VILNIUS UNIVERSITY
FACULTY OF MATHEMATICS AND INFORMATICS
INSTITUTE OF COMPUTER SCIENCE
INFORMATION TECHNOLOGIES STUDY PROGRAM

Problem-Based Project

MetaOcean

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Preface

This project was done during the 4th semester of the study programme *Information Technologies* in the specialization of Innovative studies. We chose the topic *Multiplayer Game using blockchain* suggested during the project market on the first lecture of the subject ''Problem-Based Project''. This topic allowed to combine our interests and create a game that not only provides a unique gaming experience but also demonstrates essential features of blockchain technology. Relying on this idea, we were eager to learn more about smart contracts, non-fungible tokens, cryptocurrencies and tokenomics. Furthermore, Web3 is gradually gaining more adoption and recognition in the technology sphere which is inevitably reshaping the internet space. Therefore, we were fascinated by the potential of Web3 and its underlying characteristics such as decentralization and transparency.

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Abstract

This project aims to create an HTML5 multiplayer game that leverages blockchain technology to provide a secure and decentralized gaming experience. The game revolves around fishing, leveling up, and collecting non-fungible tokens (NFTs) while interacting with other players. Players can register on the website and access the game, where they can choose from various locations and fish for different fish species. Each fish has a unique rarity and value, providing an engaging gameplay experience. As players level up, they can unlock new locations, new items and catch more valuable fish. To enable real-time interaction between players, the game uses WebSocket communication protocol, allowing for seamless multiplayer functionality. The team has deployed its own blockchain to support the game, which offers a secure and transparent method of tracking player assets and interactions. To facilitate the in-game economy, the team has implemented a custom token called Poseidon Token, which can be used to buy and sell items in the market. In summary, this HTML5 multiplayer game offers a unique and exciting combination of blockchain technology and fishing gameplay. It offers players the ability to collect valuable NFTs, interact with other players in real-time, and explore new locations as they level up.

Keywords: WebSocket, Web3, Phaser, React.js, Smart contracts

Santrauka

"MetaOcean" žaidimas naudojant blokų grandines

Šis projektas siekia sukurti HTML5 daugelio žaidėjų žaidimą, naudojantį blokų grandinės technologiją, kad būtų suteikta saugi ir decentralizuota žaidimo patirtis. Žaidimo idėja yra apie žvejybą, žaidėjo lygio kėlimą ir nepakeičiamus žetonus, kuriuos galima parduoti ar pirkti. Norint žaisti žaidimą, vartotojai turi prisiregistruoti internetinėje svetainėje. Žaidime galima pasirinkti iš įvairių žvejojimo lokacijų ir sužvejoti įvairių rūšių žuvis. Kiekviena žuvis turi unikalią vertę, suteikiančią įtraukiančią žaidimo patirtį. Keldami lygį, žaidėjai gali atrakinti naujas vietoves, naujas meškeres, šarvus ir žvejoti vertingesnes žuvis. Norint užtikrinti žaidėjų tarpusavio sąveiką realiu laiku, žaidimas naudoja WebSocket komunikacijos protokolą, leidžiantį nepertraukiamą daugelio žaidėjų funkcionalumą. Komanda dislokavo savo blokų grandinę žaidimui, kuri užtikrina saugų ir skaidrų žaidėjų turtų ir veiklos stebėjimo būdą. Norint padėti žaidimo ekonomikai, komanda įdiegė specialų žetoną, vadinamą "Poseidon Token". Žaidėjai gali šį žetoną panaudoti daiktų pirkimui ar pardavimui žaidimo prekybvietėje. Apibendrinant, šis HTML5 daugelio žaidėjų žaidimas siūlo unikalią ir įdomią blokų grandinės technologijos ir žvejybos žaidimo patirties kombinaciją. Jis suteikia žaidėjams galimybę rinkti vertingus nepakeičiamus žetonus, bendrauti su kitais žaidėjais realiu laiku ir tyrinėti naujas vietas.

Introduction

Welcome to our exciting project that brings together the worlds of HTML5 multiplayer gaming and blockchain technology! Our aim is to create an engaging and immersive gaming experience centered around fishing, leveling up, and collecting non-fungible tokens (NFTs). Our game allows players to create an account on the website and enter a virtual world where they can explore various locations and fish for different species. Each fish has its own unique rarity and value, adding a layer of excitement to the game. As players level up, they gain access to new locations, items, and more valuable fish, keeping the gameplay fresh and engaging. One of the key features of our game is real-time interaction between players. We use WebSocket communication protocol to ensure seamless multiplayer functionality, allowing players to interact with each other and share their experiences in real-time. To support the game, we have deployed our own blockchain technology, which provides a secure and decentralized method of tracking player assets and interactions. This ensures the safety and transparency of the game, preventing any potential fraud or cheating. To further enhance the in-game economy, we have implemented a custom token called Poseidon Token, which can be used by players to purchase and sell items in the market. In summary, our HTML5 multiplayer game provides a unique and thrilling combination of fishing gameplay and blockchain technology. We invite you to join us on this exciting adventure, where you can collect valuable NFTs, interact with other players in real-time, and explore new locations as you level up.

1 Analysis

The following analysis includes an evaluation of the advantages, disadvantages, and overall user experience, aimed at comparing the competitiveness of other similar games in the market. In addition, we also conducted an analysis of a scholarly resource to gain further insights about NFT based games.

1.1 Analyzed similar games

1.1.1 RollerCoin

RollerCoin is an innovative online platform that combines cryptocurrency mining with the fun of gaming. The game offers users a unique opportunity to earn real cryptocurrency such as Bitcoin, Ethereum and Dogecoin by playing various engaging mini-games. It operates as a virtual mining simulator, allowing players to build and customize their virtual mining farms to generate cryptocurrency.

Advantages

- In character creation field it is possible to randomize name and character.
- The pixelated theme is kept throughout the website
- Wide spectrum of functionalities and game modes so the game maintains sustained interest and engagement.
- Leaderboard seems to be exhibited on numerous occasions in this game to keep the competitiveness between players.

Disadvantages

- There are a lot of functionalities and it is a complex task to remain oriented in the given environment. Tutorial which familiarizes users with the game and its' possibilities would be helpful.
- It is hard to gain visible profitability without any investment into the game.

Conclusion

The game seems to have a lot of functionalities, which makes it unique and maintains the users' interest. However, navigating the websites' numerous functionalities can be daunting and challenging to comprehend.

1.1.2 Hypixel Skyblock

Hypixel SkyBlock is a popular Minecraft game mode created by the Hypixel server network. It offers a unique twist on the traditional Minecraft gameplay by introducing RPG elements and an economy system within a custom world.

Advantages

- Innovative fishing mechanic where you can fish out monsters and fight them.
- Wide spectrum of sea monsters and equipment.
- Possibility to trade items with other players and sell them in auction house.

- Gear scalability using leveling system.
- Global chat
- Monster dropped loot is based on RNG system.

Disadvantages

- The fishing mechanic is very repetitive and requires a lot of playtime.
- Updates are very rare.
- Early game can be enjoyable but unrewarding.

Conclusion

The game's high entertainment value and the scalability of its gear keep users engaged, ensuring their continued involvement. There are a lot of functionalities which could be used in MetaOcean project.

1.1.3 C. Karapapas, G. Syros, I. Pittaras and G. C. Polyzos, "Decentralized NFT-based Evolvable Games" [4]

The document presents a comprehensive analysis of the potential of Non-Fungible Tokens (NFTs) in various domains and proposes an architecture for a decentralized and self-sustainable system using Web3 components.

The authors categorize NFTs based on their applications in digital art, fashion, collectibles, games, domain names, virtual worlds, and sports. They emphasize that NFTs can serve multiple categories simultaneously, as they can be considered collectibles, digital art, and games. The use of NFTs in gaming is highlighted as a way to boost players' motivation by incorporating consumer-created content alongside professional artists' work. NFTs offer benefits to both creators and players through royalties earned on resales in open or in-game markets. However, the authors express concerns about security, such as cases where companies stop hosting files or alter artwork after being sold.

To address these challenges, the proposed architecture leverages decentralized storage using the InterPlanetary File System (IPFS) and the permanence and robustness of Filecoin. Decentralized storage ensures tamper-resistance, and utilizing IPFS allows files to be disseminated and cached by other nodes, enhancing availability. The system also considers the issue of artist royalties, which is not adequately addressed in a generic architecture proposed by Muthe et al.

The authors compare two different name resolution services, Ethereum Name Service (ENS) and InterPlanetary Name System (IPNS), and select ENS for its robustness, despite the associated monetary cost. They develop a proof of concept implementation to evaluate the system and provide an API for easy setup.

Looking ahead, the authors propose experimenting with steganographic techniques to provide solid proof of authenticity for NFT artwork. This additional layer of security could enhance the value of NFTs. They also consider the possibility of a decentralized and company-independent communication channel for NFT-related actors.

Overall, the document offers insights into the applications of NFTs, addresses security concerns, and presents an architecture that combines blockchain technology, decentralized storage, and name resolution services to create a fully decentralized and self-sustainable system.

2 Why blockchain?

Video games utilize blockchain technology for various reasons, offering new possibilities and benefits to both developers and players. We did a research and found following key arguments why video games are using blockchain technology:

1. Ownership and Authenticity: Blockchain provides a decentralized and immutable ledger that can authenticate and verify ownership of in-game assets. This is particularly useful for digital items and collectibles, as it ensures their scarcity and uniqueness. In video games that do not utilize blockchain technology, players do not actually own any in-game assets or items - instead, the ownership resides with the gaming company. By using blockchain, players can have true ownership and control over their virtual possessions, which can be traded, sold, or transferred independently of the game publisher.

2. Transparency and Security: Blockchain offers transparency by recording all transactions and interactions in a decentralized manner. This transparency can enhance fairness and prevent cheating or fraud within the game ecosystem. Moreover, blockchain's security features protect in-game assets and prevent unauthorized modifications, reducing the risk of hacks and data breaches.

3. Interoperability and Cross-Platform Integration: Blockchain technology enables interoperability between different games and platforms. By utilizing compatible blockchain standards, players can transfer their assets across multiple games or even trade them on external marketplaces. This fosters a thriving ecosystem where assets can have value beyond individual games, creating new opportunities for players and developers alike.

4. Player Incentives and Rewards: Blockchain allows the implementation of tokenized economies within games, where players can earn and trade digital tokens or cryptocurrencies. These tokens can represent in-game currency, rare items, or other rewards. Such systems provide players with tangible incentives and can foster engagement, as well as create opportunities for players to monetize their skills and efforts.

5. Community Governance and Decentralization: Blockchain-based games can implement decentralized governance models, where key decisions regarding game updates, features, and rules are made through voting or consensus mechanisms involving the player community. This increases player engagement and decentralizes control, providing a more democratic and inclusive gaming experience.

6. Crowdfunding and Initial Coin Offerings (ICOs): Some game developers use blockchain to crowdfund their projects through initial coin offerings (ICOs) or token sales. By issuing tokens or cryptocurrencies, developers can raise funds directly from players and investors, bypassing traditional funding models. This allows for greater financial independence and flexibility in game development.

While blockchain technology offers several advantages to the gaming industry, it's worth noting that not all games or game elements necessarily require blockchain integration. The decision to use blockchain depends on the specific needs of the game, its mechanics, and the desired benefits for developers and players.

3 High-level overview

3.1 Users

- **Non-registered user** - has the ability to look through website, read information about the game.
- **Registered user** - has the ability to play the game, use "MetaOcean Marketplace".

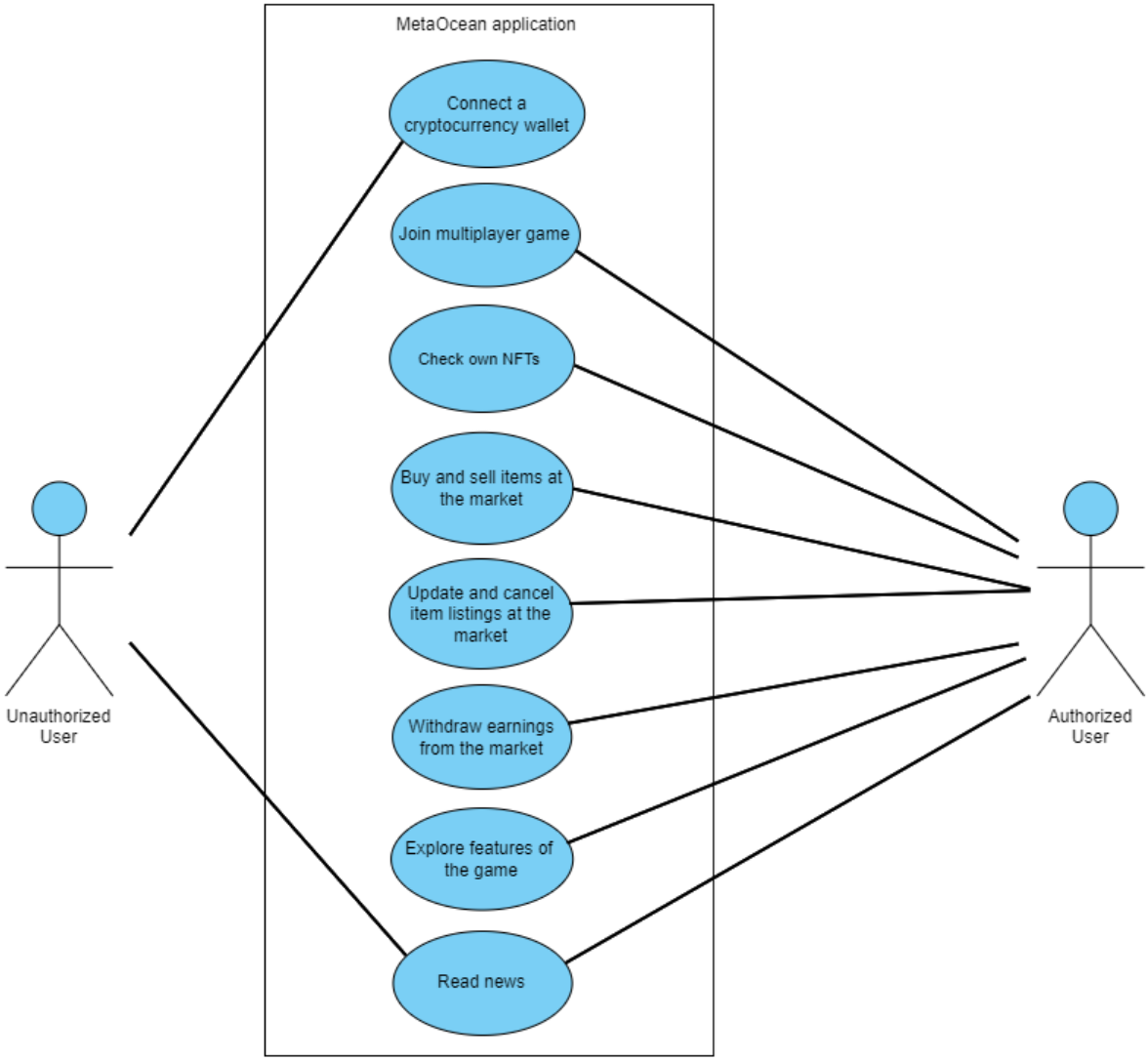

Figure 1. Use case diagram

3.2 Location

- Source code will be available at: https://git.mif.vu.lt/mamu8341/blockchaingame

3.3 Responsibilities

- Provide users a secure marketplace with the possibility to buy and sell in-game items and NFTs.
- Provide users a game with an attractive design and functionalities such as fishing, leveling up and upgrading gear.
- Provide users with an informative website where they can read the game news, get a clear understanding of "MetaOcean".

4 System architecture

4.1 UML Deployment diagram

The UML deployment diagram illustrates the execution architecture of the system, representing nodes as hardware components. Software components operate inside of hardware components and are noted as artifacts.

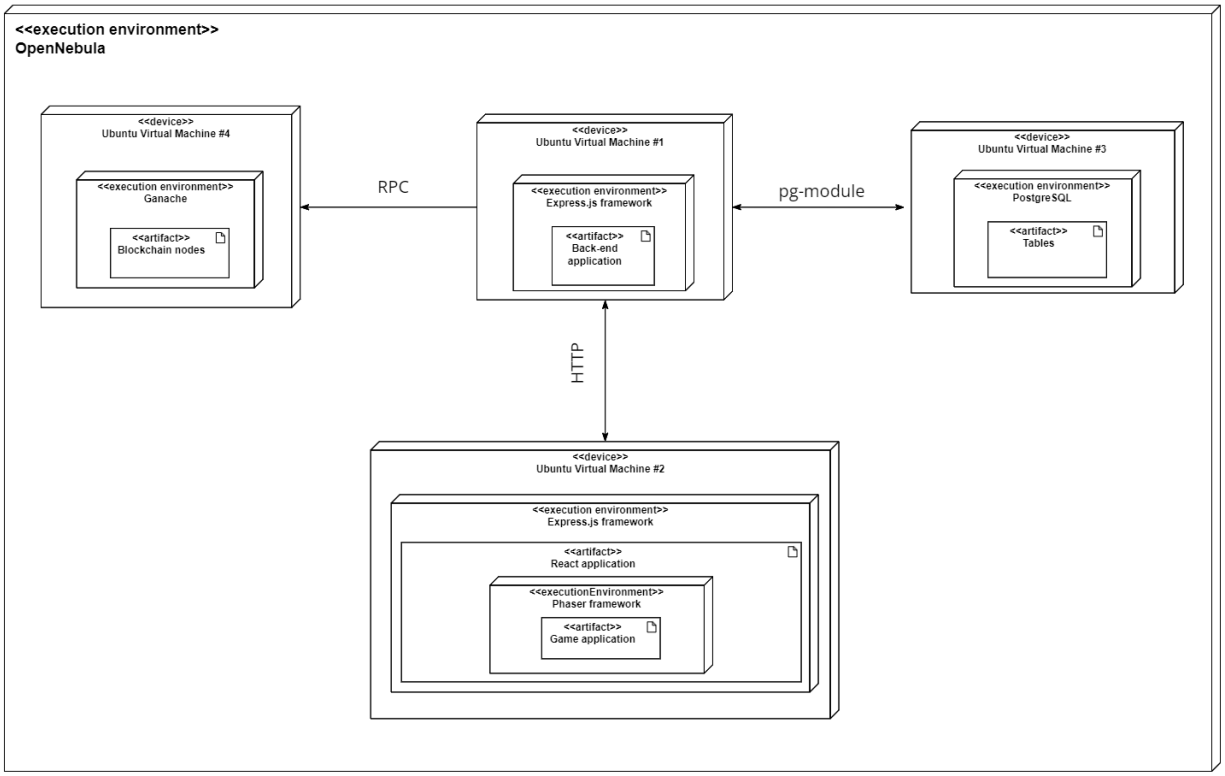

Figure 2. UML Deployment diagram

Front-end web server

A front-end web server plays a crucial role in facilitating user interaction with a website and enabling them to engage in activities such as playing game "MetaOcean". To achieve this, a Node.js application can be deployed to serve a React-based user interface as well as a game built using the Phaser framework. By doing so, users can seamlessly access and interact with the website's content, resulting in a more immersive and engaging experience.

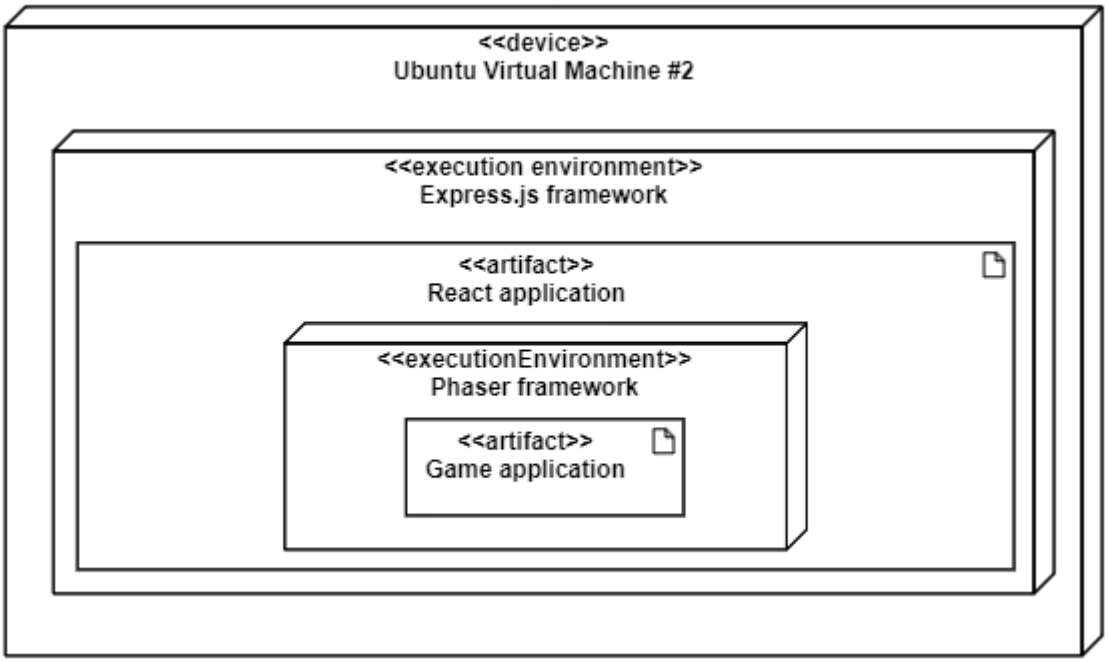

Figure 3. Front-end virtual machine

Back-end web server

In order to facilitate seamless communication between the front-end of our website and the underlying PostgreSQL database and blockchain RPC server, a back-end web server is a critical component. In addition to this, the back-end server will be responsible for ensuring that only authorized individuals are able to access sensitive data and functionality. By effectively managing and coordinating the flow of data between the front-end and back-end, our website will be able to provide a robust and reliable user experience.

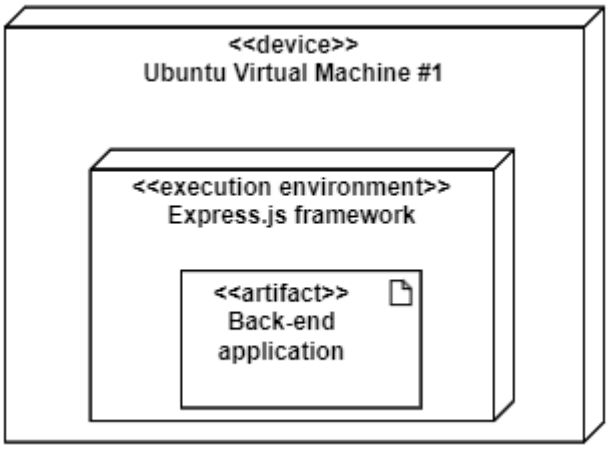

Figure 4. Back-end virtual machine

Blockchain RPC server

To host our blockchain network and facilitate the deployment of smart contracts, we will utilize a blockchain RPC (Remote Procedure Call) server. By utilizing a blockchain RPC server, we can ensure that our smart contracts are deployed and executed in a transparent and immutable manner, providing enhanced security and trust for all stakeholders involved.

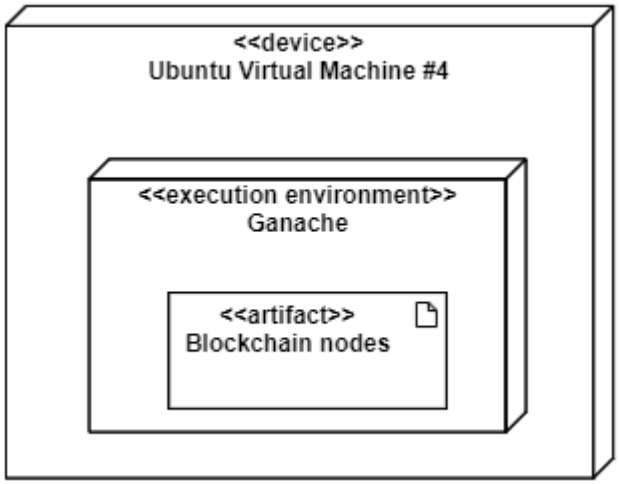

Figure 5. Blockchain virtual machine

Database

The PostgreSQL remote database serves as a crucial repository for storing and managing important player information such as usernames, wallet addresses, and game-related data such as position prior to disconnection. Furthermore, the database will be responsible for storing data related to game items ("Items" table), islands ("Islands" table), player stats and data (relationships with "Items", "Islands", "Stats"), news about the game. As a centralized and secure data storage solution, the PostgreSQL remote database will play a critical role in ensuring the reliability and integrity of our platform's user data.

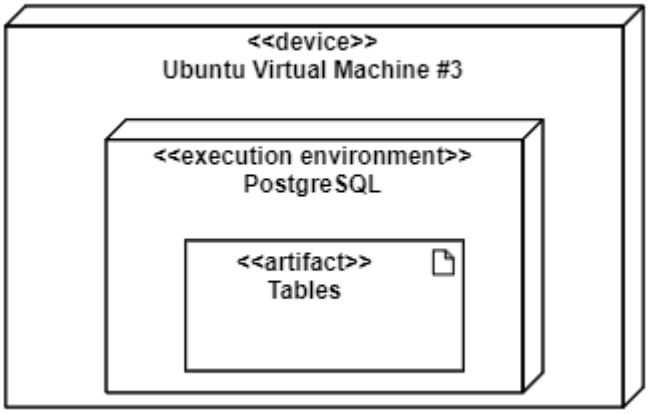

Figure 6. Database virtual machine

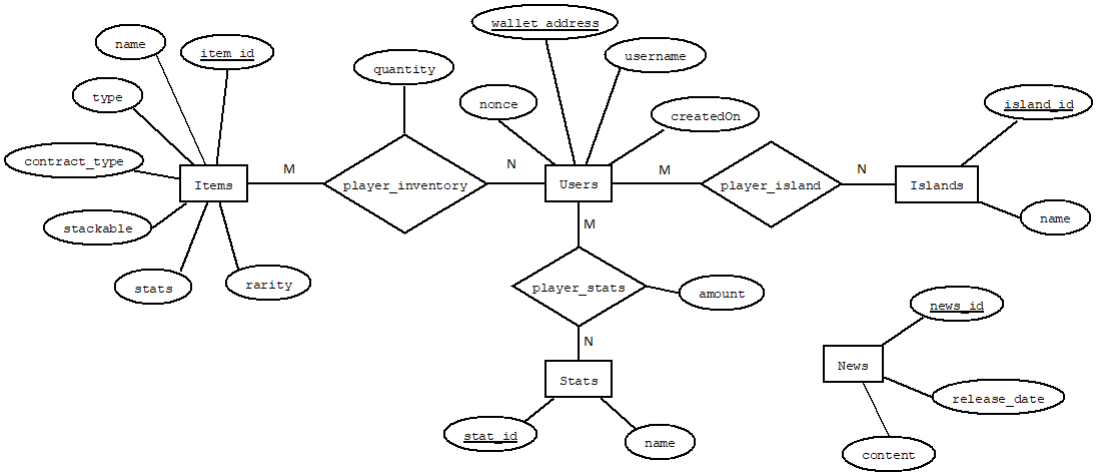

Figure 7. Remote database ER diagram

5 Technologies and Tools

This section describes programming languages and tools used in the project.

5.1 Programming languages

- JavaScript - will be used to code the game, create front-end and back-end web servers' applications.
- SQL - will be used for storing and retrieving data in databases.
- YAML - will be used to setup CI/CD.
- Solidity - object-oriented, high-level language for implementing ERC-20, ERC-721 and ERC-1155 smart contracts.

5.2 Other languages

- HTML - a markup language to create the structure of the website.
- CSS - a stylesheet language used to describe the presentation of the website.

5.3 Frameworks

- Phaser - a framework used for creating web-based 2D games.
- Express - a framework used for building web applications using Node.js.
- Tailwind CSS - a framework packed with numerous classes that can be composed to build any design.
- i18next - a framework used for developing applications that can be adapted to different languages.

5.4 Tools

- OpenNebula - an open-source cloud computing platform that will act as a hypervisor. It will allow to monitor and manage virtual machines in a single shared environment.
- PostgreSQL - an object-relational database management system that will be used for data storage.

- Visual Studio Code - software used for code editing.
- Putty - software used to connect to web servers' and database's virtual machines.
- Vite - development environment for creating web applications using JavaScript frameworks such as React.
- Ganache - tool for creating local Ethereum blockchain.
- Truffle Suite - development tool used to deploy smart contracts.
- Adobe Photoshop - image editing tool used for creating map tiles and sprites.
- Tiled - software used for creating tiled maps and map layers using tile sets.
- Dia - software used for the creation of ER diagrams.

5.5 Modules and Libraries

- "socket.io" - a real-time event-based library used for client and server communication
- "Sequelize" - a modern TypeScript and Node.js ORM for interacting with our PostgreSQL database.
- "React" - a JavaScript library used for building user interfaces.
- "dotenv" - used for storing configuration files that often contain sensitive information.
- "web3js" - used to interact with smart contracts that are on the blockchain.
- "bad-words" - profanity filter for filtering game's global chat.
- "Web3Modal" - a library that simplifies the process of managing connections to wallets. It supports many cryptocurrency wallets, provides UI components for easy connection management, transaction history and real-time updates.
- "wagmi" - is a library containing everything needed to start working with Ethereum.
- "loot-table-advanced" - a module used to create random outcomes of loot for games.

6 Functional Requirements

6.1 Game

Multiplayer

The game will support multiplayer functionality, allowing users to play with each other and interact.

Fishing

Users will be able to fish for different types of fish in various fishing locations within the game world, using different fishing gear.

Leveling system

Users will progress through levels as they catch more fish and gain experience points, unlocking new fishing gear, locations, and challenges.

Player stats

Users will have statistical attributes such as fishing speed and catch luck, both of which can be enhanced through the acquisition of Non-Fungible Tokens and fishing rods.

Different fishing islands

Different Fishing Islands: The game will feature different fishing islands, each with its own unique fish species and challenges.

6.2 Website

News

The website will have a news section, where users can stay up-to-date on the latest game updates and events.

Marketplace

The website will have a marketplace section, where users can buy and sell NFTs related to fishing in the game.

Wallet Connection

Users will have the ability to connect a cryptocurrency wallet to the website.

7 Non-functional Requirements

7.1 Game

Compatibility

The game will be compatible with a variety of web browsers (Chrome, Firefox, Safari, Edge, etc.) and playable only on desktop and laptop devices.

Performance

The game will load quickly and run smoothly without lag or glitches to ensure an enjoyable gaming experience for the players.

Security

The game will be designed with secure coding practices, and it should use code obfuscation to prevent cheating or tampering.

7.2 Website

Compatibility

The website will be compatible with a variety of web browsers (Chrome, Firefox, Safari, Edge, etc.) and devices (desktops, laptops, tablets, and mobile devices) to reach a broad range of users.

Performance

The website will load quickly and be responsive to ensure a seamless user experience.

Internationalization

The website will be designed with internationalization in mind, including support for different languages, to appeal to a global audience.

Security

The website will be designed with secure coding practices. It will also have measures in place to prevent unauthorized access and protect against common web vulnerabilities such as SQL injection and cross-site scripting attacks.

8 Game

MetaOcean is a multiplayer HTML5 game that combines fishing, leveling up, and collecting NFTs in a dynamic virtual world. Players can level up, upgrade their fishing gear, and explore different environments. The game integrates non-fungible tokens as collectible items, allowing players to trade and showcase rare fish species and special gear. With multiplayer interaction, MetaOcean offers an immersive experience for fishing enthusiasts and gamers seeking engaging gameplay.

8.1 Controls

Control	Explanation
W, A, S, D	Movement controls
Hold SHIFT	Enhance movement speed (start sprinting)
T	Open chat
ENTER	Send message
E	Start and cancel fishing / Interact with NPCs
ESC	Close chat
I	Expand and collapse the inventory
F	Travel to another location (at specific places)

8.2 Movement and Inventory Controls

To navigate the game world, players can utilize the intuitive control scheme. Movement is achieved by using the W, A, S, and D keys, while the Shift key allows for enhanced speed when necessary. Additionally, the I key expands and collapses the inventory, enabling players to manage their items effectively. Using mouse players can move items within the inventory by dragging and dropping them. Players can travel to another island by standing near the boat and pressing the F key.

8.3 Chat Functionality

Players can engage with each other in real-time - by pressing T key the chat interface will activate, allowing players to communicate, share fishing strategies and establish connections within the community. Messages can be sent by pressing the Enter key and canceled using ESC key on the keyboard.

8.4 Leveling and Progression System

Player's progress is rewarded through a comprehensive leveling and progression system. By catching fish and gaining experience points, players advance through different levels, unlocking a variety of enticing features. Each level presents new locations, and the opportunity to encounter more valuable and rare fish species. Access to distinct fishing islands is contingent upon meeting specific level requirements, ensuring a sense of achievement and providing a progressively rich gameplay experience.

8.5 Fishing Functionality

By standing in designated fishing zones located near the water on each island and pressing the E key players can start fishing and catch fishes. Players have a chance of catching a variety of fish species and potentially valuable non-fungible tokens (NFTs) related to fishing. It is a captivating experience that brings players closer to the serene and rewarding world of fishing.

8.6 NPCs and Fish Trading

Non-Playable Characters (NPCs) serve as essential characters in our game, providing players with valuable opportunities to engage in fish trading. When players approach NPCs and stand in close proximity to them, they can interact by pressing the 'E' key. This action opens up the NPC's shop interface, where players can conveniently sell their caught fish. By clicking on the sell button next to each fish in their inventory, players can initiate the transaction and receive in-game currency, represented by "golden coins," in return. Each island features a unique NPC with a dedicated shop, creating a localized trading experience.

8.7 Player stats

Players will have statistical attributes that directly impact their fishing experience. Two important attributes are fishing speed and catch luck. The fishing speed attribute determines how quickly a player can catch fish. By acquiring Non-Fungible Tokens and fishing rods, players can enhance their fishing speed, allowing them to reel in fish at a faster rate. On the other hand, catch luck represents the probability of successfully catching rare and valuable fish. Players can also acquire NFTs and fishing rods to improve their catch luck attribute, increasing their chances of encountering rare and valuable fish.

8.8 Fishing Islands

Each island boasts its own unique ambiance, fish species and challenges, inviting players to embark on thrilling fishing experience. As players progress and fulfill level requirements, they gain access to these islands, expanding their horizons.

8.9 Collisions and fishing zones

In our game, we utilize a tile map system consisting of three layers to enhance gameplay. The first layer (whole image) displays the map image, providing players with a visual representation of the game world. The second layer (marked with a green color) denotes fishing zones, where players can engage in the fishing activity. Lastly, the third layer (marked with a red color) comprises collision zones, serving as invisible barriers that prevent players from accessing restricted areas or walking on water. This three-layered tile map system enhances immersion, facilitates fishing gameplay, and ensures players stay within intended boundaries.

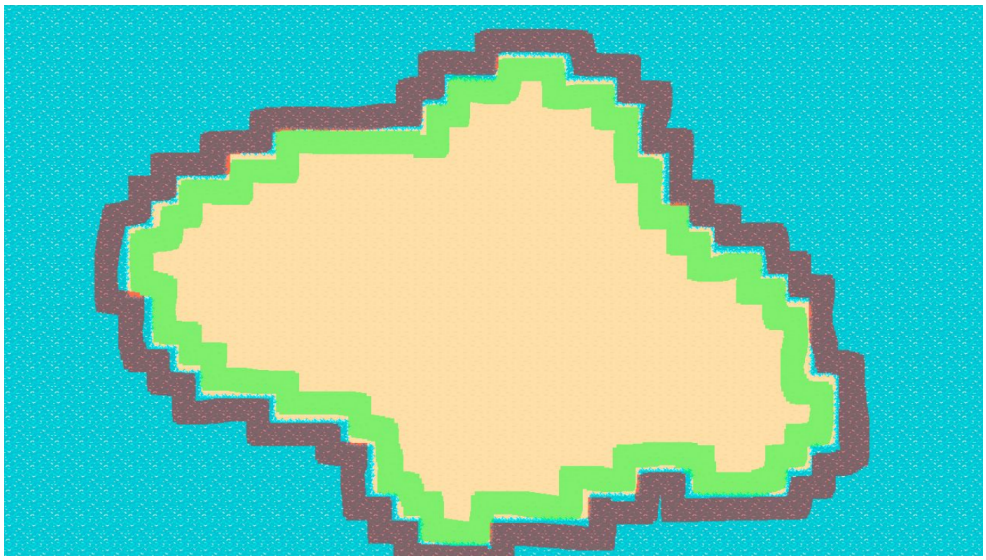

Figure 8. Game island with invisible layers

9 Multiplayer functionality

In this game, sockets are used to enable real-time communication and interaction between multiple players. Sockets provide a mechanism for bidirectional communication between the game server and connected clients, allowing them to exchange data and events seamlessly.

9.1 Client Connection

When a player launches the game, their client application in the Main Menu establishes a socket connection with the game server. This connection allows the client to send and receive information in real-time.

9.2 Player Interactions

As players interact with the game world, such as moving their character, performing actions, or sending messages, these events are captured by the client application.

9.3 Sending Events

The client application sends these player events to the game server by using the socket connection. For example, if a player moves their character, the client sends a movement event to the server, along with the movement coordinates.

9.4 Broadcasting Events

Upon receiving an event from a player, the game server processes the event and updates the game state accordingly. After processing the event, the server broadcasts the event to all connected clients.

9.5 Real-Time Interaction

As players receive updates from the server, they can see the actions and movements of other players in real-time. This allows for a multiplayer experience where players can interact with each other, for example, chatting or fishing and exploring islands together.

9.6 Socket Rooms

In our game, we have implemented socket rooms to create a unique and immersive multiplayer experience. Each room represents a specific island within the game world. This design allows players to interact and see only those players who are in the same island as them, enhancing the sense of exploration and creating a dynamic environment. When a player joins the game, they are automatically assigned to the socket room corresponding to the island they disconnected in or the Tutorial island if the player joined the game for the first time.

9.7 Disconnecting

Socket connections can be interrupted due to various reasons, such as network issues. The game server handles such scenarios by detecting disconnections. This ensures that players can seamlessly join back into the game without losing their progress.

10 Smart contracts

ERC-20, ERC-721, and ERC-1155 are Ethereum-based token standards that have transformed the landscape of digital asset creation and management on the blockchain. Our project consists of 4 different smart contracts that will be used to create game token, NFTs, SFTs and a game item marketplace. This section provides comprehensive insights into these token standards, their functionalities, and their applications in the context of achieving our needs.

10.1 ERC-20

ERC-20 is the most widely adopted token standard on the Ethereum blockchain. It defines a common set of rules for fungible tokens, which means each token is interchangeable and identical to each other. Game tokens created using ERC-20 are typically used as in-game currencies or utility tokens within the game ecosystem. These tokens can be used for various purposes, such as purchasing virtual goods, accessing premium features, or participating in game-related activities. ERC-20 tokens are divisible, meaning they can be divided into smaller units, allowing for flexibility in transactional value. Using this ERC-20 standard we created our game token called "Poseidon Token".

10.2 ERC-721

ERC-721 introduced the concept of NFTs, which are unique and indivisible tokens. Unlike ERC-20 tokens, each ERC-721 token has a distinct value and cannot be exchanged on a one-to-one basis. In the context of gaming, ERC-721 tokens can represent in-game assets with unique properties, such as rare items, characters, or land. Game developers can use ERC-721 tokens to create collectibles or unique virtual assets that players can own, trade, or showcase. The scarcity and uniqueness of ERC-721 tokens make them ideal for creating virtual items with inherent value and collectibility. This smart contract will allow us to create exlusive game items like fishing rods, equipment, trophies.

10.3 ERC-1155

ERC-1155 is a hybrid token standard that combines the features of both ERC-20 and ERC-721. It allows for the creation of both fungible and non-fungible tokens within a single smart contract. Game developers can leverage ERC-1155 to create SFTs, which are tokens that possess a limited degree of uniqueness or rarity. SFTs enable game designers to represent a series of similar assets, such as different levels of rarity for the same item, and provide more flexibility compared to ERC-721 tokens. For instance, a game could have multiple versions of a sword, each with its own rarity level and properties, represented as distinct SFTs. Most of the game items will be made using ERC-1155 standard. This will ensure item ownership and will make transactions between players more secure.

10.4 Game Market

The game market refers to a decentralized marketplace where players can buy and sell game items (NFTs and SFTs). The integration of ERC-20, ERC-721, and ERC-1155 smart contracts enables the creation of a secure and transparent marketplace. This marketplace allows players to engage in peer-to-peer transactions, with ownership and transfer of digital assets being recorded immutably on the blockchain. By utilizing these token standards, the game market provides an ecosystem for players to exchange in-game assets, allowing for the growth of vibrant virtual economies within games.

11 Website

11.1 Design

The website adopts a cohesive and visually consistent design approach by adhering to a pixel art theme, maintaining this distinct style throughout all its components. This deliberate choice ensures a unified and cohesive user experience, where every element, from icons and illustrations to typography and layouts, consistently reflects the pixel art aesthetic.

In terms of color selection, we have opted for a gold color scheme for the headings on the website. Gold is associated with luxury and sophistication, which aligns well with the desired aesthetic. It adds a touch of prestige and captures attention, making the headings stand out prominently. Furthermore, to enhance the user experience and engagement, we have implemented a hover effect on the headings and buttons. When a user hovers over, the color transitions to a light blue shade. This change in color serves visual feedback to the user, indicating that the heading and buttons are interactive. The light blue color choice is inspired by the ocean theme, reminiscent of the calming waters.

Figure 9. Website's color palette

11.2 Wallet connection

A wallet connection serves its purpose as a digital identity (authenticator) of the users within the "MetaOcean" decentralized application. Essentially, in conjunction with the route guard, it ensures a secure authorization process. Furthermore, the wallet connection as middleware between the blockchain and decentralized application is entrusted to execute transactions involving smart contracts, approve connections requests and sign messages of transactions.

As a matter of fact, the wallet connection is integrated relying on a web3 communication protocol called "WalletConnect". This protocol enables users to connect with a preferred wallet, simultaneously offering over three hundred different wallet providers such as Metamask, Coinbase Wallet, Trust Wallet and more. Thus, users are not limited to only one wallet connection provider. Also, "WalletConnect" allows to initiate a connection by scanning a QR code via a mobile device.

There are a few important aspects to note regarding the wallet connection process. In order to connect to the "MetaOcean" application using "WalletConnect" users are required to have the browser extensions or mobile applications of their preferred wallet providers installed beforehand. This is because the protocol itself is unable to detect and install the necessary wallet applications. In the event that multiple browser extensions are enabled simultaneously, it is essential to note that "WalletConnect" may encounter difficulty in identifying the specific wallet provider to establish a connection with. This is due to the inherent limitations of the protocol, which prevent it from accurately discerning the intended wallet provider when faced with multiple options. Therefore, it is imperative to disable or deactivate any additional browser extensions that may potentially interfere with the proper functioning of "WalletConnect."

11.3 Responsive design

Our website employs a responsive design approach, providing an optimal viewing and interactive experience across various devices and screen sizes. By implementing responsive design, we ensure that our website dynamically adjusts and adapts its layout, content, and functionality to deliver a consistent and user-friendly experience.

Regardless of whether users access our website from a desktop computer, laptop, tablet, or smartphone, they can expect a visually appealing and accessible interface. The responsive design enables content to automatically scale, reposition, and reflow, ensuring optimal readability and usability.

Additionally, our website has the capability to detect the user's device type, whether it's a desktop computer, laptop, or mobile phone. This functionality allows us to tailor the user experience accordingly. For instance, we can restrict game access to only desktop and laptop users, ensuring that the game is played on devices that provide optimal performance and user experience. By leveraging this device detection capability, we can deliver a targeted and tailored experience to different user segments, maximizing the satisfaction and engagement of our audience.

11.4 Route guard

A route guard is a mechanism implemented in a website to prevent unauthorized users from accessing specific pages or functionalities. In the context of a marketplace website, a game platform, a route guard plays a crucial role in ensuring that only authorized users can access these sensitive areas. The main purpose of a route guard is to authenticate users and check their authorization before allowing them to proceed to certain sections of the website. Here's a description of how a route guard works in our website:

1. When a user attempts to access the route that has route protection, the route guard checks if they are authenticated (if user has connected their wallet).

2. If the user is not authenticated, the route guard redirects them to a login page.

3. After successful authentication, the login page seamlessly redirects users to their intended destination, granting them immediate access to the specific page they initially requested.

11.5 Multi-language feature

The website uses i18next framework to provide multi-language feature, enabling users to switch between different languages which are English, Lithuanian, Spanish and French. This implementation ensures enhanced accessibility and user-friendliness, accommodating a diverse range of users with varying language preferences.

12 HCI principles

12.1 User-Centered Design

One of our key considerations was to prioritize easy navigation for users. We organized information and features in a logical and intuitive manner, making it effortless for users to find what they need. To enhance the user experience, we employed complementary colors in our design. By selecting a golden color that complements our black theme, we achieved a visually appealing contrast that guides users' attention to important elements. This technique not only adds visual interest but also helps users quickly identify and interact with key information. Furthermore, we adopted a user-centered mindset, constantly seeking to understand and empathize with our target audience. By putting ourselves in their shoes, we made design decisions that aligned with their needs and preferences. We focused on creating a seamless and enjoyable user experience, which in turn increased user satisfaction and engagement.

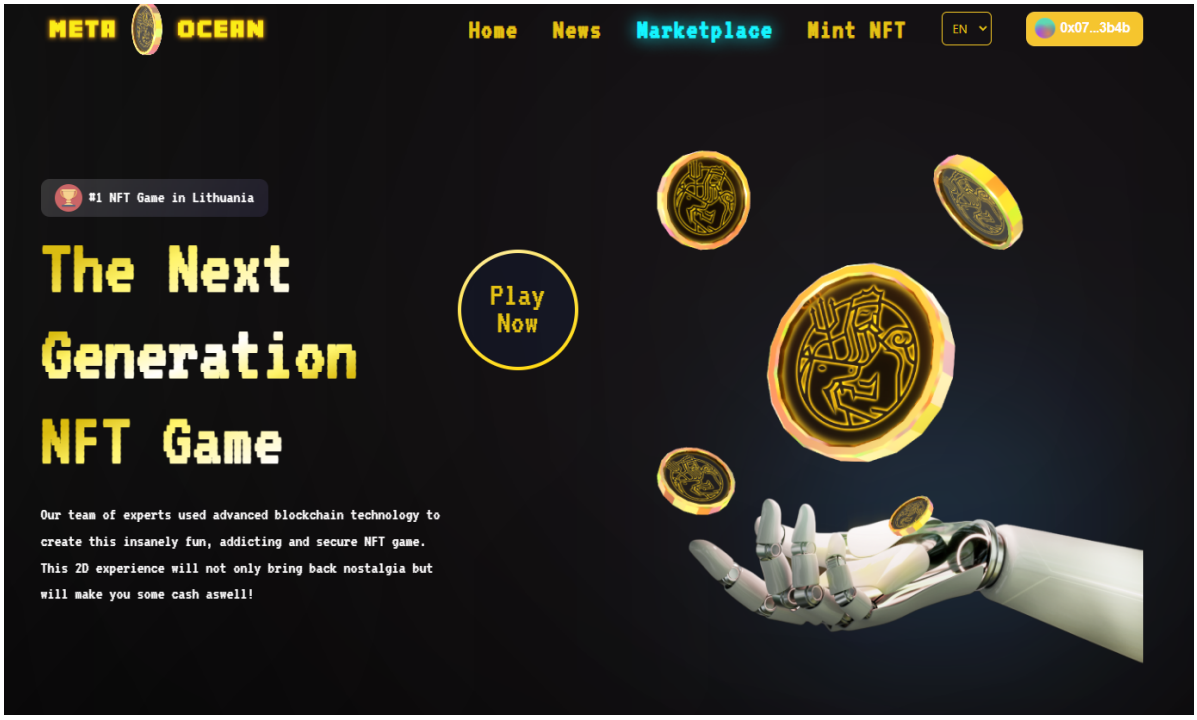

Figure 10. Website design

12.2 Feedback

We understand the importance of feedback and recovery in delivering a seamless user experience. When users encounter errors or make mistakes, we provide clear and informative feedback to guide them. For example, if a user tries to create an account with a username that is already taken, we immediately notify them about the unavailability of the username, allowing them to choose an alternative. Similarly, when users set a password that doesn't meet the specified requirements, we provide explicit details about the criteria (such as minimum and maximum length or required characters) to assist them in creating a password that fulfills the requirements. By offering such visibility into errors and their causes, we empower users to rectify mistakes easily and enhance their overall satisfaction with our system. Furthermore, while handling transactions in the marketplace, clear indications regarding the status of transactions are provided, whether the transactions have failed or succeeded.

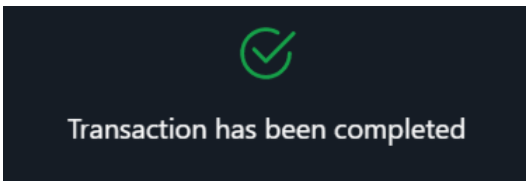

Figure 11. Successful transaction

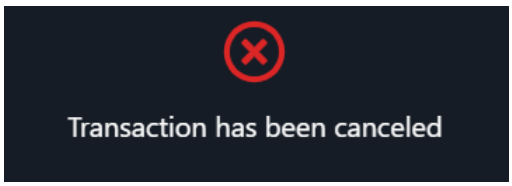

Figure 12. Unsuccessful transaction

12.3 Efficiency

The principle of performance or efficiency in Human-Computer Interaction focuses on designing systems that respond quickly and effectively to user actions, providing a smooth user experience. It recognizes the importance of optimizing system performance to meet user expectations and enable efficient interaction. In the context of web development, one technique that aligns with the performance principle is lazy loading. Lazy loading is a strategy utilized to enhance the performance of the website by loading and rendering content on-demand, rather than upfront. It addresses the challenge of dealing with large amounts of content, such as images, videos, or data, which can significantly impact initial load times and resource usage. The key idea behind lazy loading is to prioritize the loading of content that is immediately visible to the user when they first access the page. Only the essential content is loaded initially, allowing users to quickly see and interact with what they need. As the user scrolls or interacts with the page, additional content is loaded dynamically, when the content becomes visible within the viewport.

12.4 Responsive design

Responsive design refers to the ability of a website or application to adapt its layout and content dynamically based on the screen size and orientation of the device being used. It ensures that users have a consistent and optimized experience regardless of whether they access the site on a mobile device, tablet, or desktop computer. We utilized responsive design techniques so the elements of the interface, including text, images, and navigation menus, automatically adjust to fit the screen perfectly. This application of the responsive design creates a seamless and visually appealing interface for users. It acknowledges the diverse range of devices that users utilize and aims to accommodate their needs without compromising usability.

12.5 Cross-Browser compatibility

Cross-browser compatibility is the principle of ensuring that a website or application functions consistently across different web browsers. Since there are multiple web browsers available with variations in rendering engines, standards support, and user interfaces, it is crucial to design and develop websites that work well on the most popular browsers, such as Chrome, Firefox, Safari, and Edge. By implementing web standards-compliant code, we tested our website across various browsers, and addressed any compatibility issues. We acknowledge that users have different browser preferences and should not be limited in their access to our website based on their choice of browser.

12.6 Aesthetics

We pay careful attention to the visual elements and layout of our interface. We strive for a clean and intuitive design that is visually appealing. We carefully select colors, typography, and graphical elements that complement each other and create a cohesive visual identity. By utilizing complementary colors, such as the combination of a golden color against a black theme, we create a visually striking interface that captures users' attention.

Conclusions and Recommendations

Our project creates an immersive multiplayer game experience through real-time communication and interaction between players. Sockets enable seamless bidirectional communication, allowing players to move, take actions, and chat in real-time. The game server processes these events, updating the game state and broadcasting them to all players. Furthermore, smart contracts based on Ethereum token standards support the in-game economy, with ERC-20 tokens as currencies, ERC-721 tokens representing unique assets, and ERC-1155 tokens combining fungible and non-fungible properties. A decentralized marketplace facilitates secure buying and selling of game items. The website complements the game with wallet integration, responsive design, secure authorization, and multi-language support, ensuring an engaging and accessible user experience. Together, these components create a cohesive and immersive gaming environment for players to explore, interact, and trade.

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