SORBONNE UNIVERSITÈ

Computer Science

Development of Algorithms for Reticular Application

Preoject work on:

Implementation of a Collectible Card Game on Ethereum

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Chapter 1

Introduction

The primary objective of this project is to create a decentralized Collectible Card Game (CCG) on the Ethereum blockchain. This endeavor encompasses various crucial components, including the development of CCG cards as Non-Fungible Tokens (NFTs) that adhere to the ERC-721 standard and the establishment of a marketplace where players can engage in trading their unique digital assets. Furthermore, a user-friendly frontend has been thoughtfully designed to streamline card collection management, offering an intuitive and robust user experience.

This report will guide through the project details, covering both the on-chain and off-chain aspects. We will elucidate the rationale behind significant design choices and critical steps such as the creation of NFT contracts, the management of collections and the building of the meticulous procedures for minting and assigning cards.

The integration of blockchain technology enhances the collectible card gaming experience by enabling secure, transparent, and tamper-proof transactions. Virtual cards are transformed into unique, tradable, and verifiable assets. Each card is represented as an NFT on the blockchain, thus it's unique and can be owned, bought, sold, and traded like physical trading cards directly on blockchain-based marketplaces guaranteeing players ownership rights and allowing for secure and transparent transactions..

It's important to point out that no engine-game has been implemented and the focus has been set only on the foundational elements that underpin the collectible aspect of the game, thus requiring also the addressing of a real-world TCG scenario where new card sets are released at regular intervals, typically every three to four months. Our task, therefore, has been to constructing an infrastructure capable of managing these frequent additions to the game's card repertoire.

Chapter 2

On-chain development

The on-chain development phase focuses on creating a solid infrastructure for the management of digital card collections as NFTs on the Ethereum blockchain. It ensures that users can create and redeem booster packs, participate in card auctions and get cards minted for them by the user. Here follows a more detailed explanation of the the key on-chain components:

- *CardManager* Contract:
  The primary purpose of the CardManager contract is to handle the creation, management, and distribution of individual cards that are part of our CCG. It also manages collections of cards, allowing users to group cards together based on different themes or sets. Cards are represented as Non-Fungible Tokens (NFTs) on the blockchain, giving each card a unique identity and making it tradable among players. This contract ensures that cards can be minted, transferred between users, organized into collections, and retrieved by users on the game's frontend.

  The 'CardManager' contract is responsible for managing individual collectible cards. It provides a function to mint new cards, associating each card with a unique token ID and also a 'transferCard' function which requires the card's ID, and the card is then transferred to the recipient. Moreover, a 'userToCards' function is provided, which returns an array of card objects owned by the user, a 'getAllCollections' function which allows the retrieval of a list of all the available collections, and the 'getCardsFromCollection' function which retrieves the cards associated with a specific collection.

- *Market* Contract:
  The primary purpose of the Market contract is to enable the creation and management of auctions for NFTs. Users can create auctions for their NFTs, place bids, accept or reject bids, and conclude auctions. This contract ensures the secure and transparent transfer of NFTs from sellers to bidders while recording the status and details of each auction.

  So it implements an auction system for trading cards. It's initialized with the address of the CardManager contract, which is used to manage the NFTs involved in the auctions and it also initializes the _auctionCounter and internal mappings. Moreover, it defines an AuctionInfo struct, which contains information about each auction(the seller's address, bidder's address, the NFT tokens being traded by both parties, and the current status of the auction).
  Users can:

  - open auctions for specific cards (represented by token IDs) using the 'open' function. The auction starts in the "OPEN" state.
  - place bids on auctions by using the 'offer' function. Bids can include card token IDs, and the contract tracks the highest bidder.

  The seller can:

  - accept or reject bids using the 'acceptAndExchange' or 'reject' functions, depending on whether they want to complete the trade or not.

  - cancel an auction using the ‘cancel‘ function. This invalidates the auction.

  The $IMarket$ contract is just an interface for the $Market$ contract.

- $BoosterManager$ Contract:
  The primary purpose of the BoosterManager contract is to handle booster packs, which are sets of cards that players can obtain and open in our CCG. These booster packs are an integral part of the game, allowing players to expand their card collections and discover new cards. This contract ensures that booster packs are created, distributed, and handled securely and efficiently on the Ethereum blockchain.
  The contract defines a Booster struct, which includes information about each booster, such as its unique identifier (tokenId), the cards it contains (cards), whether it has been redeemed (redeemed), and an expiration date (expireDate).

  It allows the TCG owner to mint booster packs which contain a collection of cards. When a booster is minted, it generates a unique booster ID and assigns it to the user who requested the minting.

  Users can redeem a booster pack, provided that it hasn't already been redeemed. Then, when a booster pack is redeemed, the associated cards are minted to the user's address by calling the ‘cardManager.mint‘ function. This allows users to receive the cards in their collection.

  In addition, if needed, the owner of the booster pack can burn a booster, making it invalid. This is done using the ‘_burn‘ function.

- $Main$ Contract:
  The ‘Main‘ contract serves as the main orchestrator of the TCG system. It interacts with the ‘BoosterManager‘, ‘CardManager‘, and ‘Market‘ contracts to provide a user-friendly interface. It provides wrappers for minting cards and boosters, making it easier for the TCG owner to manage these processes.

Chapter 3

Off-chain development -Frontend development

The frontend structure of our Collectible Card Game (CCG) project has been designed to meet the project's core requirements, offering a user-centric experience that enhances card collection management while integrating administrator functionalities. Our frontend consists of two primary sections: one dedicated to user-accessible functionalities and another reserved for administrative operations.

3.1 User Page

The User Page is divided into 4 primary sections called *Inventory*, *Marketplace*, *Auction place* and the *Booster page* which are displayed and accessible through the app bar placed at the top of the page.(see Figure 3.1)

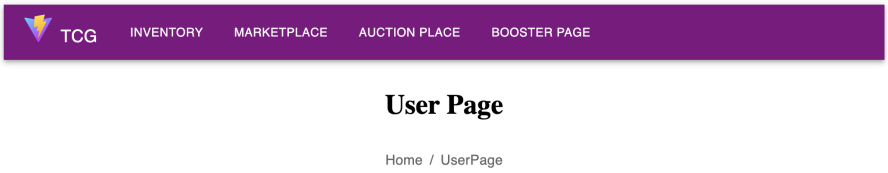

Figure 3.1: Appbar for the User Page

3.1.1 Inventory

Within the User Page section a dedicated *Inventory* page has been developed in which users can seamlessly view the cards they own organized in the various collections by allowing them to access and manage their possessions securely and efficiently. Moreover, clickable elements provide direct access to detailed information about specific cards, collections and users accessing metadata directly retrieved from the API.(see Figure3.1.1)

3.1.2 Marketplace

The second component of the User Page is the *Marketplace*. It mirrors the structure of the Inventory Page with the only difference that the cards shown here are all the available ones in the market. Users here can again interact with the page exploring detailed information about specific collections, individual cards and other users to make informed decisions when participating in trading activities.

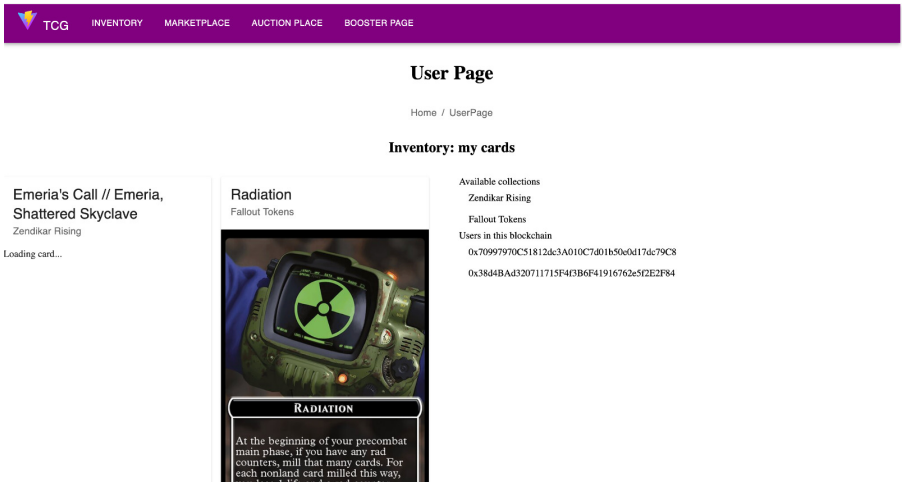

Figure 3.2: An example of the Inventory page

3.1.3 Auction place

The third page of the User Page is the *Auction Page*, a feature-rich platform where users can explore ongoing card auctions. Users can view and access detailed information about all active auctions by clicking on them and have the possibility to join ongoing auctions by offering one of their cards for trade if no cards have been already offered. In addition, the "create a new auction" button enables them to initiate their own auctions. By clicking on this button the user will be directed to a new page composed of three main steps: in the first step the user is asked to select a card, the second step displays an "Approve button" which calls a function in the market contract in order to get the permission to finalize the operation and in the third step the auction is actually created.

3.1.4 Booster page

The *Booster Page* constitutes the final segment of the User Page. On this page, users can access their booster packs. Through the "collect button", users can collect their boosters and have the corresponding rewards displayed on the right. An additional button also allows them to buy a new booster. (see Figure3.1.4)

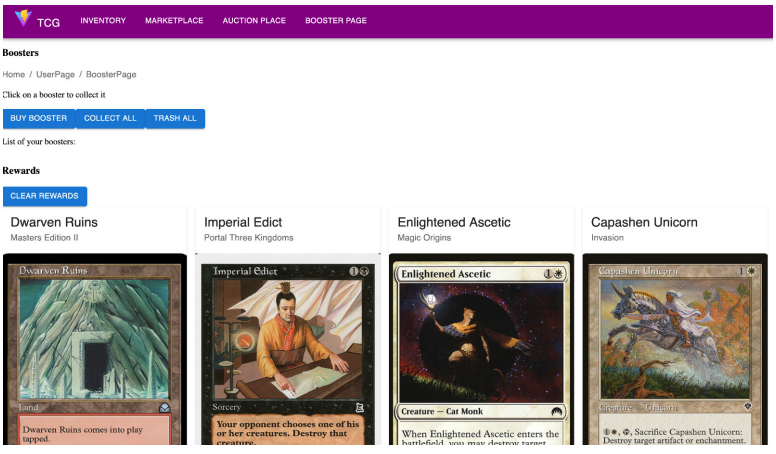

Figure 3.3: An example of the Booster page

3.2 Admin page

The Admin Page provides an overview of all cards, card collections, and user profiles within the system that proves to be valuable for the minting process.(see Figure 3.2)

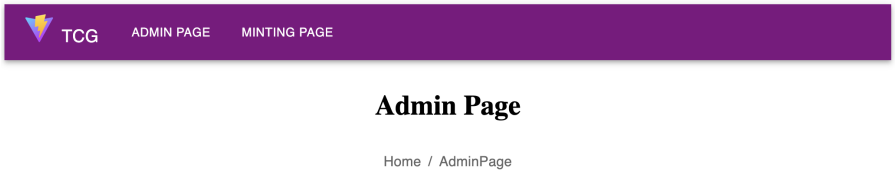

Figure 3.4: Appbar for the Admin Page

3.2.1 Minting page

Within the Admin Page, administrators have access to the *Minting Page* on the app bar displayed at the top of page. Here they can perform the operation of minting cards for a selected user. Minting a card is a multi-step process.

- Collection Creation: Initially, administrators must create a collection to which the card will belong. This step involves specifying the collection's name and setting the maximum allowable number of cards within the collection.(see Figure 3.2.1)

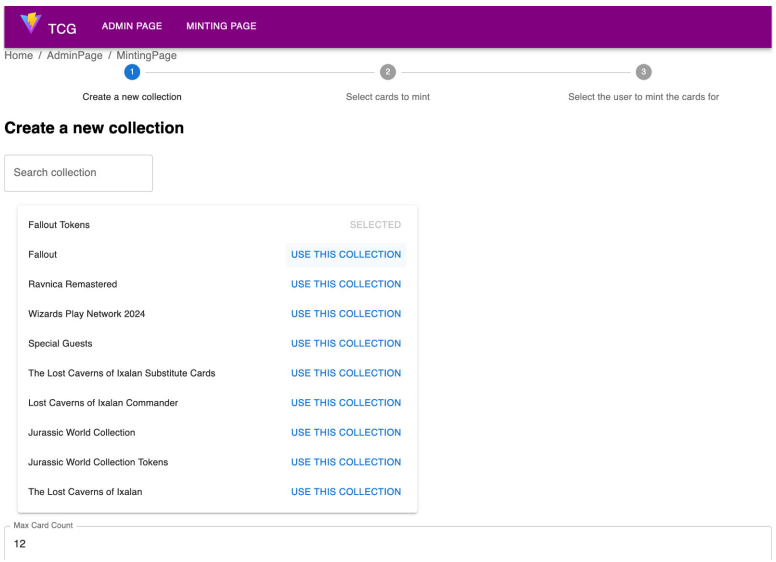

Figure 3.5: An example of the "create a new collection" step in the minting page process

- Card Selection: Once the collection is established, administrators can proceed to the card selection phase. They choose the specific cards to be minted and the selected ones are displayed on the right. An error message is shown when the number of selected cards exceeds the maximum allowed.
- User Assignment: The final step of minting involves selecting a single user to whom the newly minted card will be assigned.

This structured approach to minting ensures that card creation and distribution are carried out methodically guaranteeing accuracy and transparency and adhering to the specified constraint that each time new cards are minted, their corresponding collections must be created as required.
In conclusion, by creating dedicated pages for inventory management, marketplace exploration, auctions, and booster pack collection, we ensure that users can effortlessly navigate and explore the key aspects of the game, while admin can have a supervising and overseeing role thanks to the efficient information retrieval and an interactive game environment.

Conclusions

In the pursuit of creating a decentralized Collectible Card Game (CCG) on the Ethereum blockchain, this project has successfully combined the benefits of blockchain technology with the engaging world of collectible card games, enhancing the overall user experience and providing a robust platform for secure, transparent, and tamper-proof transactions.

The core components of the on-chain development phase are the basis for the creation and management of digital card collections. Each card is represented as a unique NFT on the blockchain, offering players ownership rights and the ability to trade these assets directly on blockchain-based marketplaces. Moreover, the organization in collections and the minting process ensures that new cards are introduced accurately and systematically, adhering to predefined constraints.

An API for NFT information, sourced from the Magic: The Gathering dataset, has been integrated to enrich the user experience by providing accurate metadata and visuals for each card. And the frontend development provides a clear and efficient interface distinctly separating the user and administrative functionalities. The User Page provides access to inventory management, marketplace exploration, auctions, and booster pack collection. The Admin Page is dedicated to the minting process, contributing to efficient and organized card creation and distribution.

In summary, this project has successfully established the framework for a decentralized Collectible Card Game on Ethereum, enriching the overall card-collecting experience. Through the integration of blockchain technology and a user-friendly frontend, it has paved the way for a secure and engaging gaming environment, catering to the needs of both users and administrators.