MINISTRY OF SCIENCE AND HIGHER EDUCATION OF THE REPUBLIC OF KAZAKHSTAN

INTERNATIONAL INFORMATION TECHNOLOGY UNIVERSITY

FACULTY OF COMPUTER TECHNOLOGY AND CYBERSECURITY

**Andronov M.D.**

**Abilov M.**

**Chiverdin E.A.**

**Development of a Blockchain-Based Gaming System**

**DIPLOMA PROJECT**

**Major 6В06110 – Software Engineering**

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AND SOFTWARE ENGINEERING

Approved

Head of Department,

Full name

« » 20

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**Development of a Blockchain-Based Gaming System**

Major 6В06110 – Software Engineering

Done by: Andronov M.D.

« » 20

(signature)

Abilov M.

« » 20

(signature)

Chiverdin E.A.

« » 20

(signature)

Research Supervisor: Zhakypbekov S.Z.

« » 20

(signature)

Reviewer: Armankyzy R.

« » 20

Almaty 2024

(signature)

International Information Technology University

Faculty Of Computer Technology And

Cybersecurity

Major 6В06110 – Software Engineering

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Students

Andronov M.D., Abilov M., Chiverdin E.A.

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Research Supervisor

(signature)

Assignment received by

(signature)

Diploma Work/Project Writing Schedule

# Andronov M.D., Abilov M., Chiverdin E.A.

Title: Development of a Blockchain-Based Gaming System

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Student: Andronov M.D.

(signature)

Student: Abilov M.

(signature)

Student: Chiverdin E.A.

(signature)

Research Sepervisor : Zhakypbekov S.Z.

(signature)

R.T. Date « » 20

ABSTRACT

The project is dedicated to the development of a blockchain-based gaming system integrating Play-to-Earn (P2E) mechanics. The goal is to create an indie game with elements of RPG-roguelike and platformer, where players receive NFTs for completing key tasks, which can be used in the game, sold or exchanged. Binance Smart Chain (BSC) is used for implementation due to its low fees and high transaction speed. Data is stored on IPFS using Pinata, ensuring decentralization and security. Integration with Moralis, Alchemy and MetaMask tools simplifies interaction with the blockchain, asset management and user authentication. The project is aimed at introducing a decentralized economy into the gaming environment, increasing user engagement and providing real value to in-game achievements.

АННОТАЦИЯ

Жоба Play-to-Earn (P2E) механикасын біріктіретін блокчейн негізіндегі ойын жүйесін дамытуға арналған. Мақсат - ойыншылар ойында пайдалануға, сатуға немесе айырбастауға болатын негізгі тапсырмаларды орындау үшін NFT алатын RPG-рогуге ұқсас және платформа элементтері бар инди ойынын жасау. Binance Smart Chain (BSC) төмен комиссиялары мен транзакция жылдамдығының жоғары болуына байланысты іске асыру үшін пайдаланылады. Деректерді сақтау орталықсыздандыру мен қауіпсіздікті қамтамасыз ететін Pinata көмегімен IPFS жүйесінде жүзеге асырылады. Moralis, Alchemy және MetaMask құралдарымен интеграция блокчейнмен өзара әрекеттесуді, активтерді басқаруды және пайдаланушының аутентификациясын жеңілдетеді. Жоба ойын ортасына орталықтандырылмаған экономиканы енгізуге, пайдаланушылардың қатысуын арттыруға және ойын ішіндегі жетістіктерге нақты құндылық беруге бағытталған.

АННОТАЦИЯ

Проект посвящён разработке игровой системы на основе блокчейна, интегрирующей Play-to-Earn (P2E) механику. Цель — создание инди-игры с элементами RPG-roguelike и платформера, где игроки за выполнение ключевых задач получают NFT, которые можно использовать в игре, продавать или обменивать. Для реализации используется Binance Smart Chain (BSC) из-за её низких комиссий и высокой скорости транзакций. Хранение данных осуществляется на IPFS с помощью Pinata, обеспечивая децентрализованность и безопасность. Интеграция с инструментами Moralis, Alchemy и MetaMask упрощает взаимодействие с блокчейном, управление активами и аутентификацию пользователей. Проект направлен на внедрение децентрализованной экономики в игровую среду, повышая вовлечённость пользователей и предоставляя реальную ценность внутриигровым достижениям.

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INTRODUCTION

The integration of blockchain technology into various industries has paved the way for groundbreaking innovations, particularly in gaming. Blockchain’s decentralized nature, coupled with its ability to secure and transparently manage digital assets, has revolutionized how games are developed and monetized. This project focuses on creating a blockchain-based gaming system that incorporates the Play-to-Earn (P2E) model, offering players real ownership of in-game assets through Non-Fungible Tokens (NFTs).

The proposed game combines elements of RPG-roguelike and platformer genres, providing an engaging experience where players earn unique NFTs as rewards for achieving milestones, such as defeating bosses or completing levels. Unlike traditional games, where in-game items are confined to a single ecosystem, this project leverages blockchain to tokenize these assets, allowing players to trade, sell, or utilize them across different platforms.

The system is built on Binance Smart Chain (BSC), chosen for its low transaction fees and high processing speeds. Tools like Moralis, Alchemy, and MetaMask simplify blockchain integration, enabling seamless wallet authentication, transaction management, and NFT handling. Additionally, IPFS, supported by Pinata, ensures the secure and decentralized storage of NFT metadata, enhancing transparency and reliability.

This project aims to create a robust digital economy within the game, fostering player engagement and offering real-world value for in-game achievements. By merging innovative blockchain solutions with immersive gameplay, the project sets a new standard for decentralized gaming systems.

1. THE POPULARITY OF BLOCKCHAIN
   1. Reasons for Popularity

Blockchain technology has gained significant traction across multiple industries due to its fundamental characteristics of decentralization, security, transparency, and efficiency. At the heart of blockchain's appeal is its decentralized nature, which ensures that there is no single point of control. Unlike traditional systems where a central authority (like a bank or government) has the power to manipulate or control data, blockchain relies on a distributed network of nodes. This decentralization eliminates the need for intermediaries, reduces the chances of data manipulation, and promotes a more trustworthy environment (Narayanan et al., 2016).

Blockchain’s security is another key reason for its growing popularity. It utilizes cryptographic techniques to safeguard data, making it tamper-resistant and verifiable. This is achieved through hash functions, where each transaction is encrypted and linked to the previous one, creating a secure chain of records. The immutability of blockchain ensures that once data is entered, it cannot be altered without altering all subsequent blocks in the chain, making fraud and corruption significantly harder to achieve (Crosby et al., 2016). This has made blockchain attractive in fields that require high data integrity, such as finance, healthcare, and logistics.

Another compelling feature of blockchain is transparency. Because every transaction is recorded on a public ledger accessible to all participants, it becomes difficult to hide or falsify information. Unlike centralized databases where access to data may be restricted, blockchain’s open ledger allows participants to verify the authenticity of data independently (Tapscott & Tapscott, 2016). This has led to blockchain's adoption not just in financial applications but also in areas like supply chain management and digital asset tracking.

Blockchain is also gaining traction due to its immediacy and low operational costs. Traditional systems, particularly in banking, can be slow due to intermediaries and international transfers. Blockchain, with its peer-to-peer structure, enables instantaneous transactions, often at a fraction of the cost. For instance, blockchain-powered cryptocurrencies like Bitcoin can be transferred between users across the globe within minutes, whereas traditional bank transfers may take days and involve costly fees (Narayanan et al., 2016).

Thus, blockchain is transforming industries by offering solutions that enhance efficiency, reduce fraud, and provide a higher degree of trust in transactions.

* 1. Blockchain vs Traditional Systems

The key difference between blockchain and traditional systems lies in their structural design. Traditional centralized systems, such as banking systems or online payment platforms like PayPal, rely on a central authority to control and validate transactions. This centralized approach creates a single point of failure: if the server or authority in charge is compromised, all user data or transactions are vulnerable. For example, a bank can freeze or modify a transaction without users' consent or knowledge, and cyberattacks could expose sensitive personal data (Narayanan et al., 2016).

On the other hand, blockchain technology operates on a decentralized system, where data is spread across multiple nodes. Each node maintains a copy of the blockchain, and all transactions are validated through consensus algorithms. This makes blockchain much more resilient to attacks. If one node is compromised, the rest of the network remains intact, and no single entity has control over the entire system. The decentralized model also enhances security and trust, as the data is more difficult to tamper with, and there is no central authority to override the network’s decisions.

Moreover, data transparency in blockchain is unparalleled. In traditional systems, users typically do not have access to their transaction history, and only the parties involved (e.g., the bank and the account holder) can view or validate the transaction. However, in blockchain, all transactions are publicly recorded on the distributed ledger, allowing anyone to view transaction details. This open model ensures transparency, reducing the chances of fraud or hidden manipulation (Tapscott & Tapscott, 2016).

For instance, a bank transfer in traditional systems often requires several intermediaries, which can delay transactions and incur additional fees. Conversely, blockchain transactions, like those involving cryptocurrencies (e.g., Bitcoin), are validated through the network’s consensus mechanism and can be processed almost instantly with significantly lower fees.

Furthermore, blockchain offers provable data integrity. Each transaction is cryptographically signed, making it impossible to alter past transactions without altering the entire blockchain. This is in stark contrast to centralized databases, where data can be easily modified or manipulated by an administrator. Blockchain ensures that once a transaction is recorded, it is immutable and serves as a permanent record, contributing to the trustworthiness of the system (Narayanan et al., 2016).

Overall, the blockchain model provides a more secure, transparent, and efficient alternative to traditional centralized systems, making it particularly valuable in environments that require trustless transactions and data integrity.

1. NFTS (NON-FUNGIBLE TOKENS)
   1. What Are NFTs?

Non-Fungible Tokens (NFTs) are a unique class of digital assets that exist on a blockchain, acting as proof of ownership and authenticity for various types of assets. Unlike cryptocurrencies like Bitcoin or Ethereum, which are fungible (meaning one unit is equivalent to another of the same value), NFTs are unique and indivisible, making them irreplaceable and non-transferable at an equal value. This makes NFTs particularly useful for representing digital goods like art, collectibles, and in-game items. NFTs are typically built on blockchain platforms like Ethereum, but other blockchains like Binance Smart Chain and Solana also support them. (see Figure 2.1)

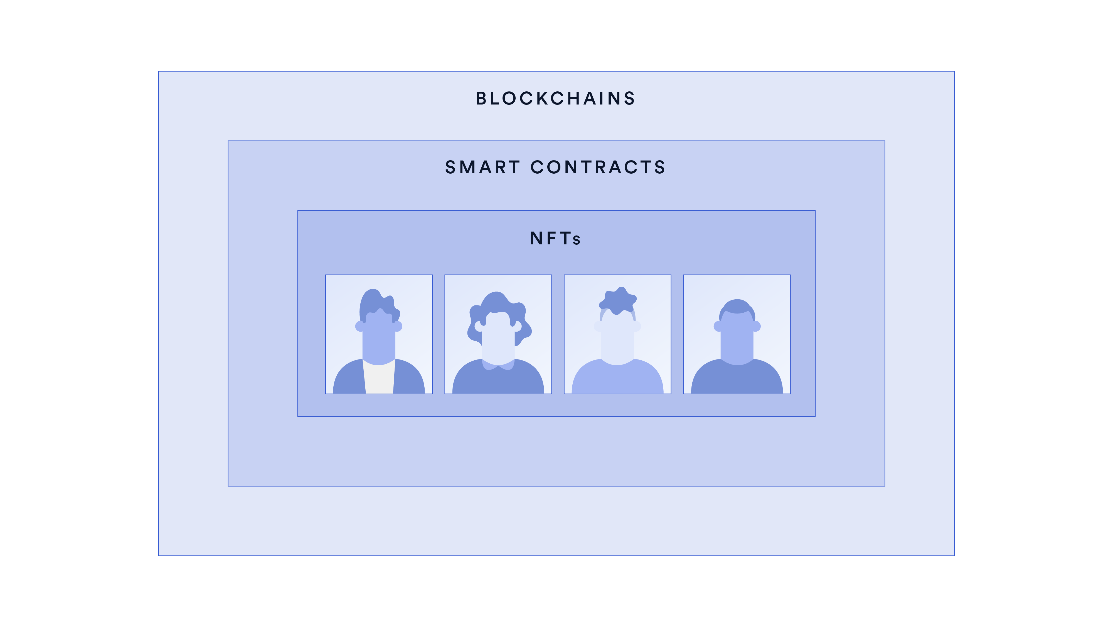


Figure 2.1 – Represent of NFT in blockchain system

NFTs have revolutionized industries such as digital art, where creators can tokenize their works, providing a method of direct ownership and traceable provenance to buyers. They also play a crucial role in the gaming industry, where in-game items like skins, weapons, or characters can be converted into NFTs, giving players true ownership and the ability to trade or sell these items outside the game environment. This contrasts with traditional games, where in-game assets are controlled entirely by the game developers, limiting players' ability to capitalize on their items. NFTs have expanded the concept of digital ownership and helped fuel the growth of Play-to-Earn (P2E) games, where players earn valuable assets as part of the gaming experience.

Some of the key benefits of NFTs include:

- Ownership and Control: Users truly own the digital asset, which they can trade, sell, or transfer.

- Provenance: NFTs ensure the traceability and history of ownership, which is recorded on the blockchain, providing proof of authenticity.

- Interoperability: NFTs can be used across different platforms and games that support the same blockchain standards, increasing their value and utility.

* 1. Unique and Indivisible Nature

One of the key features of NFTs is their indivisible nature. Unlike cryptocurrencies, which can be divided into smaller units (e.g., one Bitcoin can be split into smaller satoshis), NFTs cannot be subdivided. This characteristic makes them ideal for representing unique, collectible, and irreplaceable items such as artwork, digital real estate, or rare collectibles.

The uniqueness of NFTs is another defining characteristic. Each NFT is minted with a distinct cryptographic identifier, ensuring that no two tokens are the same. This makes NFTs perfect for creating digital scarcity — a concept that was traditionally difficult to apply in the digital world, where content could be easily copied and reproduced. For example, an artist might mint a digital painting as an NFT, making it one-of-a-kind and giving the buyer the assurance that they own the only original version of the artwork. The uniqueness of NFTs is also reflected in their metadata, which includes information about the item (e.g., the creator, the date of creation, and its history of ownership) that is securely recorded on the blockchain.

NFTs provide several benefits in this regard:

- Non-fungibility: Each NFT is different, which allows it to represent rare or unique items. This is crucial for sectors like digital art and collectibles, where rarity is key to value.

- Ownership Verification: The indivisible and unique nature of NFTs ensures that the ownership is verified and traceable, minimizing the risk of counterfeiting and unauthorized duplication.

Examples of NFT use cases include digital collectibles like NBA Top Shot Moments, which are tokenized video clips of iconic basketball plays, and digital artwork by creators like Beeple, whose NFT artwork sold for $69 million at Christie's Auction House in 2021. These examples demonstrate the growing trend of NFT-based digital assets being recognized as valuable, tradeable items.

1. BLOCKCHAIN SECURITY

3.1 Blockchain Security Key Elements

Blockchain technology is renowned for its robust security, primarily driven by its use of cryptographic algorithms and decentralized consensus mechanisms. These features work together to ensure data integrity, transparency, and resilience against attacks or alterations.

One of the primary security elements in blockchain is the cryptographic hashing technique. When data is recorded in a blockchain, it is first passed through a cryptographic algorithm that converts it into a fixed-length string known as a hash. Each block contains the hash of the previous block, creating a chain of blocks. This structure makes it impossible to alter a single piece of data without changing all subsequent blocks, making the entire blockchain immutable. For example, if someone tries to change a transaction in a block, the hash will change, causing a mismatch with the subsequent block's hash. This makes it immediately obvious that tampering has occurred, rendering blockchain highly resistant to fraud (Narayanan et al., 2016).

In addition to hashing, blockchain relies on consensus mechanisms to validate transactions and secure the network. Proof of Work (PoW) and Proof of Stake (PoS) are the two most widely used consensus algorithms.

In Proof of Work, miners compete to solve complex mathematical puzzles. The first miner to solve the puzzle gets the right to add the new block to the blockchain and is rewarded with cryptocurrency. This process is computationally intensive, making it expensive to attack the network. The PoW system is used in Bitcoin and is known for its high security and decentralization, though it is also criticized for its environmental impact due to the large amount of energy consumed by miners (Nakamoto, 2008).

In Proof of Stake, validators are chosen to add new blocks based on the number of tokens they hold and are willing to "stake" as collateral. Since validators are financially invested in the network’s success, PoS networks tend to be more energy-efficient than PoW systems while maintaining security. Ethereum 2.0 is transitioning from PoW to PoS for these reasons, as PoS offers a less resource-intensive approach to securing the blockchain (Buterin, 2014).

Both PoW and PoS ensure that there is no need for a centralized authority to validate transactions. This decentralized validation, where every participant (or node) in the network has a copy of the ledger, means that no single entity can alter or censor transactions. The system instead relies on a majority consensus to validate and secure transactions. This contrasts with centralized systems, like traditional banking, where a single authority controls and manages data. With blockchain, each participant contributes to the validation process, making the network more secure and resistant to manipulation (Crosby et al., 2016).

Blockchain’s security is also enhanced by redundancy. Since each node in the network has a copy of the entire blockchain, even if one or more nodes are compromised, the network remains intact.

1. TRANSPARENCY IN BLOCKCHAIN

4.1 Public and Transparent Ledger

One of the most compelling features of blockchain technology is its public ledger. This decentralized and distributed ledger records all transactions in a transparent manner, meaning that every participant in the network has access to the full history of transactions. This visibility fosters a high degree of trust and accountability, as anyone can verify the integrity and authenticity of the transaction data without relying on a central authority (Narayanan et al., 2016).

In traditional financial systems, such as banks or payment processors like PayPal, transaction histories are typically closed, meaning that only certain authorized entities can access and review the data. The bank or payment provider has control over this data, and customers must trust that these institutions handle their information responsibly. In contrast, blockchain's open architecture provides an alternative where all participants (nodes) have the ability to access, validate, and review the transaction records. This eliminates the potential for data manipulation or concealment, as any attempt to alter the data would require altering the entire network, a practically impossible task (Tapscott & Tapscott, 2016).

The transparency afforded by the blockchain also means that third parties no longer need to mediate transactions, such as in banking, where external verification is often required to establish trust. Blockchain's transparent nature allows for trustless transactions, where parties can conduct business without needing to know or trust one another, thanks to the security mechanisms of the blockchain itself (Narayanan et al., 2016). (see Figure 4.1.1)

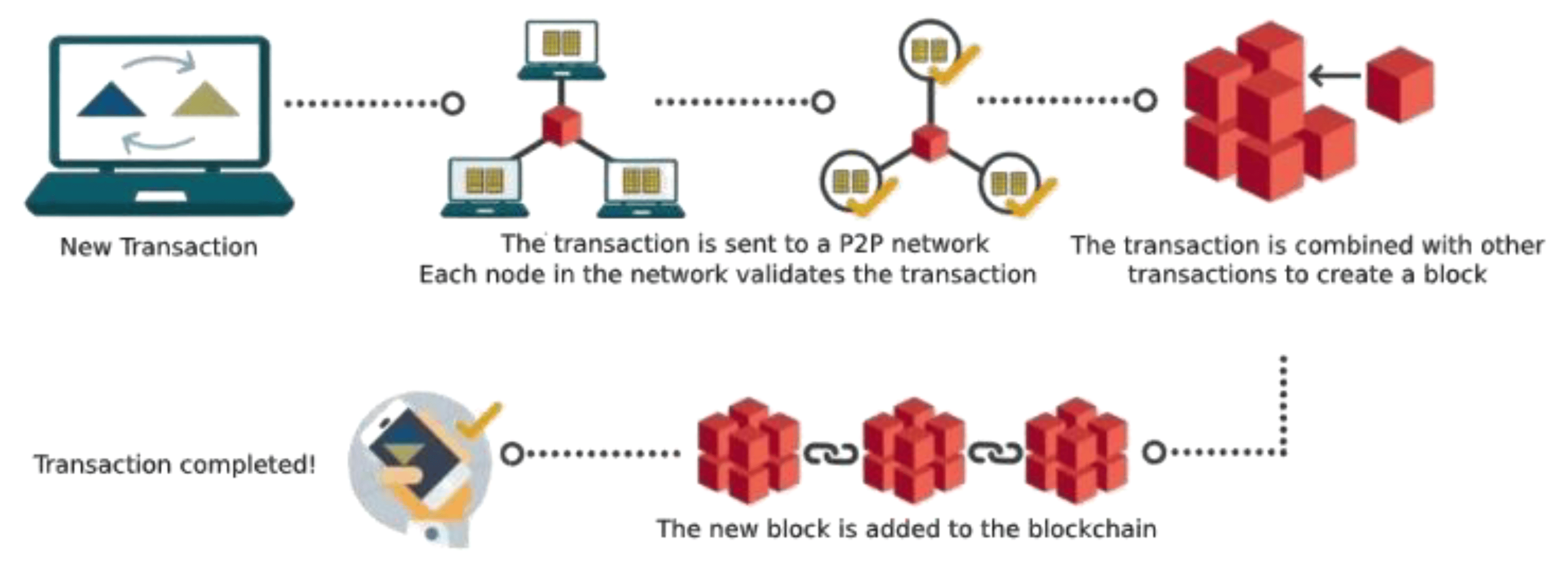


Figure 4.1.1 – Scheme of Transfer Transparency in Blockchain

For instance, platforms like Ethereum and Bitcoin offer the ability to trace the complete history of transactions associated with a particular address or asset, which helps prevent fraud, ensuring that digital assets such as NFTs or cryptocurrencies are traceable and not counterfeit (Buterin, 2014). This is especially important in areas like supply chain management, where transparency is critical for ensuring that goods are sourced, manufactured, and transported ethically and in compliance with regulations.

4.2 Irreversible and Immutable Data

The immutability of blockchain data is another critical feature that sets it apart from traditional systems. Once a transaction is recorded on the blockchain, it becomes permanent and cannot be altered or deleted. This is achieved through the use of cryptographic hashing and block linking, which makes it computationally infeasible to change any single block without altering all subsequent blocks in the chain (Crosby et al., 2016).

This immutability serves as a protection against fraud and tampering. In traditional systems, it is often possible for an entity, such as a bank, to modify a transaction record, correct mistakes, or even reverse transactions. However, on a blockchain, once data has been entered and verified by the network through consensus mechanisms like Proof of Work (PoW) or Proof of Stake (PoS), it is essentially set in stone. For example, if an error is made in a transaction, it is not possible to "delete" or "edit" the record. Instead, a new transaction must be created to correct the mistake, ensuring transparency and accountability in the system (Narayanan et al., 2016).

This permanence of records is highly valuable in industries such as healthcare, finance, and legal services, where data accuracy and trust are paramount. For instance, in the healthcare sector, blockchain’s immutable records can help verify the accuracy of patient data, reducing the risk of fraud or data manipulation in medical records (Tapscott & Tapscott, 2016).

In addition to security, this feature is also an essential tool for auditability. The ability to review all transactions in a blockchain ledger makes it much easier for auditors, businesses, and regulatory bodies to verify financial records, conduct due diligence, or investigate suspicious activity. The irreversible nature of the blockchain enhances the system's credibility and accountability, and allows for real-time auditing, making it an ideal technology for industries that require rigorous oversight.

1. PRACTICAL USE CASES OF BLOCKCHAIN AND NFTS
   1. True Ownership of In-Game Assets

Blockchain technology has redefined ownership in the gaming industry by allowing players to own in-game assets truly and permanently. In traditional gaming systems, items such as weapons, skins, or characters are locked within the game’s ecosystem and cannot be traded, sold, or used outside the game. However, by converting these assets into Non-Fungible Tokens (NFTs), blockchain enables players to transfer ownership to external platforms, opening up new possibilities for trading or selling digital items in real-world markets (Crosby et al., 2016).

NFTs on blockchain offer verifiable ownership of digital assets, making it impossible for third parties to counterfeit or steal the item. These assets are also indivisible, which means that the player’s digital item remains intact and cannot be divided into smaller units. The decentralized nature of blockchain ensures that the ownership data cannot be altered by anyone, including game developers or publishers. A notable example is Axie Infinity, a game that allows players to buy, breed, and trade digital pets called "Axies" as NFTs. These Axies are not just in-game items; they are assets that players truly own and can sell or trade outside the game environment, generating real-world value (Rosenblum, 2021).

Players can benefit from the Play-to-Earn (P2E) model, where NFTs provide economic opportunities that were previously unavailable in traditional gaming. This ownership extends to skins, weapons, and even real estate within games like The Sandbox, where virtual land parcels are tokenized as NFTs and can be traded on open marketplaces (Marr, 2021). This shift toward player ownership disrupts the traditional game model, where players are only tenants of their digital items.

* 1. Blockchain in Game Design

Blockchain has revolutionized game design by introducing new economic structures that reward players for their engagement. One of the most successful examples of this transformation is Axie Infinity, which has created a self-sustaining in-game economy by allowing players to earn cryptocurrency and NFTs. Players can breed, battle, and trade Axies, earning real-world value from their participation in the game. The game runs on the Ethereum blockchain, where each Axie is minted as an NFT, providing true ownership and a direct connection between in-game success and tangible rewards.

The introduction of blockchain in games has also led to the rise of the Play-to-Earn (P2E) model. Unlike traditional gaming, where players invest time and money without receiving any return on their investment, P2E games enable players to earn cryptocurrency or NFTs for completing tasks, defeating enemies, or reaching milestones (Rosenblum, 2021). This model has gained immense popularity, particularly in countries with limited job opportunities, as it offers players a chance to generate real income through their gaming activities.

In addition to Axie Infinity, other blockchain games like Decentraland and The Sandbox have incorporated virtual real estate as part of their economy. Players can buy, sell, or lease virtual properties, with land parcels acting as valuable NFTs. This democratization of virtual assets has turned gaming into a new economic frontier, where players not only participate in digital worlds but also create and trade within them, turning their gameplay into income-generating activities (Tapscott & Tapscott, 2016).

* 1. Supply Chain Transparency

Blockchain's impact extends far beyond gaming and digital assets. It has begun to reshape industries like supply chain management by providing complete transparency and tracking capabilities for goods as they move from production to consumption. The decentralized nature of blockchain ensures that every transaction or movement of goods is publicly recorded, reducing the potential for fraud and ensuring the integrity of the product’s history.

One prominent example is IBM’s Food Trust, a blockchain-based platform that tracks food products through every stage of the supply chain, from farm to table. This system allows consumers and businesses to verify the source and condition of their food, ensuring that products are safe and ethically sourced (IBM, 2021). Blockchain’s ability to securely and transparently record each step in the process provides an auditable trail, making it easier to identify sources of contamination or fraud.

This level of transparency is also beneficial for industries like pharmaceuticals, where blockchain is used to track drugs from manufacturer to patient. In sectors where authenticity is critical, blockchain’s permanent, tamper-proof records offer an unprecedented level of confidence, minimizing the risk of counterfeit goods entering the market.

1. HOW NFTS ACCELERATE PROCESSES IN VARIOUS INDUSTRIES
   1. Speed and Security in Transactions

NFTs (Non-Fungible Tokens) have fundamentally changed how digital assets are owned, traded, and monetized. By offering true ownership of digital assets on the blockchain, NFTs remove the need for intermediaries such as banks, galleries, or auction houses, leading to faster and more secure transactions. This shift enhances efficiency in various industries by creating direct peer-to-peer (P2P) connections. Unlike traditional systems where ownership transfers are often delayed or dependent on third-party verification, NFTs ensure instantaneous transactions and eliminate the risk of fraud, as every asset's provenance is verifiable on the blockchain (Tapscott & Tapscott, 2016).

NFTs accelerate the transfer of ownership by simplifying complex processes. In sectors like art, where ownership verification can be lengthy and costly, NFTs create an immutable record of ownership and authenticity. As a result, artists and creators can bypass traditional intermediaries, ensuring that their work reaches buyers directly. By using smart contracts, NFTs automate the execution of ownership transfers, which reduces delays and human error (Swan, 2015). This shift from traditional to decentralized models speeds up transactions, providing an instantaneous marketplace for assets that previously required third-party verification and approval.

* 1. NFTs in the Gaming Industry

In the gaming industry, NFTs are creating entirely new economic opportunities. Traditionally, in-game assets like skins, characters, or weapons were confined to the game's ecosystem. Players could accumulate these assets, but they had no real-world value and could not be traded or sold outside the game. With the advent of blockchain technology, assets in games are now tokenized as NFTs, allowing players to truly own their items and trade or sell them on external marketplaces. This ownership shift introduces a new economy within digital environments (Rosenblum, 2021).

For example, Axie Infinity, a blockchain-based game, allows players to breed, battle, and trade digital pets called Axies. Each Axie is an NFT, meaning it is unique and owned by the player. Players can sell these NFTs on secondary markets for cryptocurrency, giving them a way to earn real-world value from in-game activities. This Play-to-Earn (P2E) model incentivizes players to engage more deeply with games, as their time and efforts are now directly rewarded with tradable assets (Buterin, 2014).

* 1. New Economies and Monetization Models

NFTs are not limited to gaming—they are also revolutionizing digital art and content creation. Traditional systems for monetizing art and collectibles often involve intermediaries like galleries, auction houses, or online platforms, which take a percentage of the revenue. NFTs enable artists and creators to tokenize their work, allowing them to sell directly to consumers on marketplaces like OpenSea and Rarible, bypassing these intermediaries (Marr, 2021). Moreover, NFTs often come with royalty mechanisms embedded in their smart contracts, ensuring that creators receive a percentage of future sales whenever the NFT is resold. This creates sustainable revenue streams for artists and other content creators, accelerating the flow of money directly back to the creators.

NFTs also streamline intellectual property management and rights distribution. Instead of relying on legal paperwork, contracts, or physical documentation, NFTs can represent a clear, auditable proof of ownership and licensing rights, reducing the time and cost associated with managing intellectual property (Swan, 2015). For example, NFTs in music provide musicians with a way to sell unique rights to their songs or albums directly to fans, eliminating middlemen like record labels.

* 1. Cross-Industry Use Cases

NFTs also extend their capabilities to industries beyond gaming and art. For example, in the supply chain industry, blockchain and NFTs are being used to track products from production to consumption. By tagging goods with NFTs, companies can create immutable records of a product's journey, increasing transparency and accountability. This system could reduce the chance of fraud and ensure that products meet the required quality standards (IBM, 2021). In real estate, NFTs are being used to represent ownership of property or land, providing a secure and transparent way of buying and selling real estate assets (Tapscott & Tapscott, 2016).

1. NFT PLATFORMS: OPENSEA, RARIBLE, FOUNDATION
   1. OpenSea

OpenSea is one of the largest and most popular NFT marketplaces, offering a wide range of digital assets including art, music, virtual real estate, and gaming items. It enables users to create, buy, sell, and auction NFTs across various blockchain networks, including Ethereum, Polygon, and Solana, making it highly versatile for a larger audience. One of the standout features of OpenSea is its multi-blockchain support, allowing transactions in various cryptocurrencies like ETH (Ethereum) and SOL (Solana), with Polygon providing low-cost transaction alternatives for smaller creators (Marr, 2021).

OpenSea charges a 2.5% commission on every transaction, making it one of the most cost-effective platforms for trading NFTs. This marketplace also features robust options for auctioning NFTs and offers special tools for creators to gain visibility, such as verified collections and promotional features (Marr, 2021). Its user interface is intuitive, and it provides community-building tools to engage buyers and collectors, contributing to its position as the dominant NFT marketplace.

* 1. Rarible

Rarible is a decentralized NFT marketplace governed by the RARI token, which empowers its community to influence platform decisions. Unlike OpenSea, which operates in a centralized manner, Rarible’s governance model is community-driven, providing token holders voting rights on decisions such as platform policies, feature updates, and fee structures. This decentralized approach fosters greater community involvement, appealing to users who prioritize autonomy and decision-making power in the NFT space (Schwienbacher, 2021).

Rarible supports a royalty system, allowing creators to earn a percentage of future sales every time their NFT is resold. This ensures long-term revenue for artists, creating a sustainable income stream through secondary market transactions (Schwienbacher, 2021). Additionally, Rarible’s open-source nature encourages innovation, as anyone can contribute to the platform’s development. It positions itself as a more democratic and artist-centric marketplace compared to OpenSea.

* 1. Foundation

Foundation is an exclusive NFT marketplace that focuses on high-quality digital art. It operates on an invitation-only model, where artists need to be invited by existing members to join and sell their work. This curatorial approach ensures that only select, top-tier artists and their creations are featured on the platform, distinguishing it from platforms like OpenSea and Rarible, which offer broader accessibility to a wide range of creators.

The platform primarily uses auctions for NFT sales, which allows artists to potentially sell their work at higher prices due to the competitive bidding process. Foundation also has a royalty system, enabling creators to earn ongoing income from resales of their NFTs, which is a key feature for long-term engagement (Schwienbacher, 2021). This focus on exclusivity and quality has made Foundation a popular choice for high-end digital artists looking for a more refined and dedicated audience.

1. HOW NFTS ARE USED IN GAMING
   1. Traditional vs NFT-Based Ownership

NFTs (Non-Fungible Tokens) represent a significant shift in how in-game assets are owned, traded, and used. In traditional gaming systems, assets such as skins, weapons, and characters are locked within a specific game’s ecosystem. Players may accumulate these items, but they cannot transfer them to other platforms or sell them outside of the game environment. This means that, in traditional systems, players essentially rent the assets from the game developers, who retain full control over the items.

In contrast, NFTs allow players to truly own their in-game assets. Each item is tokenized as an NFT, which is stored on the blockchain. This guarantees that the asset is unique and verifiable, and ownership is recorded in a decentralized manner. As a result, players can trade, sell, or use their NFTs across different games or external platforms. This opens up a broader digital economy where players can profit from the assets they earn or purchase in-game. For example, in a traditional game like Fortnite, skins are merely cosmetic and can only be used within the game. On the other hand, NFTs enable players to monetize or use skins and items across various games, further enriching their gaming experience (Marr, 2021).

* 1. Axie Infinity: A Leading Example

Axie Infinity is one of the most prominent examples of NFT-based gaming. Players breed, battle, and trade Axies, which are digital creatures represented as NFTs. Each Axie is unique, with varying attributes, and is recorded on the Ethereum blockchain. Players earn rewards, such as Smooth Love Potion (SLP) tokens, by participating in battles and breeding new Axies, which can then be sold on secondary markets like OpenSea for real-world value. Axie Infinity also operates on a Play-to-Earn (P2E) model, where players can earn cryptocurrency or NFTs based on their in-game progress. This model demonstrates how NFTs can create sustainable virtual economies and financial opportunities for players, particularly in regions where there are limited income-generating avenues (Buterin, 2014).

* 1. The Sandbox: Virtual Real Estate and Creativity

The Sandbox is another successful example of NFTs in gaming. It allows players to buy, sell, and develop virtual real estate as NFTs within a blockchain-powered virtual world. In The Sandbox, players can purchase land as NFTs, which they can then develop into virtual experiences, ranging from games to art galleries to entertainment venues. These creations can be monetized, either by charging users to access them or by selling the assets on NFT marketplaces. This opens up new possibilities for entrepreneurship and creativity, as users can turn their virtual space into a profitable venture.

What distinguishes The Sandbox from traditional games is the fact that ownership of the land and its contents is fully controlled by the players, not the game developers. The virtual real estate aspect of The Sandbox represents a new economic model in the gaming world, where players can not only create but also profit from their creations, encouraging a more active and participatory player base. In fact, the virtual real estate market within The Sandbox has seen substantial growth, with land prices and demand increasing as more users build and interact within the virtual environment (Schwienbacher, 2021).

* 1. Cross-Game Interoperability

One of the most exciting aspects of NFTs in gaming is the potential for cross-game interoperability. This means that items, characters, or assets from one game can be used in another, provided both games support the same blockchain standards, such as Ethereum, Polygon, or Binance Smart Chain. In a traditional game ecosystem, items are confined to a single game, with no ability to transfer or use them in another environment. NFTs, however, enable cross-platform functionality, creating a broader ecosystem for digital assets.(see Figure 8.4.1)

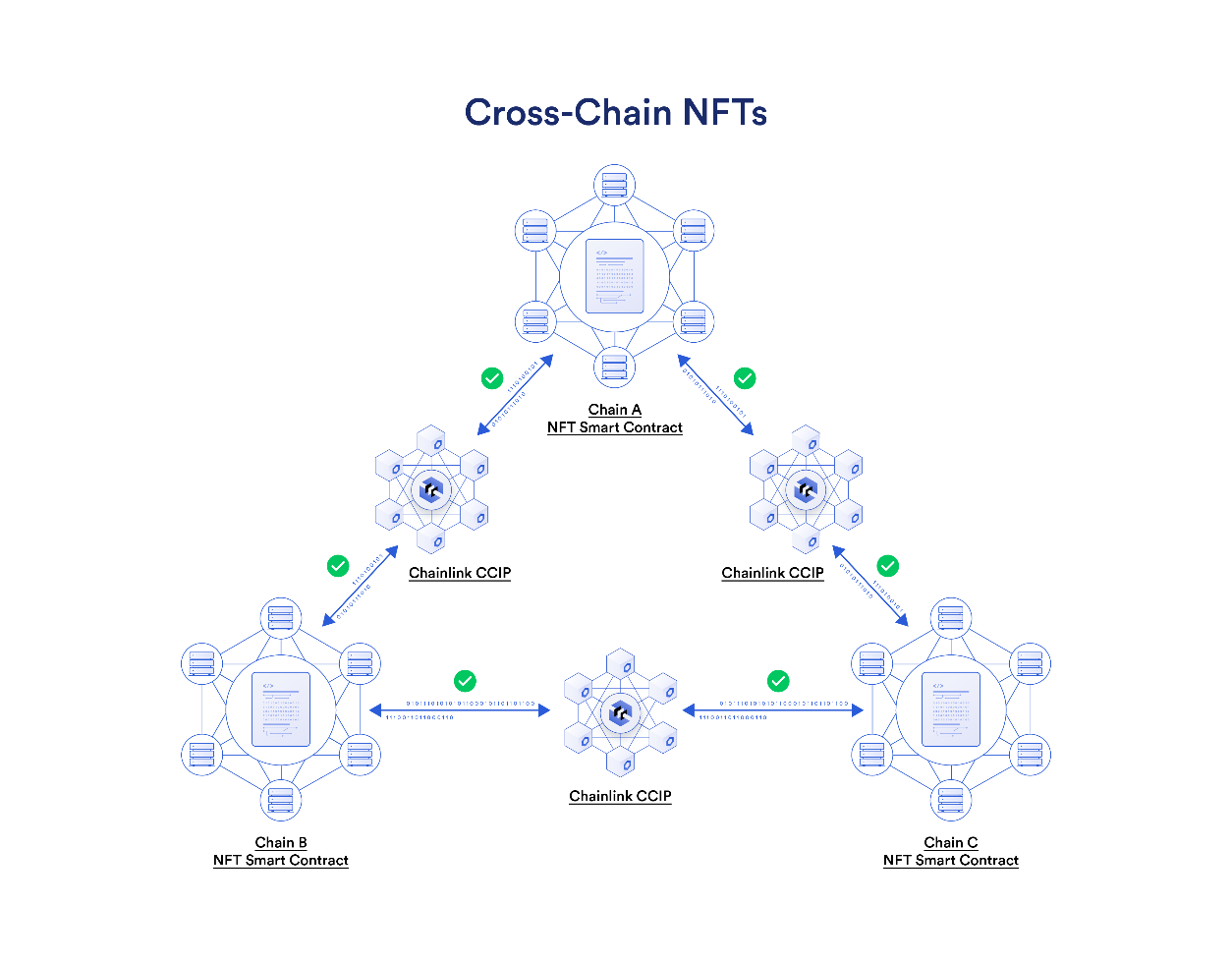


Figure 8.4.1 – Scheme of Cross-Chain NFT connection

For instance, a rare NFT sword acquired in one game could be transferred and used in another game that supports the same blockchain ecosystem, adding extra utility to the item and increasing its value. This cross-game functionality expands the potential applications of NFTs beyond the confines of one game, enhancing the player experience and creating a more interconnected digital world (Tapscott & Tapscott, 2016). It is a significant step towards the vision of Web 3.0, where users control their digital identities and assets across multiple virtual spaces.

1. WEB 3.0 AND ITS RELATION TO NFTS
   1. What is Web 3.0?

Web 3.0 is often referred to as the next generation of the internet, building upon the foundational concepts of decentralization and blockchain technology. Unlike Web 2.0, which is dominated by centralized platforms like Google, Facebook, and Amazon, Web 3.0 aims to give users control over their own data, digital identities, and assets through decentralized applications (dApps). In Web 2.0, centralized services control user data and interactions, whereas Web 3.0 leverages blockchain and peer-to-peer networks to ensure transparency, security, and user autonomy. Blockchain-based systems like Ethereum are fundamental to Web 3.0, as they allow the development of decentralized platforms where users own their assets without relying on a central authority (Buterin, 2014).

One of the key features of Web 3.0 is the concept of ownership. It enables users to own their digital assets, such as cryptocurrencies, NFTs, and personal data, and to participate in decentralized finance (DeFi) ecosystems. Unlike Web 2.0, where users’ data is owned and controlled by platforms like social media companies, Web 3.0 allows users to retain control of their digital identities, facilitating more secure, private, and user-centered interactions (Berners-Lee, 2020).

9.2 NFTs and Web 3.0

NFTs (Non-Fungible Tokens) are deeply intertwined with the Web 3.0 ecosystem. Web 3.0 allows for the creation and ownership of unique digital assets that are stored on blockchains. NFTs are an example of this digital ownership model—they are indivisible and unique assets that prove ownership of digital goods such as art, music, collectibles, and even in-game items.

Web 3.0 makes it possible for users to own, sell, and trade NFTs without the need for centralized intermediaries like auction houses, galleries, or platforms. This decentralized nature aligns perfectly with the goals of Web 3.0, as it empowers creators and collectors with direct access to the marketplace, ensuring that digital content creators can monetize their work and retain control over it (Tapscott & Tapscott, 2016).

By integrating NFTs into Web 3.0, users not only gain ownership of digital goods but also participate in a broader ecosystem where interoperability between platforms is possible. For instance, NFTs earned in one game can be used in another game or virtual world, creating a cross-platform economy that empowers players and creators alike. This feature is enabled by blockchain standards, such as Ethereum or Polygon, which provide a common framework for digital assets to be transferred and verified across different platforms.

Thus, NFTs in Web 3.0 represent more than just collectibles—they are part of a larger digital economy that aims to provide value and ownership to individuals, creating an interconnected, decentralized digital world (Shadab, 2021).

* 1. Web 3.0 vs Web 2.0

Web 3.0 differs fundamentally from Web 2.0 in its architectural principles and the role it envisions for users. While Web 2.0 focuses on centralized platforms, where companies control user data and digital experiences, Web 3.0 envisions an open internet that is peer-to-peer and decentralized. In Web 2.0, platforms like Facebook or Instagram profit by selling users’ data to advertisers, whereas Web 3.0 aims to give users control over their personal information, allowing them to monetize it as they see fit. This shift creates a more democratic digital environment, where individuals participate in decision-making processes, ownership of digital assets, and engagement in decentralized applications.

The integration of NFTs in Web 3.0 further reinforces this shift by enabling immutable, verified ownership of digital assets. In traditional Web 2.0 models, the ownership of digital items like art or music was often unclear, with content creators often relying on centralized platforms to protect their rights. However, with Web 3.0, NFTs provide clear, transparent ownership and ensure that creators receive fair compensation for their work. The decentralization of ownership, transaction validation, and digital rights management reflects the core values of Web 3.0, aiming for a user-centric internet (Marr, 2021).

1. WHAT IS GAMEMAKER AND ITS ADVANTAGES?
   1. GameMaker

GameMaker Studio is an integrated development environment (IDE) designed for creating 2D and 3D games. Developed by YoYo Games, GameMaker is renowned for its flexibility, user-friendly interface, and a wide array of tools that cater to both beginner and advanced developers. The platform provides an intuitive drag-and-drop interface, which allows users with little to no coding experience to create functional games. This makes it particularly attractive for indie developers and hobbyists.

For more experienced developers, GameMaker offers the GameMaker Language (GML), a powerful scripting language that allows for greater flexibility and customization in game mechanics, giving developers full control over their creations. This dual approach, combining ease of use with depth for advanced developers, is one of the core advantages of GameMaker, making it accessible yet capable of handling complex game development needs.

* + 1. Ease of Use

GameMaker’s drag-and-drop functionality enables developers without prior coding experience to build games easily. This accessibility opens the door for aspiring game creators, as they don’t need to learn complex programming languages to bring their ideas to life (Chesnais, 2021). The platform also includes a large community of users who share resources, tutorials, and assets to support newcomers.

* + 1. Powerful Scripting (GameMaker Language - GML)

For more advanced users, GameMaker provides the GameMaker Language (GML), a C-like programming language that allows developers to script game mechanics, implement custom functionality, and control the game environment in great detail. GML provides full access to all the features of GameMaker, enabling developers to create high-performance games with complex mechanics (Chesnais, 2021).

* + 1. Cross-Platform Support

One of the standout features of GameMaker is its cross-platform publishing capabilities. Developers can publish their games across multiple platforms, including iOS, Android, Windows, macOS, and consoles such as PlayStation and Xbox. This wide compatibility is crucial for indie game developers who wish to maximize their reach without needing to redevelop the game for each individual platform (Roberts, 2021).

10.1.4 Rapid Prototyping

GameMaker's visual scripting system and built-in features make it ideal for rapid prototyping. Developers can quickly experiment with game mechanics and ideas, testing their concepts without spending a significant amount of time on code or technical barriers (Chesnais, 2021). This speed of iteration is one of the reasons GameMaker is favored by indie developers looking to bring their ideas to life efficiently.

10.1.5 Robust Asset Management

GameMaker offers a powerful set of tools for managing assets like sprites, sounds, animations, and backgrounds. These tools streamline the workflow, enabling developers to create visually engaging games without extensive external tools. The visual interface for managing assets further enhances the development experience.

* 1. GameMaker for Blockchain and NFT Integration

As GameMaker is highly versatile, it can also be integrated with blockchain and NFT technologies to create decentralized gaming experiences. For example, NFTs can represent in-game assets such as skins, characters, or items, and GameMaker’s ability to handle complex interactions with external services (via APIs and scripts) makes it ideal for integrating these features. By utilizing smart contracts and blockchain networks like Binance Smart Chain (BSC), developers can mint NFTs as rewards or tradeable assets directly within the GameMaker environment (Buterin, 2014).

11. BINANCE SMART CHAIN (BSC) AND NFT INTEGRATION IN GAMEMAKER

* 1. Web3.js and Ethers.js

Web3.js and Ethers.js are two popular JavaScript libraries that enable developers to interact with Ethereum-based blockchains, such as Binance Smart Chain (BSC). These libraries offer essential functionalities for integrating blockchain features into games, particularly for handling wallet connections, smart contract interactions, and transaction monitoring.

11.1.1 Web3.js

This is a comprehensive library for connecting to Ethereum and Ethereum-compatible blockchains. It allows developers to interact with the blockchain by querying smart contracts, retrieving wallet balances, and tracking transactions. With Web3.js, developers can easily create and manage decentralized applications (dApps) that require interaction with a blockchain. It supports multiple blockchain networks, including Ethereum, BSC, and Polygon (Web3 Foundation, 2021).

11.1.2 Ethers.js

A more lightweight and focused alternative to Web3.js, Ethers.js simplifies many of the tasks involved in working with the Ethereum network. It is designed for developer ease, offering functionalities such as signing transactions, interacting with smart contracts, and querying blockchain data. Ethers.js has a smaller footprint and a simpler interface, making it ideal for applications that need to work with Ethereum-compatible networks like Binance Smart Chain (Bounford, 2020).

Both libraries provide the backbone for integrating blockchain technology into GameMaker, helping developers create games where players can interact with NFTs, wallets, and smart contracts seamlessly.

* 1. Integrating Blockchain in GameMaker

GameMaker Studio can integrate blockchain functionality through Web3.js and Ethers.js to create blockchain-based features, such as NFTs and wallet connections.

11.2.1 Minting NFTs through Smart Contract Functions

GameMaker developers can use Web3.js or Ethers.js to call smart contract functions that mint new NFTs directly from the game. These NFTs can represent in-game assets, such as items, characters, or skins, offering players a form of true ownership over digital items. By linking the game to blockchain networks like Binance Smart Chain (BSC), developers can ensure these NFTs are tradable, secure, and transferable across platforms. In a GameMaker RPG, players might earn an NFT after completing a difficult quest, and the game uses Ethers.js to mint a new NFT that represents this achievement.

11.2.2 Checking Wallet Balances and Managing Transactions

Both Web3.js and Ethers.js can be used to query wallet balances and handle transactions in the game. For example, if the game has an in-game marketplace, the player’s balance of cryptocurrencies (such as BNB on BSC) can be checked and displayed. Players can then use these funds to purchase or trade NFTs within the game. Additionally, these libraries help manage transaction signing, allowing players to perform secure transactions directly through their wallet. When a player purchases a rare NFT item from the in-game store, Web3.js would handle the wallet transaction and trigger the NFT transfer to the player’s wallet.

11.2.3 Authenticating Players through Wallet Connections

GameMaker can authenticate players using wallet connections through MetaMask or other Web3-compatible wallets. Web3.js or Ethers.js can facilitate this process by allowing users to log in with their MetaMask wallet, enabling secure login and interaction with blockchain features without requiring traditional user registration systems. This method is particularly popular in Web3 games, where the players' digital assets are tied directly to their blockchain wallets. Players can log into the game using their MetaMask wallet, which then automatically links their in-game profile to their Ethereum or BSC wallet. This ensures seamless ownership tracking and NFT integration for the player.

* 1. Integrating Blockchain into GameMaker Project

By integrating Web3.js and Ethers.js into our GameMaker project, we can take full advantage of blockchain technology and NFTs, providing players with true ownership over their digital assets. These tools simplify the process of connecting the game to blockchain networks and enable seamless interactions between the player, the game, and the blockchain. This opens up a new realm of possibilities for NFT-based gameplay and enhances the overall player experience with the benefits of decentralization, security, and transparency.

1. WHAT IS IPFS AND WHY DOES IT NEED PINATA?

12.1 IPFS Overview

IPFS (InterPlanetary File System) is a decentralized file system designed to provide an alternative to the traditional, centralized client-server model. In conventional systems, files are stored on centralized servers, meaning a single point of failure can compromise data access. IPFS, on the other hand, distributes files across a peer-to-peer network, ensuring data is stored on multiple nodes, enhancing both security and availability.

The fundamental innovation of IPFS lies in its content-based addressing system. Instead of using URLs tied to a server's location, IPFS uses cryptographic hashes to identify content. When a user requests a file, the system retrieves it from any node in the network that holds a copy, based on the content's unique hash. This mechanism guarantees data immutability and integrity, as files cannot be altered without changing the hash itself. As a result, IPFS ensures permanent access to files, making it ideal for applications requiring long-term, verifiable data storage.

IPFS has wide-ranging applications, especially in the decentralized web (Web3), NFT storage, and blockchain-based systems. It is used extensively to store metadata for NFTs, digital assets like images, and even entire applications, ensuring transparency, security, and permanence. A key feature of IPFS is that it prevents data loss by eliminating reliance on a single server or provider, significantly reducing the risks associated with traditional cloud storage services.

12.2 Pinata's Role in IPFS

While IPFS offers a decentralized file storage solution, it has a limitation: data availability. If no nodes "pin" or store specific data, that data can become inaccessible. Pinata, a popular service for interacting with IPFS, solves this problem by pinning the data to ensure its availability across the network.

Pinning refers to the act of keeping certain files stored on a node permanently, ensuring that those files remain accessible on IPFS. This is especially important for NFT metadata and other assets that need to be constantly available for decentralized applications (dApps) and NFT projects. Pinata guarantees that NFTs' critical data, such as images, descriptions, and properties, remain permanently stored and retrievable from IPFS. This process significantly improves the reliability of decentralized systems by ensuring the continuous availability of content tied to NFTs.

Why Pinata Is Essential for NFTs:

1. Reliability: Pinata ensures that the metadata for NFTs (e.g., images or descriptions) is securely stored and always available, even if the original IPFS nodes become unavailable.
2. Scalability: As the NFT space grows, particularly with large games or platforms involving thousands of NFTs, Pinata handles massive amounts of data storage and retrieval seamlessly, guaranteeing data remains accessible and properly organized.
3. User Experience: By integrating Pinata with IPFS, developers can ensure their users always have access to the most up-to-date and accurate information about NFTs, improving the overall user experience within blockchain-based games and applications.

For example, if a player acquires an NFT sword as a reward in a GameMaker game, the sword's metadata (e.g., name, rarity, image, properties) is uploaded to IPFS. Pinata then ensures this metadata is pinned and available at all times. The smart contract that governs the NFT references the IPFS hash (a unique identifier for the data), guaranteeing the sword’s details are immutable and verifiable on the blockchain.

By ensuring permanent data availability and improved scalability, Pinata and IPFS are crucial for decentralized blockchain gaming. Without them, the reliability of NFT-based games would be compromised, as players would have no assurance that their in-game assets or achievements would persist long-term.

13. HOW CAN OUR GAMEMAKER GAME USE IPFS?

Integrating IPFS (InterPlanetary File System) into your GameMaker project can significantly enhance the decentralized nature of your game. IPFS allows for permanent, decentralized storage of game data, ensuring data availability, reliability, and transparency.

13.1 Storing NFT Metadata

NFTs (Non-Fungible Tokens) represent unique digital assets, such as characters, skins, or weapons, in the blockchain world. These assets can be tokenized and stored on IPFS, with their metadata (e.g., name, rarity, image, and attributes) securely stored in a decentralized way. Storing this data on IPFS ensures that it is accessible to everyone and remains immutable. Since NFTs are tied to blockchain smart contracts, this decentralized storage guarantees their authenticity and verifiability.

In your game, when a player defeats a boss, they may receive a unique NFT weapon. The image, name, and attributes (e.g., damage, rarity) of the weapon can be stored on IPFS. The IPFS hash (which uniquely identifies the metadata) will be associated with the NFT in the smart contract, ensuring that the weapon’s details are verifiable and cannot be altered.

By storing NFT metadata on IPFS, you are ensuring that all in-game items linked to the blockchain are accessible, transparent, and permanent, thus enhancing player trust in the game ecosystem.

13.2 Transferring Game Files

Beyond NFTs, game assets like textures, audio files, models, or even entire levels can be stored and transferred across a decentralized network using IPFS. This avoids the reliance on traditional centralized servers, ensuring that the game’s assets remain accessible to players even if the central server goes offline. This is especially beneficial for games with large amounts of media content that needs to be reliably distributed to players worldwide.

Your game may feature downloadable content (DLC) or expansions that include new levels or skins. By uploading these assets to IPFS, the game files can be retrieved from multiple nodes across the decentralized network. This ensures better scalability as the game grows, and reduces the risk of server failure or service interruptions.

IPFS also improves efficiency in distributing large files, as players can download data from the nearest available node in the network, minimizing latency and improving performance.

13.3 Supporting Mods and User-Generated Content

Many games thrive because of the modding communities that create custom content such as new levels, skins, or game mechanics. IPFS is an excellent solution for storing and sharing these mods because it ensures that mods are decentralized, immutable, and freely accessible. By integrating IPFS with GameMaker, you can allow players to create, share, and download mods, knowing that the data will always remain available and verifiable, independent of a central server.

Suppose your game allows players to create custom skins or levels. Instead of relying on centralized servers to store and distribute these mods, you can use IPFS to store them. Players who want to use these mods can simply query the network to retrieve the mod's IPFS hash and associated metadata, ensuring they access the correct version and details.

Advantages of Using IPFS in Your GameMaker Game

1) Decentralization: IPFS enables decentralized storage, ensuring that game assets are not reliant on a central authority, reducing the risk of data loss and manipulation.

2) Transparency and Authenticity: Since all data is stored on a public and immutable ledger, players can verify the authenticity and ownership of their in-game items and assets.

3) Scalability: As the game grows and thousands of NFTs or assets are created and traded, IPFS ensures that these assets are distributed across the network, handling increased traffic without compromising on performance.

4) Cost Efficiency: By using a peer-to-peer network, IPFS reduces the need for expensive server infrastructure, which can lower operating costs for the game developer.

* 1. Implementation Considerations

- Pinning Services: While IPFS guarantees that data is stored across a decentralized network, you may need to use Pinata or similar services to pin your files, ensuring they remain stored permanently. Pinning ensures that metadata, images, and other assets are not lost over time.

- API Integration: Integrating IPFS into your GameMaker project is relatively easy with the Pinata API, which automates the process of uploading and managing files on IPFS.

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