperledger Fabric for IP solutions.	Both leverage Hyperledger Fabric. [19] for remote sensing image copyright; [20] for optimizing traditional media copyright.	Both use Consortium/Private Blockchain. Focus differs (image vs. process).
General Trend	Most studies are Qualitative.	Most findings are qualitative, showing feasibility or efficiency. No specific quantitative metrics (e.g., PSNR, % improvement).	Indicates field is in proof-of-concept stage; needs more empirical/quantitative validation.

2.1 Research Methodology

This work examined blockchain-based IP protection systems under a Systematic Literature Review (SLR). Keywords including "Blockchain," "Intellectual Property," "Smart Contracts," "NFTs,", "Digital Rights Management" and "IPFS," were searched extensively throughout key academic databases including IEEE Xplore, Scopus, Web of Science, ScienceDirect, and Google Scholar .The search turned over research published between 2018 and 2024. The inclusion criteria focused on peer-reviewed papers regarding Blockchain applications in intellectual property; sources irrelevant or non-academic were excluded .Important information gathered from a few selected papers included the year of publication, the technologies used, the IP issue fixed, the main ideas, and the limitations. At last, nine studies were selected. their similarities, shortcomings, and strengths were compiled to create relative tables (Tables 1 and 2).

3. Intellectual Property Rights Management and Challenges

3.1 Intellectual Property Rights (IPR) Overview

Any creative endeavour is referred to as "intellectual property" (IP) Intellectual property laws give people the short-term right to own and profit from their scientific, artistic, and technological creations. Inventors receive a variety of intangible assets, such as ideas, business plans, inventions, discoveries, words, phrases, symbols, artwork, music, and designs. In order to assist industries, which in turn facilitate the transfer and dissemination of knowledge as well as the growth of technical innovation, intellectual property rights are primarily intended to promote ideas by promoting their use and protection [21].Examples of intellectual property rights (IPR) include a patent on the process used to create chewing gum, a copyright for a book or article by an author, a distinctive logo for a soft drink company and its products, or distinctive elements of a website design[22].

3.2 Conventional IP Management Systems

Traditionally, territorial rules have controlled intellectual property. Still, cross-border intellectual property rights protection and economic exploitation including copyrights, trademarks, designs, and patents usually spans many jurisdictions these days. Nowadays, websites all throughout the globe employ nationally protected trademarks, and copyright information is exchanged, communicated, and duplicated in a borderless environment [23]. First formed in the philosophical and historical context of the eighteenth century. the complex network of reasons and rules that forms the present intellectual property system was first Legal positivism and formalism therefore modified their tools to suit human inventions and creations as a kind of property right. primarily based on the late 19th-century Berne Convention for the Protection of Literary and Artistic Works and the Paris Convention for the Protection of Industrial Property.the usual methods of distributing and protecting intellectual property rights are primarily founded on these techniques [24],[25]. The fast expansion of economic globalization has attracted public and multinational company attention to the internationalization of the intellectual property system. The whole international community has indeed created a quite extensive legal framework [26]. Protection of traditional knowledge creates challenges that need to be addressed in these frameworks in order to recognize collective rights as it often deviates from typical industrial property rights [27].

3.3 Digital Content Piracy

The internet distribution of intellectual property works is mostly under control of others. Special characteristics of digital copies of protected works include loss, limited reproduction, and almost unrestricted distribution. Digital copies are ideal replicas, thus they are seeds to generate even better copies. Two examples of natural limitations to infringement that no longer apply are the cost of replication and the declining quality of later generations of analogue media copies. A few years ago, the typical computer owner could have easily carried out the kind and scope of copying required by a significant financial outlay and maybe illegal motivation. Moreover unbounded by technology is the count of concurrent users able to access these digital works from anywhere with an Internet connection. Rapid and cheap worldwide information distribution of current Internet technologies is another benefit. For people or pirates, this makes creating and distributing illegal copies easier and more fairly affordable [28]. Online distribution of the work causes lost control over it. Most probably, a copyright holder is unaware of the infringement. Moreover, even aware of it, it is quite challenging to start effective legal action against it [29].

4. Blockchain technology

Blockchain technology has drastically changed the digital transformation of contracts, transactions, and records that form the pillar of the worldwide legal, political, social, and economic systems. Launching Bitcoin in 2008, the anonymous Satoshi Nakamoto started the first generation of blockchain technologies [30]. One can consider blockchain as a sequence of blocks, each of which references the one before it. Blockchain is a type of distributed ledger or data structure with decentralization. Once transaction or event data has been entered into the Blockchain, the shared data with network participants cannot be changed [31]. New blocks help it to keep expanding. Among the main technologies allowing the distributed consensus algorithms, digital signatures, and cryptographic hash to support the decentralized environment blockchain technology operates in [32]. Blockchain technology, which underlie Bitcoin, has lately drawn a lot of. interest. Blockchain technology is an unchangeable ledger that allows decentralized transactions in a range of fields, including cryptocurrency, financial services, risk management, the Internet of Things (IoT), public and social services Among its several benefits are auditing, anonymity, decentralization, and persistence [33],[34].

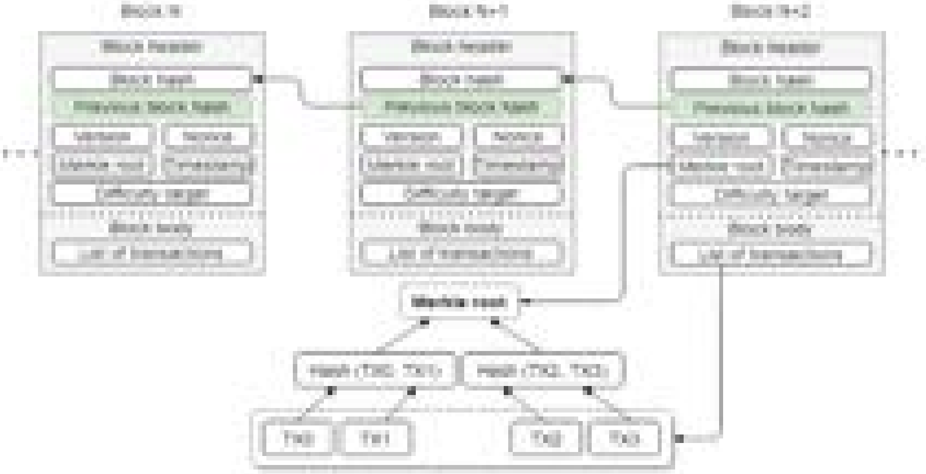

Figure 1. Blockchain and block structure [35].

4.1 Blockchain types are generally classified into three types

4.1.1 Public Blockchains : Public blockchains have emerged as a promising trend to revolutionize data-driven systems that rely on centralized service providers [36]. A blockchain is called public if every participant can read it and use it to make transactions, but also if everyone can participate in the consensus-building process. Thus, there is no central ledger, no trusted third party [37]. Public blockchains are sweeping the board Public blockchains, such as Bitcoin and Ethereum, enable secure peer-to-peer applications such as cryptocurrencies or smart contracts [38].
4.1.2 Private Blockchains: Private blockchains have recently gained more interest in the industry because they are faster, cheaper, and privacy-oriented compared to public blockchains [39]. Private blockchains restrict access to the data in the blockchain by requiring users to first obtain permission before they can read or write data in the blockchain [40].
4.1.3. Consortium Blockchains: Collective blockchains have emerged as an interesting architectural concept that leverages the transaction efficiency and privacy of private blockchains, while taking advantage of the decentralized governance of public blockchains [41]. Collective blockchains remove individual autonomy, which is granted to only one entity by a private blockchain. Here, instead of one entity in charge, we have multiple entities in charge. A group of organizations or actors can make decisions for the benefit of the entire collective blockchain network, as a way to get things done faster and have more than one checkpoint [42].

Table 3. Comparison of different blockchain types [43].

Attribute	Public	Consortium	Private
Accessibility	Entirely open to all	Accessible to specific organizations/groups	Accessible to a single individual or entity
Writing Permissions	Anyone can write	Designated multiple nodes can write	Solely controlled internally
Reading Permissions	Anyone can read	Anyone can read	Publicly accessible / Can be restricted
User Identity	High anonymity	Low anonymity	Low anonymity
Transaction Speed	Slower	Faster	Extremely swift
Architecture	Fully decentralized	Partially decentralized	Partially decentralized

4.2. Consensus Mechanism

Decentralised networks in distributed computing will unavoidably cause networks to lose faith in one another,To achieve network dependability, network systems will employ pertinent protocols to arrive at a consensus process, or agreement, that guarantees a particular operation is dependable, consistent, and unbreakable [44].

There are some commonly used Consensus Mechanisms such as:

4.2.1 Proof of work (PoW):

A proof-of-work (PoW) block algorithm based on hashing is used to secure Bitcoin transactions,The mining process, also known as proof-of-work (PoW), is a helpful component of the Bitcoin system that authenticates all incoming data to thwart distributed denial-of-service (DDoS) attacks and spam The process of adding a new block to the blockchain through computations utilising hash algorithms like Hashcash is known as bitcoin mining [45].

4.2.2 Proof of stake (PoS):

"Stake" describes how many tokens a user needs to stake in order to take part in the validation procedureThe idea is rather straightforward and was first proposed by Peercoin in 2012 By creating or approving the subsequent block based on your stake level, nodes take part in the consensus process. You have more influence over the next block's validity the more you stake To answer a mathematical puzzle, nodes do not have to compete with one another [46].

4.2.3 Proof of Authority (PoA):

An efficient method for resolving blockchain issues, especially private ones, is the proof of authority algorithm Before machines are permitted to produce new blocks in proof-of-authority, they must successfully complete a stringent screening procedure Only reliable validation tools can safeguard Pos blockchains Pre-approved people that monitor transactions and blocks are known as system moderators [47].

4.3. Blockchain Platforms

Bitcoin has contributed to the rise in popularity of cryptocurrencies in recent years "Blockchain" was the most promising technology that enabled Bitcoin. Although blockchain was first only used for financial transactions, research has proven that it may be utilised for a wide range of purposes Globally, blockchain technologies that provide a decentralised form of control are expanding quickly There are numerous blockchain platforms, including Corda, Ethereum, and Hyper Ledger Fabric[48],[49].

5. Smart Contracts

As blockchain technology and cryptocurrencies expand rapidly, platforms like Ethereum and Hyperledger have began to allow a spectrum of smart contract forms These days, blockchain technology and smart contracts are merging more and more. Blockchain technology guards the states and samples of these executable codes Smart contracts and blockchain technology thus help to design a permanent, traceable, trustworthy protocol free from outside players Though some would interact with a distributed smart contract created by a user [51],[52], the fundamental blockchain technology ensures constant functioning. Once the pre-defined criteria are met, they want to automatically execute the contractual agreement at a minimum transaction fee so eliminating the need for a third party.Smart contracts expand the applications for blockchain technologies [53]. Smart contracts could be triggered when transactions point to their unique main addresses on the Blockchain network. Network nodes have to execute deterministic smart contracts.Thus, the results of execution should be same for every node in the network; moreover, the Blockchain logs the results [54],[55],[56]. Smart contracts lack artificial intelligence thus they only use language that is machine-readable. It thus can control numerical conditions without converting spoken language into codes.Two flavours of smart contracts exist: "smart legal contract" and "smart contract code" [57]. On the Blockchain, smart contract codes are a body of verified guidelines easily executable as executable code How efficient the code is depends on the technical characteristics of the Blockchain on which a smart contract is implemented as well as the efficiency of the programming language used to express the contract.Depending on their technological bases, smart contracts either improve or replace legal contracts. This does not suggests that every element of the contract exists in a computer-programmable form.Rather, it implies that everyone has concluded that having some of the key terms electronically would be advantageous [56].Whether or not the technology can produce legally enforceable agreements will depend on the political, legal, and commercial institutions' choices on how to apply the technology as well as on the present legal system Three criteria specify the relevance and applicability of a smart legal contract [57]: The users' faith in the system, Lawmakers who acknowledge the use of the technology and Comprehending by the courts.

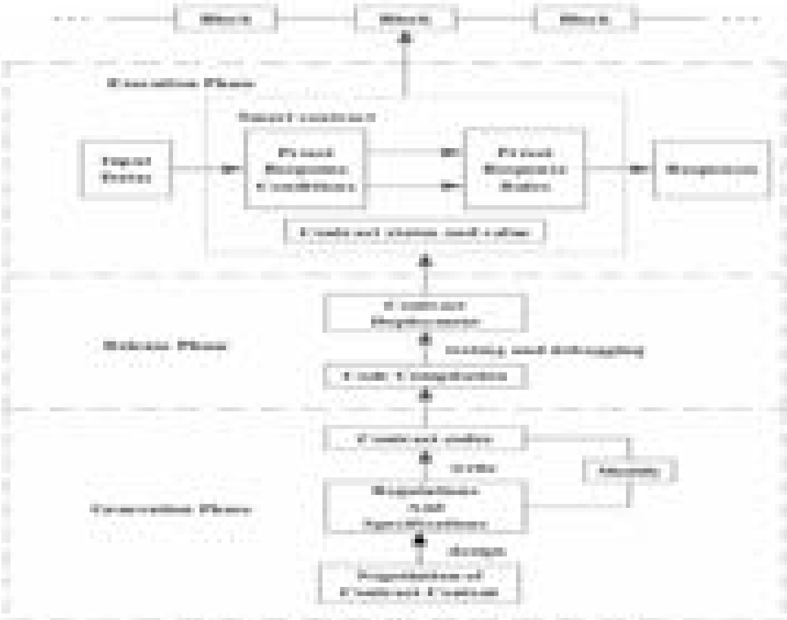

Figure 2. The life cycle of smart contract [58].

6. The Management And Protection Of Intellectual Property Rights Through The Use Of Blockchain And Smart Contracts

6.1. Overview

Based on Open Innovation's approach for problem-solving, blockchain supports IP tracking [59]. Among them were concepts of security and the orderly development from start to finish. Apart from modelled or created outputs, the authors digitally recorded and captured spoken, written, or drawn outputs utilising independent interfaces depending on the "Design Thinking Process". Understanding, observing, defining, ideating, prototyping, and testing six steps of the Design Thinking Process help designers organise their research and decisions. Results records tie back to the content producer.Every digital good is put onto the bitcoin blockchain using an original fingerprint derived from Origin Stamp decentralised trusted timestamping method. Blockchain data underlines presence and proof of origin. This thus provides a reliable and unbroken record of the full invention process, from the idea stage to the beginning of manufacture. Suggested to provide a completely open chain of trust for the many manufacturing phases was a Secure Additive Manufacturing Platform (SAMPL [60]) based on blockchain technologies Managing the intellectual property of the 3D print supply chain using blockchain technology helped the writers stop IP theft.They suggested putting a security component akin to those found in a copy machine into the equipment controlling the 3D printer's Blockchain .connection to stop money from being replicated.The connection of 3D printers with the Blockchain will establish a trustworthy relationship between service providers and copyright owners.From creation of the 3D printing data leveraging a trust service provider (three 3D printers with the secure element) to tagging the final components with an RFID chip, the Blockchain tracks every stage of the process. Their usage was justified in part by the exceptional tools, documentation, and flexibility to embed smart contracts into complex Ethereum Blockchain process mapping.

Under the direction of a smart contract, the Blockchain lets the licensor and licensee monitor license and use.Transactions guaranteed the signature with the industry-standard Elliptic Curve Digital Signa Ture Algorithm (ECDSA) and a public/private-key scheme.Found in the wallet, the digital signature comes from the private keys of the licensee and licensor.Another research argues that private blockchain technologies could be used to handle the product development data and procedures of additive manufacturing [61].The effort distributed and certified industrial intellectual property using a multi-agent system blockchain technology. Stored on a blockchain, the intellectual property also known as production phase data IP is shared with managers, designers, engineers, and other departments both inside and outside of the organisation.Signed on the blockchain, the sender's private key stops anyone involved from changing the transaction's contents.All further product-related data, technical documentation, CAD files, and so on is housed in a cloud-based repository. Combining the public key checksums from the sender and recipient for the CAD file produces a verified cryptographic hash for each block, therefore reducing the potential for fraud.

Examining intellectual property rights (IPR), [62] looks at the challenges facing online open innovation and the ways in which creating an intelligent online platform can be of use. To enable SMEs to collaborate, the authors developed safe online Network Innovation Rooms (NIR) SMEs must digitally sign an NDA upon choosing to cooperate before they may enter the safe and secure collaboration environment Following this NDA, they have to give whatever intellectual property or data they supply to the NIR timestamped and recorded on a blockchain. The NDA still follows smart contract structure on the Ethereum network Apart from their limited NIR usage, it defines specifically which joint operates and intellectual property should be protected.Among other issues, blockchain [63] can support privacy, provenance tracking, multiparty aggregation, traceability, inter-organizational record keeping, data ownership, Building Information Modelling (BIM) technology in construction management Another author published IoT and blockchain integrated design for IP administration. Through a cloud-based peer-to-peer system using Blockchain architecture, several applied IoT devices can be connected to their suggested method [64]. Another idea offered by [65] proposed a microfilms IP protection method based on Blockchain.Microfilms are short films aired on multiple media sources. As their names and scripts mainly identify them, the authors advocated keeping microfilms on the Blockchain.Still another initiative entails blockchain technologies and intellectual property in the fashion industry [66].

6.2. Transparency In Ownership Information

Blockchain could significantly raise the awareness of copyright ownership information availability One can obtain such information by "trusted timestamping" A timestamp is a precise moment an event happens recorded by encoded data or a set of letters Usually it shows the date and time of day occasionally it is precise to minuscule fraction of a second [67]. Blockchain looks in some ways like a publicly verified timestamp database It lets everyone freely and precisely assert that a given incident happened at a specified moment. Blockchain technology can thus significantly contribute to define the presumption of authorship and solve problems on priority in this field Expert literature already notes blockchain intellectual property promise. Melanie Swan [68] claims, "people can use the [blockchain] web-based service to hash things like art or software to prove authorship of the works".

6.3. Smart Contracts For Digital Asset Transfers

Smart contracts are also beneficial for transfers of digital assets This especially relates to the way the business deals with suppliers and clients, especially in situations involving financial interests Smart contracts help to translate conventional asset transfers into digital form For instance, a bank or other business managing consumer credit cards would have a whole database to monitor credit card use and balances Among other things, "amount," "owner," and "asset type," would be recorded in a standard table in such a database [69]. Usually, multinational companies deal with thousands of daily clients While some customers are handled personally, others are handled by automated systems including online stores linked to checkout systems Basically a specific kind of contract is created when a company buys or sells a good depending on the circumstances, it could or cannot be enforceable Cong contends that a company owes a duty of care to its employees and customers thus it has to make sure that activities are carried out with the required care to safeguard the interests of both sides [70]. As such, one can view every sale or purchase the business does as a contract A contract could be used by a client buying a service package or by a company buying products Digital tokenized assets let one engage in these agreements Pettersson and Edström [71] ,define any type of asset expressed electronically that lets one or more units be transferred to another as a digital tokenised asset.

7. Non-Fungible Tokens (NFTs)

In an editorial by Peres et al. [72] a non-fungible token (NFT) is described as a "cryptographic asset on a blockchain containing unique identifying information and codes that separate them from one another." While the Ethereum-based game CryptoKitties first attracted attention to NFT products in late 2017 [73], the industry's explosive expansion is clearly linked with the entrance of COVID-19. According past studies, bitcoin market liquidity surged [74] after the World Health Organisation declared a global epidemic. The unexpected decline in global market interest rates drew investors to several bitcoin markets, including NFT at the same period [75]. Above all, NFT's expansion was facilitated by epidemic lockdown rules increasing online interaction. Apart from attracting a lot of interest from supporters and investors, NFT has seen a consistent increase in academic study. Though much research on Bitcoin and other cryptocurrencies has been done, shockingly little on NFTs [76]. There is great potential and uncertainty since NFTs are still in their

infancy and imply inadequate research or data to support many initiatives. Still, the multidisciplinary character of NFT research aids to clarify this. In many spheres, it calls for more corpus of knowledge and understanding. NFT research mostly covers computer science, economics and finance, law, and other disciplines, much as studies on cryptocurrencies [77]. Research on NFTs is absolutely necessary considering the knowledge acquired about the evolution of cryptocurrencies. Since NFT is supposed to maximise the possibilities of decentralised, distributed ledgers [78], some scholars predict that it will expand at a pace and level comparable to those of cryptocurrencies. Given the current degree of scientific research,

it is typically expected that NFTs would have especially negative effects on the financial and economic sectors. Initially, NFTs highlight the several uses for blockchain technology [79]. This is so since it generates digital scarcity, so raising the value of digital assets by means of a new ownership structure [80]. Second, by supporting a new economic ecology to flourish, NFTs inspire content creators. Apart from facilitating their entry into new markets where they can profit from products like music, artwork, and images [81], it helps content creators enhance contracts with current markets or reduce the number of third parties, so enhancing efficiency and lowering overhead costs.

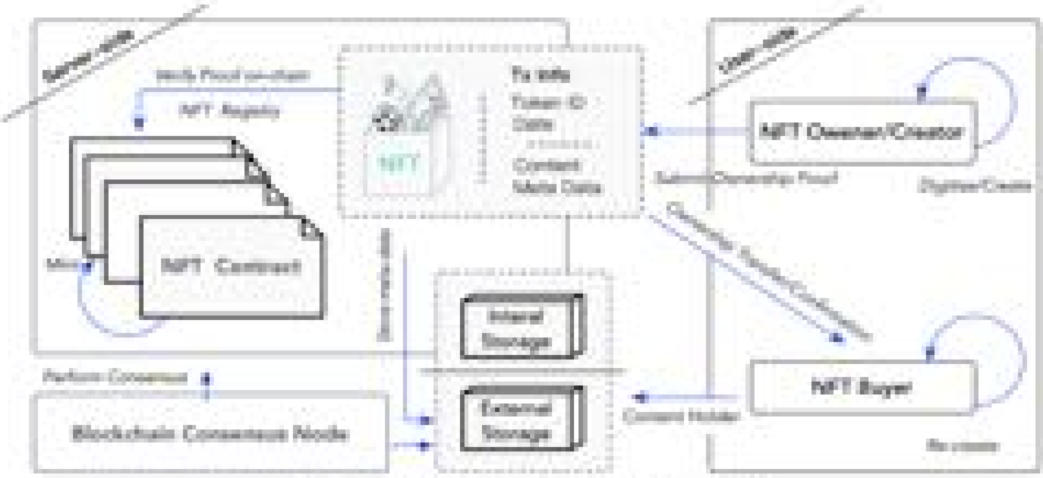

Figure 3. Workflow of NFT Systems [73].

8. Interplanetary File System (IPFS)

One centralised power is the surplus of data kept on cloud servers Among the several hazards a central power can be prone to include single-point failure. Third parties create data backups to help avoid such failures Introduced to eliminate third parties from the process of creating a trust-based model, a blockchain offers confidence and openness Decentralised storage is one way to let data be maintained as a distributed ledger spanning several network nodes be independent The restrictions in the capacity for processing and storage of the network nodes present a difficulty For this reason we apply an interplanetary file system (IPFS) Seeking to link every computing device to a single file system, the Interplanetary File System (IPFS) is a peer-to-pee distributed file system IPFS is similar to the Web in some ways, even if it can also be regarded as a single BitTorrent swarm trading objects within a single Git repository Stated differently, IPFS provides high throughput content-addressed block storage together with hyperlinks This produces a generic Merkle DAG, a data structure appropriate for blockchains, versioned file systems, and even the Permanent Web IPFS aggregates distributed hash table, incentive-based block exchange, and self-certaining namespace IPFS lacks a single point of failure thus nodes do not have to rely on one another [82].

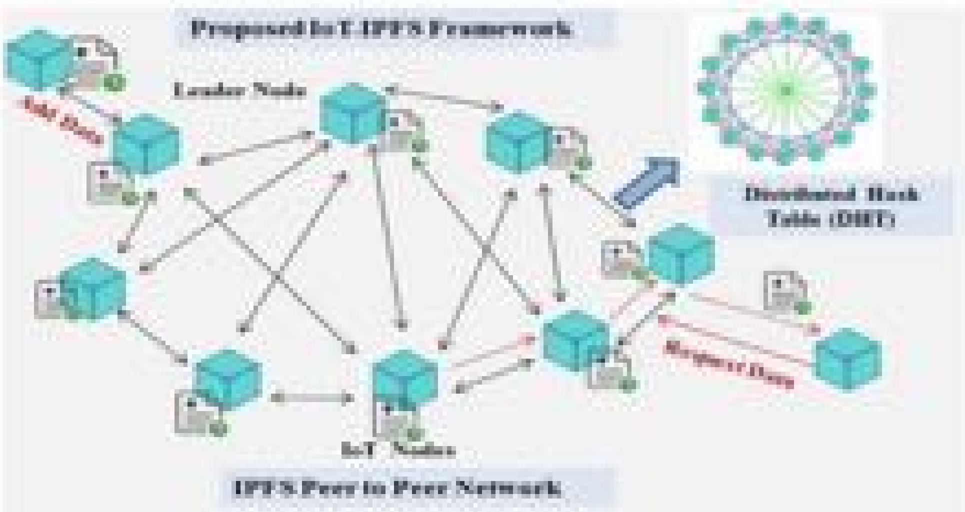

Figure 4. Proposed IoT-IPFS architecture [83].

9. CONCLUSION

Blockchain technology offers many chances to manage intellectual property (IP) in order to avoid the problems with current systems. Blockchain argues that digital assets could be tracked, confirmed, and transmitted without middlemen. The secrets of this are openness, distribution, and immutability. Smart contracts help to ease intellectual property and legal handling, so enabling a change and reduction of complexity. By giving creators a direct means of income from their work and so preventing illegal use of their creations, non-fungible tokens (NFTs) have also changed the way digital assets are kept and used. Even with these developments, blockchain still finds challenges being generally embraced in IP management. This addresses legal recognition, scalability, and system platform integration over several platforms. Moreover turning some people away are the technical difficulties and high running costs of blockchain systems. But constant research and development will allow blockchain technology to create more efficient and safe digital environments, so changing intellectual property management. Future development in this field will surely solve current issues and expand the spectrum of IP applications for blockchain, so enabling creators and inventors to protect their intellectual property in a technologically scattered environment.

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