MAGE RUNNER: THE GAME USING BLOCKCHAIN TECHNOLOGY

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A B S T R A C T

Today, digital asset ownership records are stored in a decentralized, distributed database on the basis of blockchain technology. It is no longer possible to modify any stored information on a Blockchain, which makes this technology a legitimate disruptor for sectors such as payments, cybersecurity and healthcare. Considering the increasing implementation of blockchain technology in various fields, this paper aims at focusing its application as a basic gaming experience to newbies, who wish to step into the world of blockchain gaming. Firstly, this paper presents the conceptual design and implementation of blockchain gaming in the framework of a 2D game hosted. This game highlights the incorporation of Fungible and Non-fungible tokens (NFT), which represent the rewards collected by the player. The collected reward bonus in the form of NFT is published on the player's OpenSea account, connected to MetaMask. The Game flow includes the development of a user-friendly, theme-based interface supported by Solidity as a technological support for building smart contracts using ERC20 and ERC1155 token standards. IPFS (Inter planetary-file system) is used for decentralized storage of metadata and token images, and Hardhat and Alchemy for deployment and overall execution. This game demonstrates a basic implementation of blockchain in gaming and unveils its broader scope through its incorporation in even simple children's games. This game carries pedagogical significance which can be utilized by the professors to demonstrate the practical usage of fundamental elements of blockchain to the students.

1. INTRODUCTION

Blockchain facilitates the recording of transactions and the tracking of assets within the business network by means of a shared, immutable ledger (Zhang et al., 2020, Wang et al., 2021). An asset may include physical property, including buildings, cars, money, land or intangibles like intellectual property, patents, copyrights, and brands. To reduce risk, and cut costs for all parties involved, nearly everything of value can be tracked and traded in a Blockchain network (Laroiya et al., 2020). While often associated with crypto currencies, blockchain technology is not exclusive to the digital asset market (White et al., 2020). Many industries, including medical, food, fishery, agriculture,

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etc. are integrating this technology for better efficiency, streamlined management and monetary benefits.

For all generations, digital gaming has become one of the most engaging forms of entertainment (Magerkurth et al., 2005). In accordance with their interests and preferences, players in various age groups have made use of different kinds of available online games. By enhancing their thinking capabilities and encouraging the development of divergent and analytical thoughts, they may also be able to challenge and enhance their brain power after selecting a good game. Games like puzzles, riddles, card games like poker, war games, etc. encourage people to strategize, analyse and find solutions by encouraging tactical thinking.

Evolution of gaming from Super Mario on a 16-bit gaming to a warehouse of emotion-churning, engrossing virtual reality games is incredible. This evolution continues to ongoing exploration of blockchain in digital gaming (Min et al., 2019). Any game that uses blockchain technology to improve or rearchitect traditional video games is a blockchain game (Patrickson, 2021). The purpose of blockchain games is to change the relationship between players and game creators to be fairer and more transparent, regardless of the genre they come from (Bastos, 2020). However, in terms of implementing the blockchain technology into video games it is possible to do so at different levels. The amalgamation of the two worlds of blockchain and gaming has created ample opportunities for the gaming industry. Blockchain Gaming enables real ownership of assets in game, which make a competition more exciting compared to similar games available on the market (Muthe et al., 2020). The players' ownership of the game allows them to have more control over how they play. This will allow them to monetize their assets that may be transferred outside of virtual games and exchanged for real dollars on the crypto platform. Blockchain-based gaming is the next step toward safeguarding video games, increasing transparency and establishing a long-term industry standard. As a result, crypto currency and video games can drastically alter the gaming industry (Trojanowska et al., 2020, Gao & Li ,2021, Yuen et al., 2019).

2. BACKGROUND

People's daily activities have changed as a result of the increased use of the Internet. Kids are using the Internet to play games and communicate with each other through social media. Children tend to prefer video games, rather than playing physical games in particular, because the variety of online games available is extensive and constantly increasing, allowing players to choose from a variety of options that fit their interests and preferences. The digital conversion of board games and cards has made them attractive to young children and adults. Despite having a knowledge of the advantages and disadvantages of these games, people in all age groups are fond of playing online Games (Lee et

al., 2019, Kanchanaratanakorn & Chutima, 2022). Some of the advantages of digital gaming is that you can purchase games instantly on the console and it also takes up less physical space in your home. There is also an option to join streaming services and play more games. All digital consoles are cheaper, and you don't have to worry about losing them as it has ability to play them on multiple platforms (Du et al., 2019). Moreover, online games provide a platform for social interaction with a large audience globally.

Besides the above advantages of digital games, there are still some limitations, that is, the player does not actually own the game, all rights belong to the company. The basic workings of reward distribution are not transparent and therefore not trustworthy. Additionally, completing the game can sometimes feel less rewarding without the physical collection. In general, you cannot own, display, or resell your game rewards. Ultimately, players have to rely more on their internet connection, making it vulnerable to privacy violations and security issues.

The gamers need constant evolution to fulfil their game experience. The gaming experience can be ameliorated by overcoming the stated limitations. Moreover, instead of banal process, the gamers expect innovation, which can be brought about by the basic properties of blockchain technology like decentralization, immutability, transparency, and enhanced security by integrating it successfully with current digital games. This would result in greater control, smoother transfer of assets, more immersive experience and better earning opportunities.

3. MOTIVATION

Each sector is given four specific characteristics of the blockchain: decentralization, immutability, transparency, and enhanced security. In addition, the video game industry could be transformed by these features. No content, history, data, or in-game currency leaves the base game. Consequently, the developers remain in possession of all ownership rights.

In contrast, blockchain has been promoting decentralization, particularly in the area of asset exchange. Decentralized games allow for the sale in one game and use of items acquired or purchased in another game. During this period, the player will be the true owner and will be able to profit from the resale of the goods. Smart contracts are used for ownership. When certain conditions are fulfilled, such as purchase of an asset or completion of a target, the Digital asset's ownership will be transmitted to the Player.

A further advantage of using blockchains is transparency, which today's digital games do not have. Different types of resources, such as gear, cars, swords and tanks, must be bought by the players in order to successfully complete missions. A lot of the items have been attributed to rarity and are quite expensive, but we

can't verify whether that is truly what it costs or not. In this respect, the blockchain is in a league of its own.

The blockchain is a means of tokenizing gaming assets, enabling the creation of decentralized markets. Information on a specific item, as well as the process for buying and selling can be tracked in view of that ledger being open to all. That is why the transparency of blockchain enables gamers to better trust each other and ensures that they own an original or rare item.

Due to the decentralized nature of blockchain and highly efficient data encryption techniques, it will be nearly impossible for hackers to access data on the server. Therefore, it creates a safe environment for game developers and entrepreneurs, which in turn results in higher production quality and **increased security**. Hackers will not be able to shut down the decentralized blockchain network because there are no servers to target. An illegal digital asset trade in video games may also be prevented by blockchain technology.

The blockchain-based game network is immutable.

This ensures that the shows and game series deployed on the network will not change in the future. This allows users to download and install different versions of video games from anywhere without affecting their gaming experience.

Focusing the blockchain technology implementation in various sectors including logistics, internet of things (IoT), healthcare, smart contracts, money transfer, personal identity security, etc. and noting these many advantages of integrating blockchain in gaming over traditional digital gaming influenced us to study to understand the underlying process of blockchain technology in gaming industry and how the things work in the background while playing the game. It included the research of necessary technological support and software needed to be installed as a prerequisite for the successful implementation of the simplest of the games.

4. OBJECTIVES

The main goal of this research is to overcome the limitations of digital games and improve player experience through blockchain.

It covers an understanding of the implementation of peer-to-peer, **decentralized distributed ledger technology** (DLT) that eliminates the need for a central authority in the gaming industry, highlighting the tools and knowledge required for the actual implementation at a basic level using off-the-shelf software.

Moreover, carry out a practical implementation of theoretical knowledge of **smart contracts** to **design game logic** and create a chain of transaction records in the blockchain using solidity.

Design a user-friendly, low-maintenance, **simple user interface** for game, which is comprehensible by varying age groups of people.

Overall, we wanted to emphasize the use of blockchain in gaming by using a simple, easy-to-play game.

5. METHODOLOGY

Implementation of total game included designing of all the components individually according to the below algorithms and integrating into a single component to work in coordination. Overall game was divided into three main phases namely frontend implementation and backend implementation and blockchain reward system implementation.

Frontend involved all the designing of the User interface and themes including the main character MAGE. Design of dashboards, buttons, tokens (bonus) and themes focused during this phase. In short, enhancing the user experience with easy to interact display, usage of fonts and creating an enthralling vibe by embedding background sounds and animations according to the themes. The game was developed using HTML and CSS technologies for basic framework and beautification and animations, with additional support of JavaScript. JavaScript is a prototype based, single-threaded, multi-paradigm, dynamic language which is used for the frontend development of the user-interface of Mage Runner

Backend implementation involved handling of game process and flow in accordance with the players' directions given by keyboard. The movement of the character MAGE, the acceleration and jump magnitude, progressive increase of the difficulty and placement of bonus and obstacles in the game frame was managed during this phase. JavaScript was the main technology used here for adding dynamicity and robustness to the project.

Blockchain Reward System includes integrating of blockchain smart contracts, storage of game assets in decentralized storage with IPFS (Interplanetary file System) and connecting MetaMask wallet for secure reward collection and managing the overall process. Solidity, MetaMask, OpenSea, Hardhat and Alchemy is used during this phase.

Finally, after the completion of overall implementation, the code was debugged for errors, pruning of unwanted codes was carried out and then the contracts were deployed, for solidity debugging using hardhat on polygon testnet service provided by alchemy for testing purposes.

5.1. Implementation Methodology
5.1.1 Front end implementation modules:
Frontend implementation starts with the Home page, which is responsible for displaying main dashboard of the game, (Figure 1). This dashboard helps the user to direct to specific theme of his choice by clicking the display. This would land the user into 3 different themes according to his choice, where the actual game arena is presented, and all configurations are done to successfully start the game. The available themes are Fun with Fireflies, Spirits are calling, and Heaven is

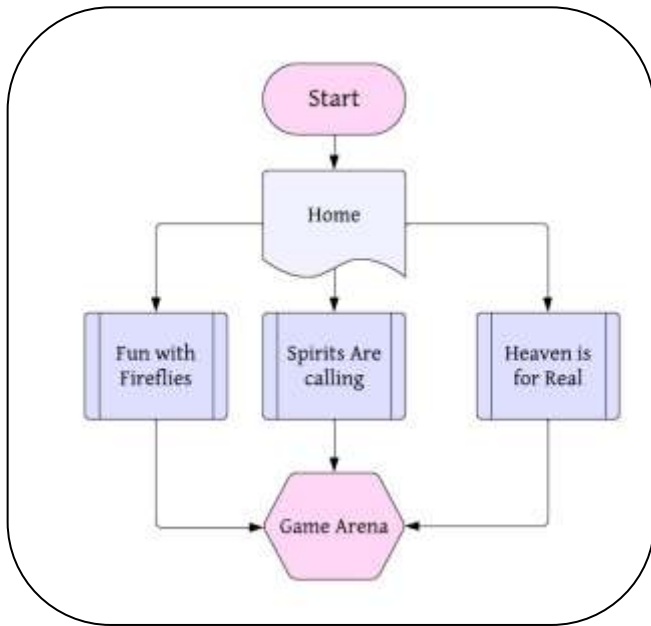Real. Each theme has different enthralling experience with background audio and animations.

Figure 1. Front End Implementation

Images 2, 3, 4 and 5 shows the outcome of the frontend implementation.

Figure 2. Home Page

Figure 3. Fun With Fireflies

Figure 4. Spirits Are Coming

Figure 5. Heaven is Real

5.1.2 Back end implementation modules:
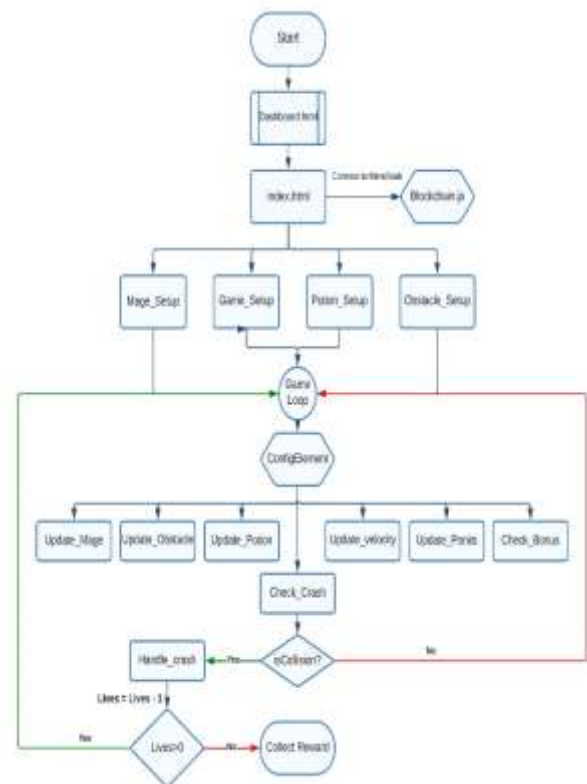Structure of back end is presented on figure 6.

Figure 6. Back End Implementation

Once the player enters the game arena (index.html), he is required to connect to the MetaMask account by clicking 'Connect to MetaMask' button. He can even skip this process for now and do it during the reward collection. Further, various game elements like the player(MAGE), obstacles and Potion(rewards) are setup and given the properties like velocity, acceleration, jumping heights, positioning heights etc. These functions are implemented using four modules namely Mage_Setup, Game_Setup, Potion_Setup, and Obstacle_Setup. These properties are timely updated to give dynamic effect to the game in a game loop with continuous implementation of next 6 modules, which are in Update_Mage, Update_Obstacle, Update_Potion(NFT rewards) and Update_Velocity, modules and score is monitored and displayed using Update_Points and Update_Bonus modules. The crashing conditions are checked simultaneously and every collision results in reducing the lives count by 1. Total lives provided are 3 and once the lives reach the mark of 0, the Game is ended and you are prompted to collect your liable reward.

5.1.3 Blockchain Reward System Implementation modules

Blockchain is implemented at the backend for reward collection purpose using Solidity programming language (Figure 7).
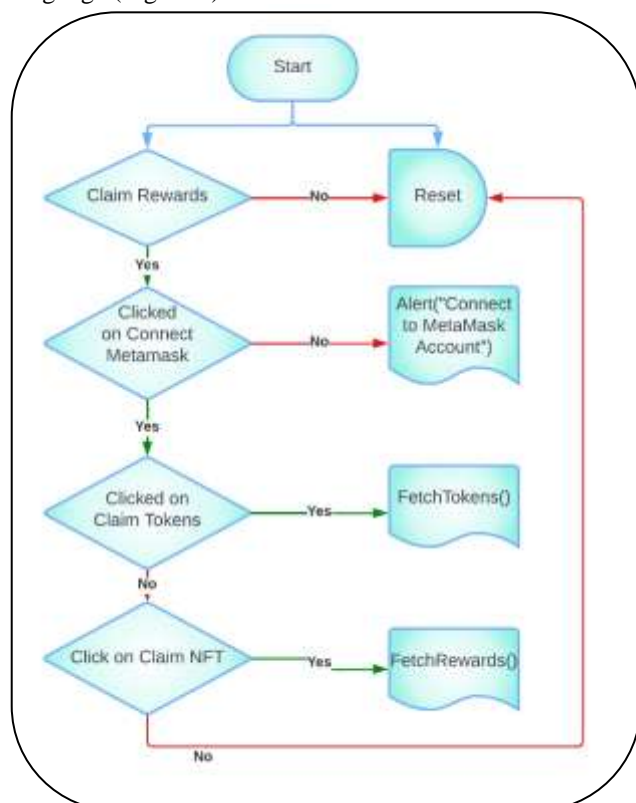
Figure 7. Blockchain Reward Collection Algorithm flowchart

Two contracts are drafted which are based on Open Zeppelin's ERC 20 token standard used to mint the fungible tokens. It is implemented when the FetchToken() module is called, to collect the game tokens(points).

A solidity file is drafted using ERC1155 token standard contract that supports non-fungible as well as fungible tokens which is used to mint NFT's in this game as Reward for collected potions on the way. It is triggered when FetchReward() module is called for collection of Bonus NFT's.

The images and metadata required is stored on decentralized storage - IPFS (Interplanetary file system) which can be directly accessed by the game to mint the NFT'S on the OpenSea account. Hardhat helps easily deploy the contracts, run tests and debug Solidity code without dealing with live environments.

Another module (Blockchain.js) is created to connect user's wallet to the browser and send a request to mint the tokens and NFT's, according to the deployed contracts. Alchemy is used as a service provider for testing the working of the DApp(game) on Polygon testnet network.

6. PROCESS DESCRIPTION

MAGE runner is simple and fun to play game implemented using blockchain technology. This Game has 3 unique themes namely Fun with Fireflies, Spirits are calling, and Heaven is Real with different backgrounds and sound effects. User can choose any one of those to start with his game. MAGE is the main character in the game, who has to cross various hurdles in his way to cover as much as distance he could, in order to gain maximum points(tokens).There are even some potions in his way which he can collect in form of rewards or bonus(NFTs: Non fungible tokens).There is no end point in this game(distance), but he has limited 3 lives to sustain till his defeat. The velocity of MAGE will gradually increase, hence increasing the difficulty level as he travels further. Once all the lives of MAGE are exhausted, he can collect his rewards in form of tokens and NFT's by connecting his account to the game browser and initiating the transaction. The points will be reflected in form of tokens (POCOS), whereas the potions collected will be minted in form of NFT's and published on the players openSea account connected to Meta mask

6.1 Steps To play

1. Choose any of the theme you are interested to play in.
2. You will be landed onto a new game arena. Click **Space Bar** to start the game as well as to jump over the hurdles.
3. Once you hit any hurdle, from your total 3 lives, one life will get reduced each time until it reaches 0.
4. Once your lives are exhausted the Collect reward buttons will get activated.

   First you will have to click Connect Metamask to connect your wallet to the browser window

5. Then Click on Collect tokens/Collect Rewards to collect the tokens in your account in form of POCOS(token currency) and the reward in form of NFT in your OpenSea account (Process explained further in detail with screenshots under game process).

6.1.1 Game automatically ends after exhausting all 3 lives (Figure 8). A popup appears signaling the end of game and t to collect the rewards.


Figure 8. End of the game

6.1.2 To collect reward, first connect your Meta mask account with the browser, by entering the password of your account (Figure 9). You should have minimum MATIC in your account to charge for the transaction fees.
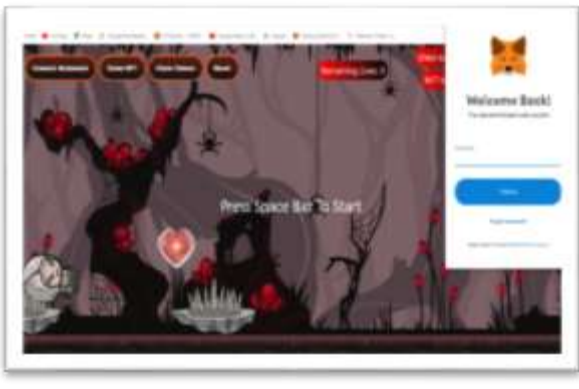

Figure 9. Meta mask account

6.1.3 Collect NFT

6.1.3.1 To collect the artifacts in form of NFTs, click on **Claim NFT** button. Following window will appear. Confirm the transaction (Figure 10).
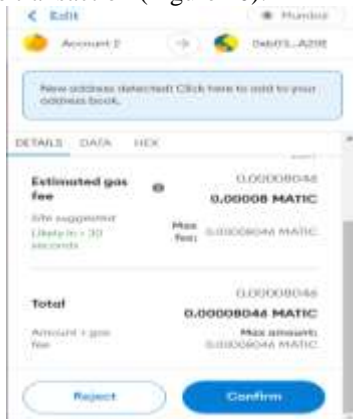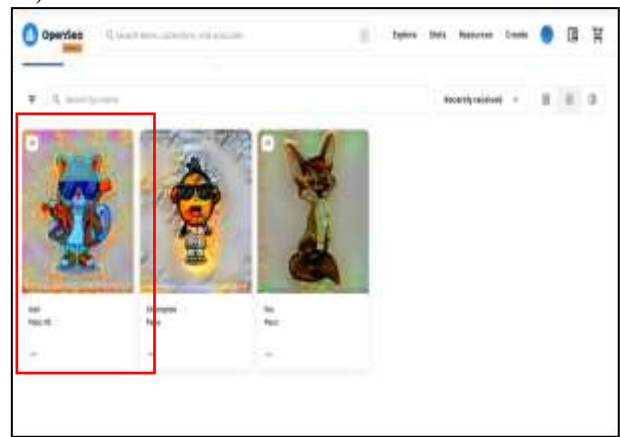

Figure 10. Claim NFT

6.1.3.2 Transaction confirmation notification will pop up at the bottom of the window which can be expanded into following window stating all the transaction details including transaction hash, status, block, timestamp, transaction fee, etc (Figure 11).
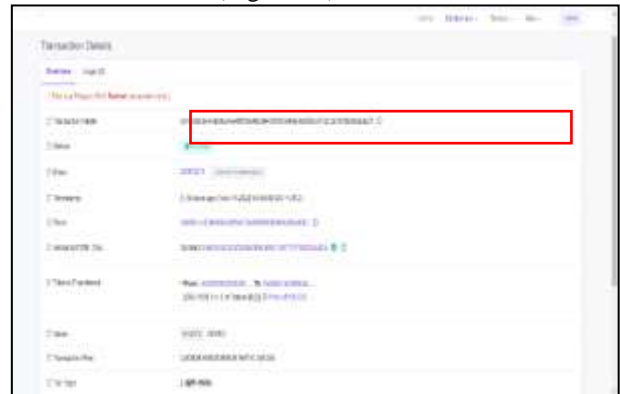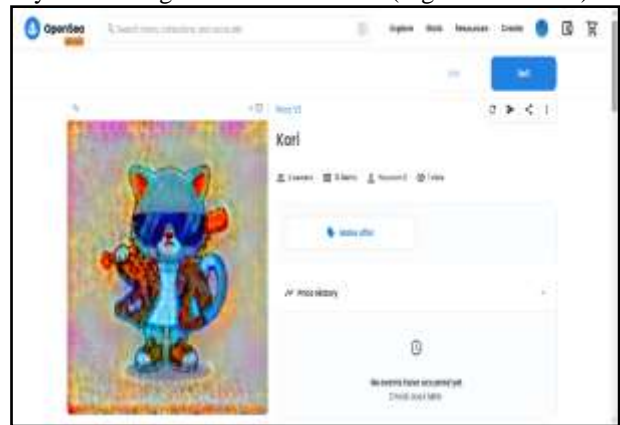

Figure 11. Transaction confirmation

6.1.3.3 Open your OpenSea account to view your collected NFT's with the quantity you scored in the game. The NFT's are minted in your account with unique images. These can be publicly viewed and showcased, even exchanged for monetary value (Figure 12).

Figure 12. OpenSea

6.1.3.4 NFT's are collected. These can be sold to anyone owning a MetaMask wallet (Figure 13 and 14).
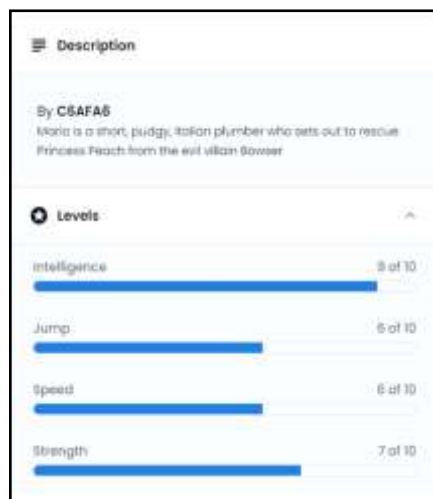

Figure 13. NFT's are collected.

Figure 14. MetaMask wallet

6.1.4 Collect Tokens

6.1.4.1. To collect tokens, click on **Claim Token** button, following window will appear. Confirm the transaction (Figure 15).
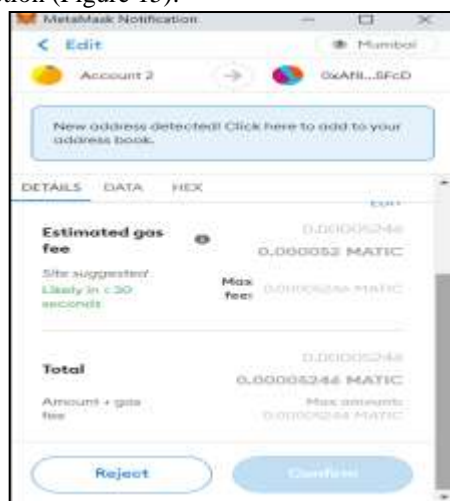

Figure 15. Claim Token

6.1.4.2 Transaction confirmation notification will pop up at the bottom of the window which can be expanded into following window stating all the transaction details including transaction hash, status, block, timestamp, transaction fee, etc (Figure 16).

Figure 16. Transaction confirmation notification

6.1.4.3 Copy above marked address to import the scored POCOS into your account (Figure 17).
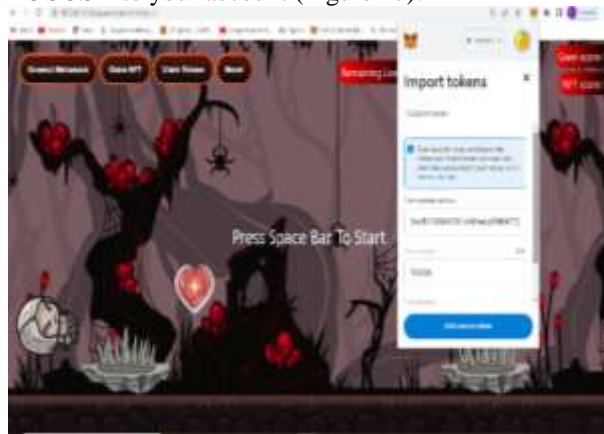

Figure 17. Scored POCOS into your account

6.1.4.4 After clicking add custom token, the POCOS starts reflecting in your account (Figure 18).
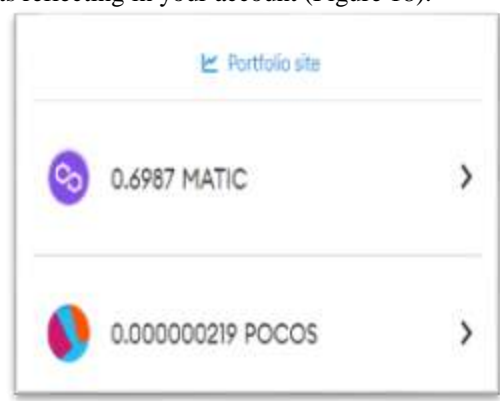

Figure 18. POCOS

6.2 Technology support

6.2.1 Solidity

The Solidity programming language is used to create smart contracts running on the Ethereum Virtual Machine. Smart contracts are programs carried out within a peer-to-peer network, where no one has specific responsibility for their execution and so they let anyone make token of value, ownership, voting or other types of logic.

In this game, we have used solidity to develop smart contracts for defining rules for reward collection which will be implemented every time a player loses and wishes to collect his rewards.

We have drafted two smart contracts using two token standards: ERC1155 AND ERC20, for minting NFT's and token collection respectively.

6.2.2 ERC 20:

An ERC20 token contract tracks fungible, i.e., any one token is identical to all others, and there are no special rights or behavior associated with them. This makes ERC20 tokens useful for things like a medium of exchange currency, staking, voting rights, and more. A number of ERC20 related contracts are offered by OpenZeppelin Contracts (https://docs.ethers.org/v5/api/signer/)

Using these contracts, we have created our own ERC20 token contract, which will be used to track Game Score (POCOS), an internal currency in MAGE RUNNER game.

6.2.3 ERC 1155

The ERC 1155 is the single token for creating all types of assets, from currency and real estate to Digital Art and Games. ERC 1155 makes it possible to include a large number of assets in one Smart Contract, which enables them to be transferred with limited network congestion and reduced transaction costs. The support for non-fungible and fungible tokens will be another significant feature of the ERC 1155 token standard. (https://docs.ethers.org/v5/api/signer/)

Using Contracts, we have created our own ERC1155 token contract, which will be used to Collect the non-fungible tokens in form of rewards in MAGE RUNNER game.

6.3 IPFS:

The Inter Planetary File System, or IPFS for short, is a peer-to-peer hypermedia protocol which aims to create a worldwide, decentralized file system that stores and shares files. By allowing files to be stored in a range of locations, which is resistant to censorship and ensures that they can always be accessed while some nodes are down, it hopes to improve the performance and resilience of existing web protocols.

The IPFS loads the content from thousands of peers instead of one centralized server. Every piece of data stored gets a unique content identifier (CID), which is cryptographically hashed. This prevents duplication of similar files in storage (https://docs.ipfs.tech/concepts/how-ipfs-works/)

We have used IPFS to store the NFT token images and token metadata, which can be directly accessed by the game to mint the NFT'S on the OpenSea account.

6.4 Hardhat

Without being confronted with real environments, Hardhat helps you easily deploy your contracts, run tests and debug Solidity code. The Hardhat Network is an Ethereum local network that's intended for development and debugging Solidity. When transactions are unable to be performed, you will receive Solidity stack traces, console.log and explicit error messages, which simplifies the overall execution of task.

We have used hardhat for compiling and deploying our contract on polygon testnet Mumbai network.

6.5 Alchemy

To help you create and scale your DApp with ease, this is the most comprehensive set of web3 development tools. Alchemy is a platform for developers that enables companies to build and maintain reliable, decentralized applications without having to manage the scalable infrastructure of the blockchain. Moreover, currently it is more reliable, and scalable in comparison to the rest of the solutions on the market while being extremely simple to integrate! Alchemy's software tools provide an out of the box kit that is especially helpful for scaling cryptocurrencies, particularly for Ethereum blockchain applications. It's also allowing crypto firms to speed up complex and expensive tasks like debugging and writing for nodes. (https://www.alchemy.com/)

We have used Alchemy as a service provider for testing the working of our DApp(game) on Polygon testnet network.

7. RESULTS

We successfully deployed the Game contracts on the following addresses with necessary rules for reward generation, on polygon testnet Mumbai network (Figure 19). These are accessed by the game during reward collection and accordingly the reward is generated on the players MetaMask wallet and OpenSea account.

- **NFT Token Contract address(ERC 1155):**0xb03Dc0353F3e2eB5f0e380d1D5770718D 02CA20E (Figure 20)
- **Token Contract address(ERC 721):** 0xAf81708B15781C4d1EaCaf58847722AE09425F cD (Figure 20)
- **Testnet:** Polygon testnet Mumbai
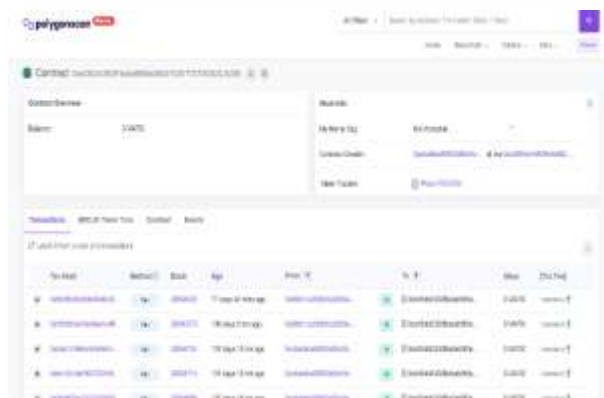

Figure 19. Game Homepage

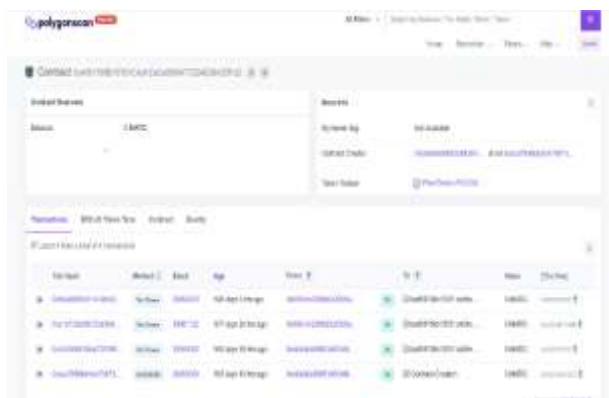**Figure 20.** NFT Token Contract(ERC1155)

Figure 21. Token Contract(ERC 721)

8. CONCLUSION

The game implemented is very simple and user-friendly, easy to understand and play, which is designed for kids as well as adults. Primarily, it helps to get insights and experience with blockchain gaming at an elementary level. As a future scope, we can include various levels of the game with some complicated tasks and integrate the usage of collected tokens as a medium of some advantage in upcoming levels of game. There is a high scope of advanced UI/UX design to the game with improved game process.

9. LIMITATIONS

Despite the various advantages of blockchain games over digital games, there are still some shortcomings that need to be addressed. In the first place, avid gamers need more than just the ability to buy and earn collectibles. They're looking for having fun with a engrossing plotline, exciting battles and a true sense of competition. Second, it's pretty complicated to play a blockchain game, not due to its complexity in the plan, but in the system itself. You must have an account in order to play with this as well as other games that uses the Blockchain technology. Moreover, depending on the type of blockchain the game is based on and the wallet the system uses, the user must create a cryptocurrency wallet and purchase a certain amount of cryptocurrency. There are also transaction fees. Sometimes there is lag and network congestion. The difficulty in scaling, low throughput of only 13 to 15 transactions per second and high transaction costs are known issues with the blockchain. The developers of the Blockchain need to continue working on protocol improvements, as well as addressing current issues like low scaling, significant transaction costs and energy consumption.

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