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Rewarding Developers by Storing Applications on Non-Fungible Tokens

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Abstract: Non-fungible tokens (NFTs) are individual tokens with valuable information stored inside them over blockchain technology. They can be purchased and sold like other physical and virtual art pieces because their worth is mostly determined by the market and demand. The unique data of NFTs render it simple to verify and authenticate their ownership and transfer of tokens between owners. However, in Pakistan, developers cannot acquire different licences to accomplish their projects not because they cannot afford it, but because they cannot invest in every piece of software to accomplish each new sensitive task. Rather, they can render the product platform independent. Considering this technology, this paper provides IT professionals with a new NFT approach and business policies that solely belong to the information technology domain. In addition, this paper also introduces how NFT tokens can hold software applications. Since we can store files, we can let NFTs also store complete applications to help developers in further utilising virtuality and having the metaverse at their fingertips. Whenever they succeed in a project, they never receive rewards, and their skills only pay the bills. In a nutshell, this paper presents a prototype of NFTs that would be further polished to save and utilise applications in a decentralised manner while rewarding the developers.

Keywords: non-fungible tokens (NFTs); Ethereum; information technology (IT); blockchain; smart contract

MSC: 68U35

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1. Introduction

Non-fungible tokens (NFTs) fall under the umbrella of cryptocurrencies. NFTs came into existence using Ethereum's smart contracts [1]. In order to run the system, an application designed to execute most of the functions, such as verification and validation request transactions on the Ethereum platform, is known as a "smart contract". This is a set of programs and state-related data stored at a particular address that is registered on the blockchain network. However, NFTs are distinct from traditional cryptocurrencies such as Ethereum in terms of their fundamental characteristics.

However, in this scenario, Ethereum is like other crypto coins, but with a slight difference in currency rates [1]. It is a standard coin, meaning that every coin is identical and interchangeable [1,2]. NFTs, on the other hand, are distinct and non-fungible (i.e., non-exchangeable) tokens, rendering them appropriate for uniquely identified (digital or

physical) entities or even people. To be more precise, a creator may simply establish the existence and ownership of digital assets such as movies, photographs, event tickets, and artworks by utilising NFTs on smart contracts (in Ethereum). Additionally, the owner is entitled to royalties for each profitable transaction on any NFT market or through peer-to-peer trading [2].

In this paper, we highlight the current developments of a potential intellectual property (IP) protection solution ensured by NFTs to have full historical tradability, deep liquidity, and straightforward interoperability [3]. Innovations, literary and creative works, patterns, trademarks, names, and pictures used in business are all examples of IP (WIPO, 2022). Although NFTs are essentially just codes, they have value to a buyer when considering their relative rarity as a digital item. This effectively ensures selling prices for these IP-related items that, for non-fungible virtual assets, may have looked unimaginable [3].

Recently, NFTs have attracted much interest from both the scientific and industrial worlds. According to reports, the average 24 h trading volume for the NFT market is USD 4,592,146,914 compared to USD 341,017,001,809 for the total cryptocurrency market. In such a short time, the liquidity of NFT-related products composed 1.3% of the overall bitcoin market (5 months). By selling exclusive digital collectibles, early investors earn a million times their initial investment [4].

By June 2022, the market for NFTs had grown dramatically compared to a year earlier (April 2021). In April 2021, the total value of NFT sales recorded on the Ethereum, Ronin, and Flow blockchains over the preceding 30 days was over USD 73 million. The 30 day sales value as of 15 June 2022 was about USD 33.3 million (NFT sales value in the global art segment in the last 30 days, June 2022, Statista, Hamburg, Germany, 2022) [5].

Every token with valuable information stored inside it uses blockchain technology. They may be purchased and sold like other physical and virtual kinds of art because their worth is mostly determined by the market and demand. The unique data of NFTs render it simple to verify and authenticate their ownership and the transfer of tokens between owners. NFTs can store many sorts of files and media, but not documents, including executive files, modules, and frameworks. Considering the technology, this paper provides IT professionals with a new NFT approach and business policies that solely belong to the information technology domain. The concept is like metadata and about technology.

There are 17,140 overall primary-market sales, whereas there are 8589 secondary (user-to-user) sales. Consequently, USD 8,816,531.10 were used for primary market transactions. Additionally, there are 12,836 active market wallets, and they continue to grow rapidly over time. Surprisingly, the expected number of NFTs sold in December 2020 was 12 million, but that number surged to 340 million in just two months (February 2021). Then, as of 1 May 2021, collectors had sent over USD 37 billion to NFT markets, putting them on track to surpass the total of USD 40 billion sent in 2021. NFTs are seeing such rapid growth that some have even dubbed them the future of digital assets (NFT Transaction Activity Stabilising in 2022 After Explosive Growth in 2021–2022) [6].

As a competent developer now employed by a respected company, we were motivated to satisfy the business requirements for no compensation other than wages. Skills in Pakistan are the currency. NFTs can assist owners in receiving incentives for their talents beyond only paying to disrupt this system. Apart from businesses, freelancers also follow the same schedule. Developers can benefit in the long run by switching to NFTs. Due to ownership, their implementations may benefit them long after they have sold the product.

2. Background and Literature Review

2.1. Working of Non-Fungible Tokens (NFTs)

NFTs' unique and non-divisible properties distinguish them from other Ethereum tokens. NFTs enable the assignment or claim of ownership of any piece of trackable digital data using the Ethereum blockchain as a public ledger. As a representation of digital or non-digital assets, an NFT showcases digital items. For illustration, an NFT may look like a GIF, digital art, collectibles, music, or videos [2]. NFTs can cover real-world objects such as

the title to a car, invoicing with tokens, tickets for a live event, legal records, and signatures. This paper aims to provide students with a secure way to store their ideas and applications (in chunks) using NFTs (more on this in later sections).

2.1.1. Mining NFTs

There can only ever be one owner of an NFT. The unique ID and information that no other token can reproduce are used to manage ownership. Smart contracts that determine ownership and control transferability produce NFTs [2]. Compiled with Ethereum standards (here, ERC-721, the protocol supporting NFTs and operators), anyone can produce or mint NFTs by executing smart contracts [7]. The first NFT standard created on Ethereum, ERC-721, is free and open-source. A smart contract must implement ERC-721 API to maintain and transmit NFTs. Each ERC-721 token has a different token ID and distinct attributes. The owner's identity, a list of authorised addresses, a transfer function that enables the transfer of tokens from holders to buyers, and other helpful functionalities are all included in ERC-721 tokens [8].

The blockchain platform registers these smart contracts and receives this information in the form of blocks. From a high level, the minting procedure involves the following steps:

- New block creation.
- Information verification and validation.
- Uploading data to the blockchain.

2.1.2. Owning NFTs

Adding data to the blockchain requires NFTs with some unique characteristics. Each newly created coin has a special ID that is directly connected to a single Ethereum address. They cannot be exchanged for other tokens in a straight fashion (1:1). One Ethereum, for instance, is the same as another. With NFTs, this is not the case. Each token has a unique owner, and it is simple to confirm this information. They may be purchased and traded on any NFT market powered by Ethereum because they are Ethereum-based. Therefore, if a person owns an NFT,

- It is simple to indicate ownership.
- Verifying the ownership of an NFT is analogous to demonstrating that they have ETH in their account.
- Suppose one buys an NFT, and their public address can transfer ownership of the token to one's wallet. This token demonstrates that the digital file they have copied is the original.
- Their private key serves as ownership documentation for the original.
- The certificate of authenticity for that particular digital object is the public key of the content producer.
- The public key of the token's authors is a permanent part of its history. By proving that the token they own was produced by a certain person, the creator's public key might raise the token's market value.
- Signing messages to demonstrate ownership of the private key underlying the address is another approach to proving NFT ownership.
- Their private key serves as ownership documentation for the original, as already indicated. This indicates that the NFT is controlled by the private keys hidden behind that address.
- Without disclosing their private keys to anyone, they may use a signed message to demonstrate their ownership of the NFT.
- It is impossible to adjust NFTs in any manner. They can be sold, in some cases bringing in resale royalties for the original author.
- Alternatively, an NFT owner can keep them forever, content in the knowledge that the Ethereum wallet is protecting their asset.

2.1.3. Selling NFTs

If an NFT is developed:

- Authorship can be simply established.
- The level of scarcity is chosen.
- Each time it is sold, royalties might be received.
- On any NFT market or from peer to peer, a person can sell an NFT, do not have to use anyone as an intermediary, and they are not restricted to any platform [7].

2.2. Developing Non-Fungible Tokens

NFTs' capacity to mint the ownership of digital assets has revolutionised how artists and developers earn a living, and how people buy, trade, and interact with art. NFTs' being tied in with blockchain technology has grown beyond investments in Ethereum and other cryptocurrencies [9]. The amount of money changing hands for art backed by NFTs has the art industry, technologists, software developers, and bankers taking notice.

Because of Beeple's large sales of around USD 28.9 million or 4700 Ethereum for Human One art, the most common usage of NFTs is for artwork [10]. NFTs are so common in art because digitally native artists can place a scarcity stamp on their creations composed of pixels. They allow for artists to earn more than what they would outside the fine-art market [11].

Creators are often rewarded only when they sell a piece of artwork; if the artwork's new owner sells it to someone else, they receive profits, and the artist receives nothing. NFTs, on the other hand, employ smart contracts to verify ownership and conditions. These agreements involve paying royalties to the original artist each time the artwork changes hands. The smart contracts and royalties present an appealing proposition to artists worldwide (as indicated by Seyi Awotunde) in the marketplace for art supported by NFTs. Designers can, thus, earn a residual, lifelong income from each piece of art that they produce. As a result, full-time artists may devote more time to creating art than working or freelancing to pay the expenses [12].

NFTs are interesting to artists because they are more straightforward, quicker, more democratic, and significantly more appealing than the old art industry paradigm. Artists must attend art school and work their way up the ladder. If they are lucky, a mid-tier gallery discovers them after a few years. They are completely reliant on gallery directors to display and sell their art. Only a few people ever reach the top of the pyramid. Even if they do, success has a cost. Art galleries frequently charge a 50% fee on each transaction [13].

However, NFTs offer alternative possibilities. Any artist can create an NFT for their work. They establish their rates on online user-friendly NFT marketplaces such as OpenSea and Foundation. They have complete control over the promotion of their work via social media, and they keep all revenues other than the minimal transaction costs for selling an NFT [14–24].

The functionality of NFTs that pay royalties is hard-coded into the blockchain smart contract. Royalties are paid out automatically after the smart contract is set up on the backend. There are no sophisticated payment networks, invoicing, or logistics to deal with for artists. According to Chester (2019), collectors gain as well. NFTs, unlike actual art, are simple to keep and safeguard since ownership is validated and protected on the blockchain. It is also simple to move assets electronically between platforms and devices [15,16].

2.3. Storing Non-Fungible Tokens

Given that these collectibles are digital, physical goods such as NFT trading cards are often mined by the NFT collector. However, digital asset storage is more complicated. Because a digital asset can be lost forever relatively simply (e.g., by being inadvertently wiped due to human error or accident owing to hardware damage), methods for the persistent storage of assets represented by NFTs have arisen.

In contrast to actual tokens, digital assets represent off-chain transactions, which are expensive. Registering or storing a megabyte (MB) picture on the Ethereum blockchain cost

over USD 13,000 as of July 2020. To connect two blockchain-based tokens and digital assets stored in external storage systems, NFT platforms employ various methods of associating the token with the asset. In its primary form, one such reference can be a web connection supporting the token in its metadata.

There are primarily two digital-asset storage systems represented by NFTs: distributed storage infrastructures and centralised storage solutions. IPFS, the most extensively used storage system, is distributed and is where the assets of top crypto collectible markets such as Rarible.com and Foundation are. Apps are housed by default. On the other hand, the Origin NFT Launchpad (Origin Protocol Directly, 2021) platform is an example of a centralised storage system. Although token transactions occur on the Ethereum platform as usual, when an NFT is created and sold through the Roots NFT Launchpad, the item represented by this NFT is instead housed on the company's centralised servers [22–24].

3. Proposed Framework

3.1. Mechanism of Action–Approach

In Pakistan, the average middle-class student is not able to hold computer science degrees because of costly machines and expensive software. Students copy their projects from online resources with no practice and fail in their careers. This mechanism assists students in using applications on online networks while keeping the origin of their ideas private. In a nutshell, this paper presents a prototype of NFTs that would be further polished to save and utilise applications in a decentralised manner, as shown in Figure 1.

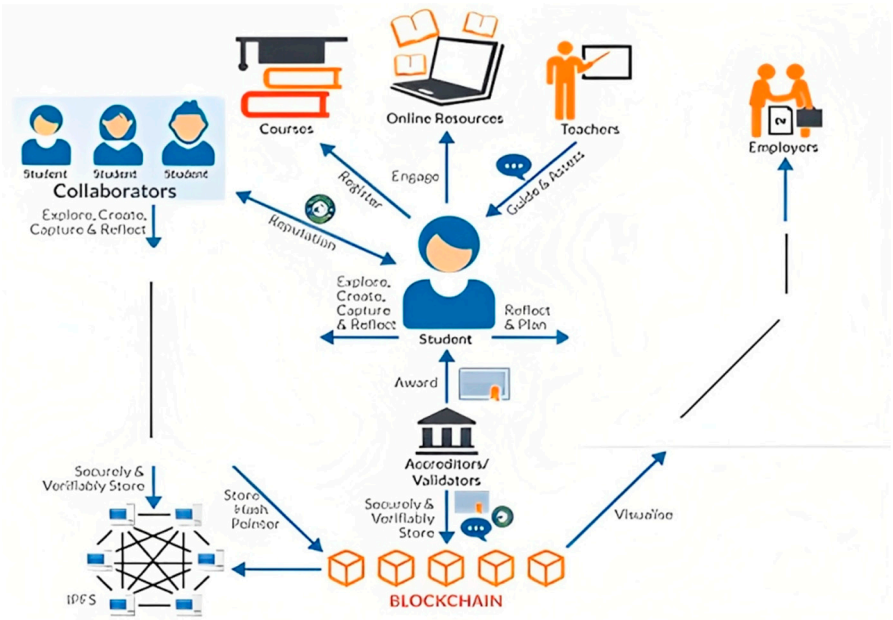

Figure 1. Proposed idea of storing applications on NFTs.

The idea proposed in the above conceptual model shows how a student can learn from their institute whether online or onsite, and receive rewards at the end of the learning period. When students participate in an IT project, blockchain (NFT) technology lets them work on a decentralised network where they can share their applications, executive files, APIs, frameworks, and modules. Sharing occurs in blocks that combine to form chains. This chain runs under the IPFS model (described above). Not only do they start sharing their work, but they also keep their project secure and verified with participant names. This authentication lets them visualise their ideas and show their implemented projects to reputable employers, which could help them in securing the best career in their fields, as shown in Figure 2.

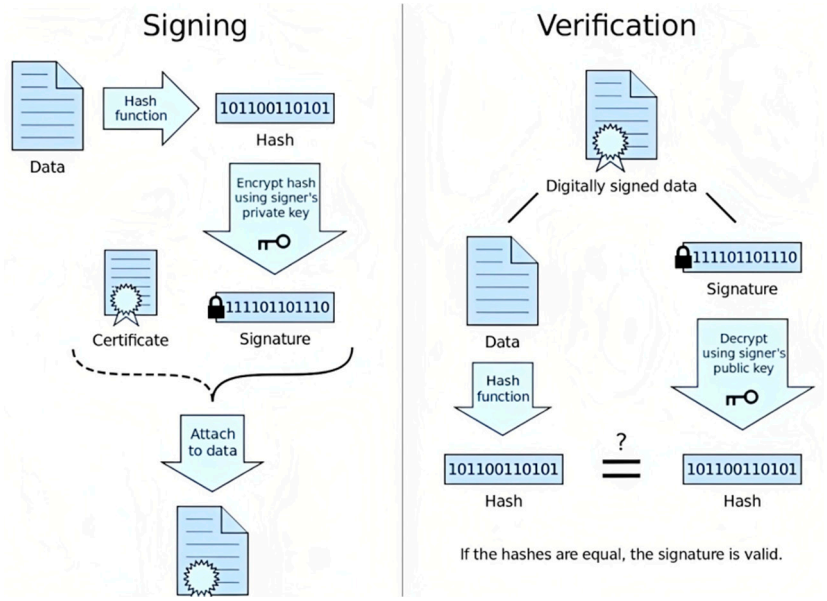

Figure 2. Validation and verification of NFTs.

The unique data of NFTs simplify verifying and authenticating their and the transfer of tokens between owners. NFTs can store many sorts of files and media, but not documents, including executive files, modules, and frameworks. Considering the technology, this paper provides IT professionals with a new NFT approach and business policies that solely belong to the information technology domain. Thus, the concept is comparable to metadata (NFT data).

3.2. Proposed NFT Mechanism

IUn this section, we present a structure for submitting NFT-based applications and storage systems. We further examine the distributed and dependable infrastructure presented for creating NFT-based storage applications. The storage, authentication, verification, blockchain, and application layers are the five core levels of the suggested structure, as shown in Figure 3. The broad principles and specifics of each layer are discussed below (as shown in Figure 4).

3.2.1. Storage Layer

Decentralised storage networks are becoming more prevalent in many information systems that show continual data growth in blockchain technology. With the advanced technology of decentralised storage networks, anyone can enjoy the following benefits:

1. Saving money is accomplished by best using the available storage.
2. Multiple copies are maintained on different nodes, preventing congestion on central servers and accelerating downloads.
3. Keeping data under owners' names.

This layer provides an infrastructure for storage with distinctive qualities for applications that students can store. These qualities are unique, and non-fungible-token metadata offer details about a token ID. On- or off-chain storage can hold NFT metadata. On-chain refers to the metadata being directly included in the tokens' token representation in an NFT's smart contract. Off-chain storage, on the other hand, entails hosting the metadata independently.

Although they offer decentralisation, blockchains are costly to store data on and never enable data removal. For instance, many projects' metadata are kept off the chain due to the Ethereum blockchain's existing storage restrictions and expensive maintenance costs. The ERC721 standard [25], which includes the Token_URI function, is used by developers. This technique informs programmes where the metadata for a particular item are stored.

InterPlanetary File System (IPFS), Pinata, and Filecoin are the three current off-chain storage options, and our framework is proposed for IPFS.

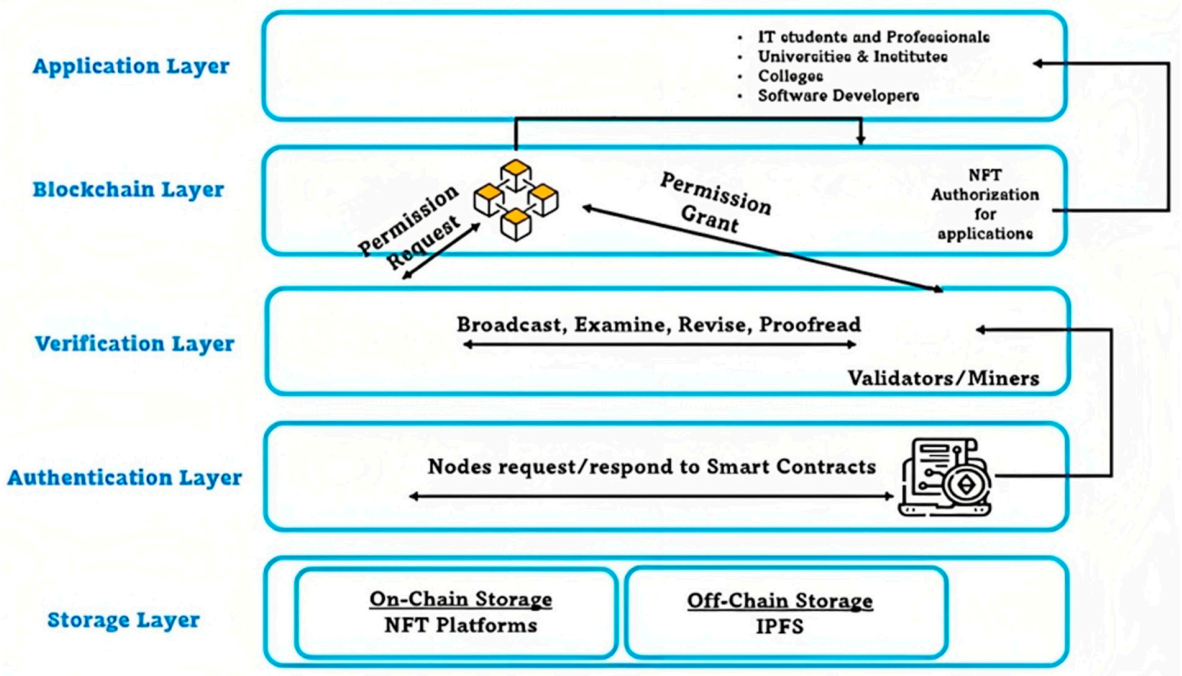

Figure 3. Layers for storing applications on NFTs.

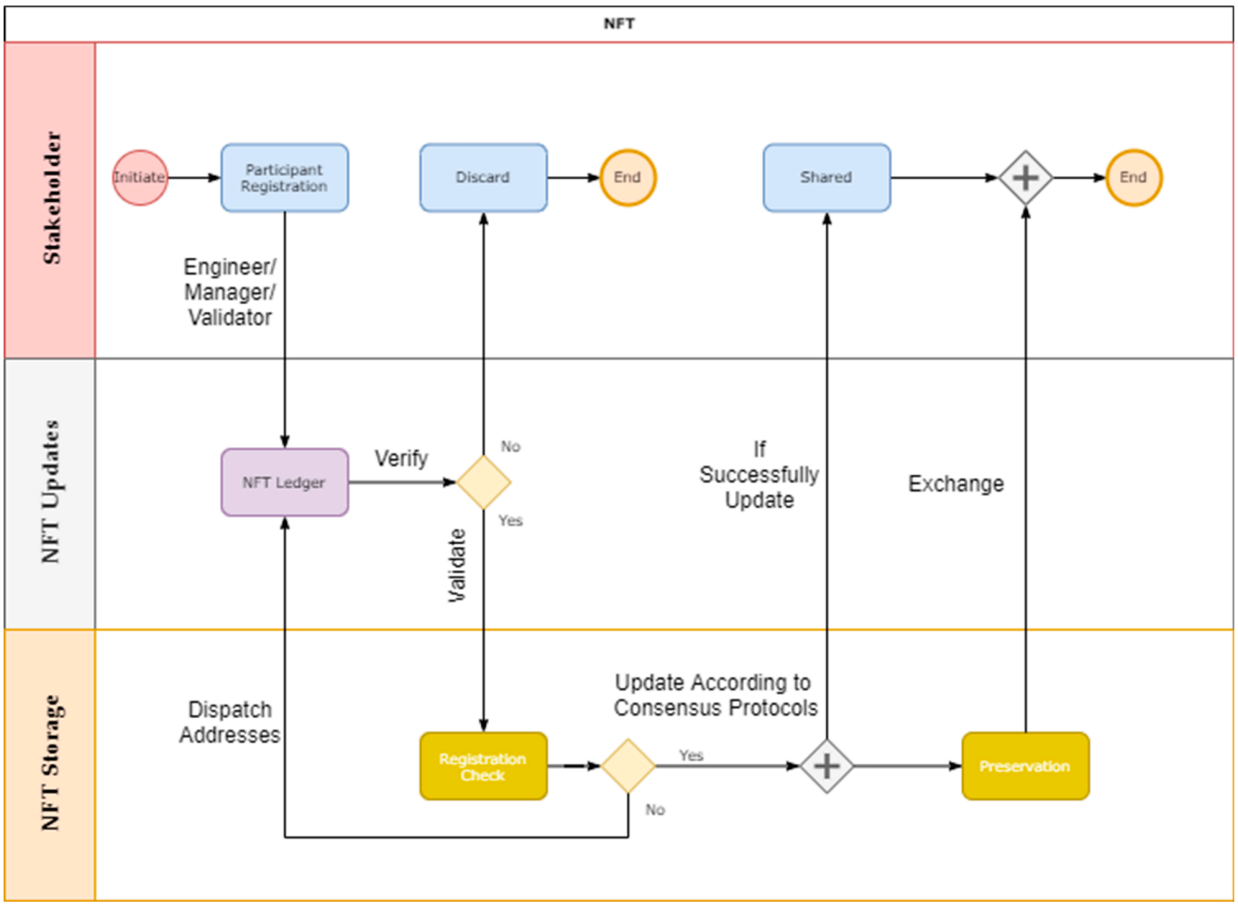

Figure 4. Sequence diagram of proposed NFTs.

3.2.2. IPFS

A peer-to-peer hypermedia protocol for decentralised media content storage is called IPFS. Given the high cost of hosting NFTS-related media files on the blockchain, IPFS may be the most cost-effective and efficient option. Gita and BitTorrent-inspired technologies such as the Block Exchange System, Distributed Hash Tables (DHT), and Version Control System are combined in IPFS. DHT is used to organise and manage metadata on a peer-to-peer network.

In other words, objects that the hash values stand for must be mapped to them. When storing an object such as a file, IPFS creates a hash value that begins with the Qm prefix and serves as a reference to that particular item. Objects over 256 KB are broken up into smaller chunks of up to 256 KB. To link all the blocks that are part of the same item, a hash tree is employed through Kamdelia DHT. The Block Exchange Mechanism (Bit Swap) is a system for exchanging blocks that was inspired by BitTorrent. Asymmetric encryption guards against unwanted access to data stored on IPFS27.

- Concerning the content, when users upload data to NFT storage, they are given a content identifier (CID), which is the content's IPFS hash. CIDs are the specific fingerprints of the data and global addresses that may be used to refer to them no matter how or where they are kept. Since CIDs are produced from the content itself, using them to reference NFT data prevents issues such as weak connections and "rug pulls".
- Demonstrable storage: Filecoin is used by NFTs, offering storage for decentralised data for a long time. To ensure the longevity and persistence of NFT data over time, Filecoin employs cryptographic proofs.
- Durable retrieval: these data may be accessed directly in the browser using any public IPFS that stores Filecoin and IPFS data.

3.2.3. Authentication (Identity Protection) Layer

Because of the public chain infrastructure, the authentication layer helps decentralised identity (DID) prospects. Users may gather login information from various project partners and store it in a digital wallet. Following the identification and access management (IAM) procedure, a verifier uses these credentials to confirm a person's legitimacy using a blockchain-based ledger. DID enables people to oversee their identities.

Infringements on intellectual property and copyright are also brought on by a lack of NFT verifiability, although the chain of custody may be followed to the creator's public address to see if a related idea left that location. However, there is no easy and reliable technique to determine the reliability of an NFT producer. If there is no such verification included in an NFT, the NFT merely demonstrates ownership over the NFT itself.

A solution to this issue is self-sovereign identity (SSI). A new identity architecture for the Internet is guided by SSI standards. SSI apps provide durable identities for users with private and selective information disclosure using public-key cryptography and public blockchains, with an emphasis on privacy and security interoperability. Blockchain technology provides a way to build trust and transparency, and a safe and publicly verifiable Know Your Customer (KYC) system. With the help of the blockchain architecture, data may be combined from many service providers into a single, cryptographically secure, and immutable database without the need for a third party to confirm the accuracy of the data. The suggested platform creates smart contracts for executive files and applications that operate on the blockchain as software to receive and transmit transactions. With a complete KYC procedure, they provide unchangeable customer identification in private. An NFT is created on the blockchain as a certificate of verification when KYC is approved.

3.2.4. Verification Layer

Only identified nodes with permissions can read and write to the distributed ledger in blockchains. Nodes have a variety of responsibilities and permissions that they can exercise. As a result, a distributed system may be created to serve as the designated node

for awarding authorities. Here, a high-level conceptual description of the system is given. This layer has the following levels:

1. Digitalisation: the applications that students create are virtual.
2. Recording: if they are available to the public on a blockchain network, miners may reject the idea and use the innovations themselves.

This can, at least, render consensus to be less reliable and motivate miners to act inappropriately. To avoid this, the innovator should first use proof of existence to privately document their discovery. The storage application document's hash is created by the developer and entered into the blockchain. The timestamp and the hash are made publicly accessible to others as soon as they are entered into the blockchain. The developer can always provide evidence of the project's validity.

3.2.5. Validation

The developers develop NFTs for their application, and publish them to miners and validators during this step. Some identified nodes, such as miners, verify NFTs before storing them on the blockchain. Miners cannot be incompetent public figures, since the application validation process is specialised. Additionally, there are not enough files for the network to be completely decentralised. As a result, miners may be associated with specialists who have received certification from their institutes. They must be given a digital certification by developers proving their qualification to serve as storage applications.

3.2.6. Electronic Certificate

Digital certificates are electronic credentials used to confirm the online identities of networked organisations. They typically contain both the owner's identification and a public key. They are granted by certification authorities (CAs) that are required to confirm the identity of the certificate holder. Cryptographic keys for signing, encrypting, and decrypting are contained in certificates. Public-key certificate formats are defined by the X.509 standard [26], which is signed by a certificate authority. The structure and several fields of the X.509 standard include:

1. Version: the CA states that validators can select the version that students prefer.
2. A certificate for a serial number.
3. Signature method identifier for indicating authority.
4. Issuer name.

3.2.7. Application Layer

The objective is to transfer intellectual property assets to a decentralised, secure blockchain network that is digital, facilitating small and medium-sized businesses to commercialise students' projects. With the use of smart contracts, NFTs may define and agree on the terms of use and ownership without paying the high legal costs associated with conventional IP transfers. This would facilitate students receiving financing, since they would more readily use the previously hidden value of their portfolios.

4. Challenges, Limitations, and Discussion

Many of the problems ailing contemporary e-learning systems have fascinating ideas in the legal and economic literature that provide what appear to be simple fixes. However, many alternatives could result in significant administrative hiccups, and impose significant, ongoing financial constraints on institutions and their customers. Many of these concepts are now administratively possible thanks to an NFT-based application storage system, which also enables their gradual, scalable, and open examination.

Additionally, an NFT-based application storage solution would facilitate IT experts all around the world sharing accurate information, lessening the workload for auditors and potentially even quickening harmonisation efforts. The complete transparency of these prizes as a reward for students' accomplishments is of great importance to technical

experts. An NFT-based application storage system can eliminate present copy/paste and plagiarism problems, and processes from an organisational standpoint by rendering them more effective, quick, and easy for applicants without sacrificing the quality of student-generated ideas.

Working Hierarchy of the Proposed Blockchain Distributed Application (DApp)

In the proposed NFT design, the blockchain layer functions as an intermediate layer between the verification and application layers. The suggested architecture includes a blockchain layer that manages IP. Switching to a blockchain-based storage system as an NFT records system allows for implementing several previously recommended enhancements to the present storage systems in a flexible, scalable, and transparent way, as shown in Figure 5.

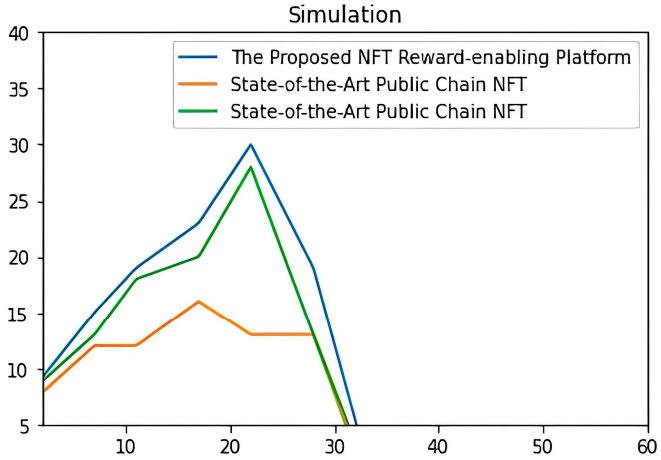

Figure 5. Simulation of the proposed NFT (1), where the *x*-axis and *y*-axis define the cost consumed with respect to time.

On the other hand, we may employ a variety of blockchain systems, such as Tezos, Flow, EOS, and Ethereum. On the basis of their consensus process, blockchain systems may be divided into two primary categories: permissioned (private) and permissionless (public). Any node can take part in a peer-to-peer network on a public blockchain, which is completely decentralised. Without the approval of the other nodes in the network, a node may quit the network.

In a private blockchain, nodes need specific access or authorisation to obtain network authentication. One of the most well-known private blockchains is Hyperledger, which only permits authorised users to join the network after authentication. This offers security to a collection of organisations that do not fully trust one another but are working towards the same goal, such as exchanging information. A permissioned blockchain network allows for the adoption of Byzantine fault-tolerant (BFT) consensus by all participants. A membership identity service provided by Fabric controls user IDs and validates the network users, as shown in Figure 6.

Members can retain privacy and confidentiality since they are not aware of one another's actions, although they know each other's identities. Private blockchains, which are more secure, have piqued the curiosity of many banks and financial institutions, which think that these platforms could upend the present centralised systems.

The following procedures are used to implement an application's storage as an NFT solution for IP management on the blockchain layer:

- The platform welcomes new creators.
- IP is uploaded by creators to the blockchain network.
- Requests by consumers to utilise the content.
- A blockchain is used by organisations to safeguard copyrights and resolve associated issues.

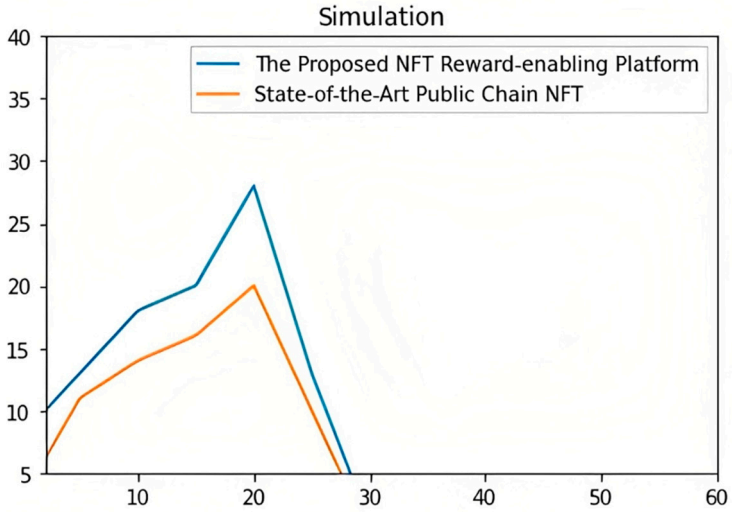

Figure 6. Simulation of the proposed NFT (2), where the *x*-axis and *y*-axis define the cost consumed with respect to time.

5. Conclusions

Strong timestamping, the possibility of smart contracts, and proof of existence are all provided by blockchain technology, allowing for the development of an environment that is accessible to everybody, transparent, distributed, cost-effective, and robust, with each transaction being auditable. On the other hand, the blockchain is unquestionably beneficial to the IP sector and helps students. Copyrights are aided when blockchain technology's inherent properties are applied to the IP domain. This study focused on a conceptual framework for presenting NFT-based storage applications with a thorough analysis of a variety of topics, including history, model components, token standards for application domains, and research obstacles. The presented structure consists of four basic layers: application, storage, authentication, and verification. The main goal of this storage applicational system is to offer an NFT-based method that educational sectors might employ as a decentralised, impenetrable, and trustworthy network for rewarding students all over the world.

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