An NFT Marketplace for Graphic Artists in Bicol Region

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Abstract

Non-fungible tokens (NFTs) are gaining popularity in the market, but graphic artists in the Bicol Region face challenges in marketability, resource allocation, and determining the best features of existing NFT marketplaces. The study aims to examine these issues and create an original NFT web platform in the Bicol Region that incorporates blockchain technology, a cryptocurrency, and a decentralized wallet. Users can earn up to US$91.8 million in a single NFT artwork when NFT products are sold. The system uses software development methodology and a design thinking process to help the researcher develop a system that benefits the graphic artists in Bicol. Users can mint, list, bid, sell, and purchase NFTs, and transactions are recorded in a blockchain with unique transaction identities. After the development of the system, vital information will be provided, such as more substantial information for readers interested in the NFT blockchain and may improve their knowledge about it.

1. Introduction

Everyone possesses unique abilities in various aspects of life, such as writing, coding, video editing, and making art. However, one of the most valuable skills in this generation is the ability to create a unique art form known as non-fungible tokens (NFTs). The NFT [1] are virtual objects linked to unique digital content, like music or photos, and are typically associated with blockchain technology [2]. In this paper, photographs published on social media platforms that can be deemed NFTs achieved popularity with the owner after obtaining a heart or like reaction and positive remarks, but the underlying worth in terms of earnings was insufficient. The most frequent price for an NFT is presently US$5-US$100 [3], whereas unusual NFTs cost about US$91.8 million [4].

NFT products are currently among the most popular in the industry. It is a unique digital identification that is stored on a blockchain and used to verify the ownership and validity of NFT users [5]. In this study, a token represents the users' ownership of NFTs. The researcher sought to create a system for an NFT marketplace that would include blockchain technology and smart contracts to improve the security and preservation of artwork created by local graphic artists in the Bicol Region. Intellectual property rights are critical to maintaining product security, ownership, and protection. These blockchains align with the system's aims and operations, allowing users and local graphic artists to present and promote their work on virtual platforms without fear of intellectual property infringement.

Identification of the problems faced by local graphic artists, such as difficulties in marketability and resource allocation of artworks, as well as the difficulties encountered by the researcher in determining the best features of existing NFT marketplaces and features that should be integrated into the proposed system followed the information analysis. While the

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existing NFT markets are sites where users may benefit from minting, selling, and purchasing NFT items, the researchers' primary goal in the current study is to examine the best features of existing NFT marketplaces, design the features that should be integrated into the proposed system, and create an original NFT web platform in the Bicol Region that incorporates blockchain technology, a cryptocurrency, and a decentralized wallet [6].

2. Related Literature

Graphic artists may benefit from a variety of art kinds in NFT markets, including painting, mixed media, vector graphics, pixel art, and many more. To improve value, NFT producers should utilize attractive, gorgeous, and intriguing design elements. Although the findings can drive art design and sustainable education, various difficulties remain, including usability, security, privacy, and governance [7]. Other researchers have created a deep learning-based approach for identifying plagiarism in NFT photos, proving its viability for use in multiple NFT markets. The EfficientNet-B0-based deep neural network outperformed other models, underscoring the rising worry about plagiarism and fake NFT pictures in digital media [8].

The adoption of NFTs is not a single technology in this study, but rather the adoption of numerous technologies. The purchasing process [9] consists of numerous methods, each with a level of complexity and risk. The lack of transparency on NFT purchases results in consumer preferences for uniqueness, trust difficulties in broader adoption, and new business models based on digital content authenticity, all of which may have an impact on trust. As a result, this study highlights four elements that influence trust in NFT purchases: confidence in the cryptocurrency wallet, purchase, marketplace, and dispute resolution [10]. Partial Least Squares-Structural Equation Modelling revealed that these factors had a considerable impact on trust, with the first three having the greatest effect.

NFTs are digital ownership records that are recorded on a blockchain, allowing for verification and easy transfer of digital assets [11]. With over 245 NFT markets and 1,000 blockchains, they facilitate free trade via decentralized apps. However, these ecosystems confront hurdles in terms of security, transparency, scalability, and issue resolution [12]. The purpose of this research is to better understand the market dynamics of NFT ecosystems, examine their technological components, and investigate prospects and difficulties in addressing these concerns. Furthermore, NFTs are digital tokens that hold important information using blockchain technology [13].

According to Tian [14], revenue in the NFT market is expected to reach US$1,601.0 million in 2023. Revenue is estimated to rise at an annual rate (compound annual growth rate) of 18.55% between 2023 and 2027, totaling US$3,162.0 million by 2027. By 2023, the average revenue per user in the NFT market will be US$114.8. According to worldwide comparisons, the United States generates the most income (US$781,900 in 2023). The NFT market is estimated to have 19.31 million users by 2027. In 2023, user penetration will be 0.18%, and it is predicted to reach 0.24% by 2027.

However, budgetary restrictions make it difficult for developers in Pakistan to obtain project licenses. This article describes a novel NFT strategy and business rules for IT professionals, including the idea of NFTs storing whole programs and allowing developers to use virtuality and the metaverse. Concerns regarding the environmental implications of blockchain technology's high energy usage continue. To reduce emissions, post-merge options including carbon neutrality, lazy minting, alternative consensus methods, Layer 2 solutions, and regulatory interventions are required [15].

NFTs are gaining popularity because of their decentralization, transparency, and security, with a trading volume of US$10 billion in Q3 2021 [16]. However, blockchain's high complexity results in increased transaction fees and restricted scalability. This study recommended alternatives such as Fantom, Avalanche, and Polygon, with the Polygon network demonstrating greater efficiency [17]. It demonstrates that the NFT Club's goal is to establish a user-friendly NFT trading platform for the general public that allows for the purchase and sale of common cryptocurrencies. The project will employ the Web3.js structure, MetaMask, and Solidity to build decentralized platforms [18], assure NFT accessibility, and secure user safety on

emerging platforms such as blockchain. Furthermore, blockchain-based technologies have transformed the security of digital assets by introducing NFTs into a variety of sectors such as education, fashion, sports, and digital art, highlighting their core technologies and applications while also addressing challenges such as security, privacy, and property rights when adopting NFT technology [19].

3. Methodology

This section provides a detailed discussion of the methodology for system development. The first is the feature-driven development (FDD) methodology to determine how the system was developed, and the second is the design thinking process to develop solutions, NFT artwork, or services that are desired for the user, economically viable from a business perspective, and technologically achievable.

3.1. Software development methodology

FDD will be used as a software methodology due to its focus on creating functional software with features that meet the needs of users. This provides the researcher with a thorough understanding of the nature and context of the system. FDD has five components, such as developing a model, building a list of features, planning out each feature, designing each feature, and building each feature that will guide the researcher in creating software designs and functions.

3.1.1. Develop an overall model

This is the stage in which the outline is written. Using the problems and objectives as a guide, the researcher will create detailed domain models, which will then be merged into one overall model that shall serve as a rough outline of the system. As seen in Fig. 1 below, the system architecture of an NFT marketplace serves as a guide for the development of the system.
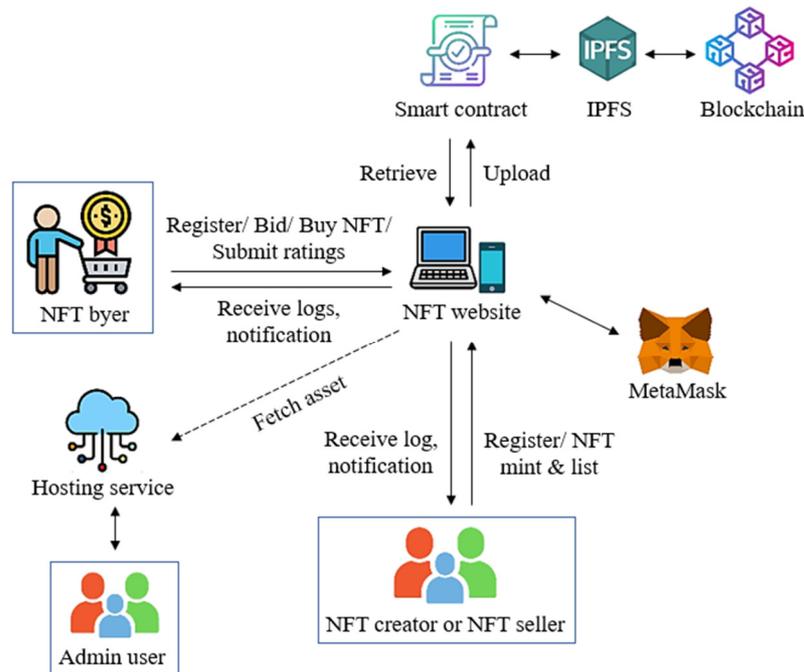

Fig. 1 System architecture of an NFT marketplace

The seller or the creator must create or register an account with MetaMask to have access to minting, listing, bidding, or buying NFT. NFT minting and listing will be done by the seller or creator for interested NFT buyers. However, NFT buyers can also create a MetaMask account in the system to make an offer for pricing or bid on the NFT products, as well as submit a rating after the transactions to the seller or creator. The admin user is also listed in the architecture to manage the hosting service of the system.

Within the MetaMask, each user, if they want to mint, list, and buy an NFT, must create or register in the MetaMask. MetaMask is useful to have a token like Polygon for exchanging NFT products with the system. It also provides a secure platform for all users in the NFT marketplace. Additionally, smart contracts are responsible for managing buying and selling in the NFT marketplace. This smart contract is also used to transfer the ownership of the NFT artwork to the buyer of NFTs, maintain the originality of the NFTs, and prevent the copyright.

Every NFT has metadata to store the NFT artwork when it is minted. A price, an identification number, and a unified resource identifier are among the details kept in the metadata. However, in the proposed system, there is also a unique hash associated with its ID, and this hash is the InterPlanetary file system (IPFS). This IPFS, a decentralized file storage network, was used to store the NFT in the metadata to be kept on the chain along with its distinct hash. This also increases the NFTs' legitimacy and helps reduce fraud. Within the blockchain, all the data uploaded as well as the transactions in the system are recorded. Additionally, this architecture shows the important features of the system that are needed to integrate into the proposed system. Using this, the researchers or the developer of the system can easily identify the needs of the system in terms of its designs and functions.

3.1.2. Build a feature list

Building a list of features is the second phase of FDD. Using the data from the first phase, the researchers listed 18 selected NFT marketplaces to determine the best features shown in Table 1. Additionally, the researcher also listed some of the unique features that should be integrated into the proposed system. These features are patterned from 18 selected NFT marketplaces, which are combined into one system, which is the proposed system by the researchers. Integrating these unique features serves as a difference between the proposed system and the existing NFT marketplaces, as shown in Table 2.

3.1.3. Plan by feature

The third phase is planning out each feature where researchers will assess each item on the list. Then, the features will be created by the researcher or developer and one of the suggested system's necessary components is Store Front, which requires constructing an NFT website with a presentable design to attract and engage users. Furthermore, having a responsive design for the system on mobile devices has greatly improved the user's ability to readily access the NFT's website.

User Profile: This feature on an NFT website improves the user's experience while modifying their NFT goods. This feature allows each user to analyze their actions as well as the transaction history for NFT purchases, sales, bids, and other marketplace activities. Furthermore, the researcher discovered that this feature allows users to quickly connect and communicate with other NFT users by following them and engaging in discussions in the comment area and on social media platforms.

Security and compliance are also crucial components of a system that protects a user's assets. Implementing an anti-money laundering strategy and getting to know your customers will help you authenticate the user's identity and avoid unlawful activity. Implementing a secure smart contract reduces the danger of future vulnerabilities and attacks while increasing the uniqueness of NFT products. Continuous monitoring and upgrading of security measures will ensure the safety of all NFT users.

In addition, NFT minting and listing are among the system's features. This functionality will aid users with the minting of NFT products. Providing required features such as title, image, description, and pricing alternatives can increase the appeal and exposure of NFT listings in the marketplace. The study also determined that reducing transaction fees, providing real-time updates, and automating metadata production will improve the user experience and ensure that each user is constantly up to date on what is going on in the marketplace.

Discovery and Curation is a useful tool for users to search, explore, and discover, as well as curate NFT items. It is beneficial for NFT consumers to find what they require in the NFT marketplace. Filtering NFT items based on category, distinctiveness, popularity, and price will help consumers locate them more quickly. The user may also manage and develop their own NFT collection, allowing them to customize their collections, improve their experience, and highlight their assets, notably the popularity of the NFTs.

The research investigates the usage of auctions and bidding for NFTs, focusing on the advantages to users. It emphasizes the relevance of a bidding system that allows users to bid on preferred artworks. The functionality also emphasizes the necessity of NFT alerts to keep users informed about bidding updates. To monetize the platform, it is recommended to include bidding and transaction fees in advance, fostering transparency and preventing unexpected expenses throughout the purchasing and selling process.

The suggested solution comprised both the user experience and the interface. User experience and interface are also essential considerations when creating NFT markets. An NFT marketplace's interface is well-designed, making interaction with it simple. Organizing the information and NFT artwork in the marketplace will allow users to interact with the platform more effectively.

Furthermore, offering a cryptocurrency wallet in the marketplace eliminates the need for customers to migrate to other platforms. The NFT marketplace, which incorporates blockchain technology via a coin and a decentralized wallet, can enable decentralization and transparency. This blockchain network might be compared to Polygon for exchanging NFT items.

It is critical to provide a variety of payment choices, including debit and credit cards [20], as well as creative options such as cryptocurrency, known as payment and monetization methods. This monetization technique ensures the NFT marketplace's long-term survival.

However, certain costs are included in minting, listing, bidding, and buying transactions for monetization to enhance the functionality of the system. These fees are also part of the NFT marketplace, which generates income and encourages usage. Minting fees, and listing, which are charged while producing new NFTs, are beneficial for paying blockchain operation costs and deterring spam.

Smart Contracts and Solidity Programming: NFT transactions require transparency, immutability, and trust, which are enabled via smart contracts and self-executing agreements. It uses Polygon's Solidity programming language to coordinate ownership transfers and enforce transaction restrictions. Solidity is a crucial tool for developing NFT markets because it enables complicated, programmable contracts. Before deployment, thorough auditing and testing are required.

However, for the unique features of the proposed system, based on the critical review, the researcher discovered a unique feature that can be implemented in the proposed system, such as:

Analytics, which provides a graphical representation of the token volume and NFT volume;

Rewards, where users can earn extra token through minting and listing an NFT artwork;

Ratings, where NFT buyers can rate the NFT creator or seller based on their experience during the transaction, like the creativity of the creator;

Downloading a single artwork in numerous formats;

filtering artworks by category;

and Multilingual, where the users change the language of the system, such as English, Filipino, and Bicol. All these features are implemented into the proposed system and act as an advantage among other NFT marketplace websites.

Table 1 Best features from selected NFT marketplaces (Exist: ✓, Does not exist: ✗)

Features	NFT marketplaces																	
	OpenSea	Magic Eden	Castle	Hyperspace	Rarible	MakersPlace	Mintable	Infinity	Foundation	NFTX	Gamma.io	Wen Moon Market	Sqwid	Hebys	GhostMarket	Prohibition	Ebisusbay	NFTEarth
Store front	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
User profile	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Security and compliance	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
NFT minting and listing	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
NFT discovery and curation	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Auctions and bidding	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
User experience (UX) and interface	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Decentralization and transparency	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Payment and monetization methods	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Smart contracts and solidity programming	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Table 2 Unique features from selected NFT (Exist: ✓, Does not exist: ✗)

Features	NFT Marketplaces																	
	OpenSea	Magic Eden	Castle	Hyperspace	Rarible	MakersPlace	Mintable	Infinity	Foundation	NFTX	Gamma.io	Wen Moon Market	Sqwid	Hebys	GhostMarket	Prohibition	Ebisusbay	NFTEarth
Analytics	✓	✓	✓	✓	✗	✗	✓	✓	✗	✓	✗	✗	✗	✓	✓	✗	✗	✗
Rewards	✗	✓	✓	✗	✗	✗	✗	✓	✓	✓	✗	✗	✗	✗	✓	✗	✓	✗
Ratings	✗	✗	✗	✗	✗	✗	✓	✗	✓	✗	✗	✗	✗	✗	✗	✗	✗	✗
Download an artwork in multiple formats	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗
Filter artworks by tags or category	✓	✗	✗	✗	✗	✗	✗	✗	✗	✗	✓	✗	✗	✗	✗	✗	✓	✗
Multilingual (English, Tagalog, Bicol)	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗

3.1.4. Design by feature

The fourth phase is the design-by-feature phase, which initiates the process of allocating features for the design's specified target development date, with a focus on feature priority. The researcher examined the outline features to identify which are priorities and how to carry out their functions during system development. As shown in Fig. 2 illustrates the target date for the creation of each feature integrated into the proposed system. Time allocation for the development of the system can manage and track the updates. This also serves as a guide on what designs or functions need to be done first.
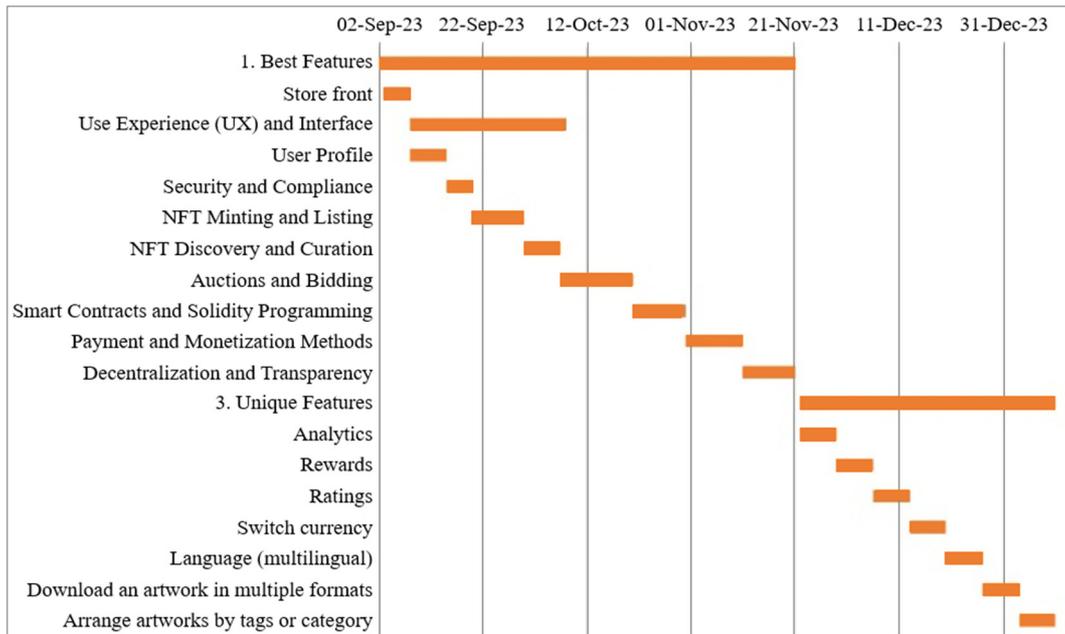
Fig. 2 Time allocated to designing and developing the system features

3.1.5. Build by feature

The final step is creating the features. This phase is concerned with the general development of the system. User interfaces, as well as the designs and functionality of each system feature, are presently in development. This section highlighted the important designs and functions of the system, such as MetaMask wallet connection, minting and listing, bidding, uploaded NFTs, downloading NFTs, and listed or owned NFTs by the user.

Integrating a MetaMask wallet is vital since it allows users to conduct transactions for minting, listing, bidding, and purchasing NFTs on the marketplace. The researcher will create an interface with a function where users can connect to a MetaMask wallet. Users must first download or install the MetaMask extension in their browser. As shown in Fig. 3, a newly created interface, and using this, the users can now purchase, sell, bid, and mint NFTs.
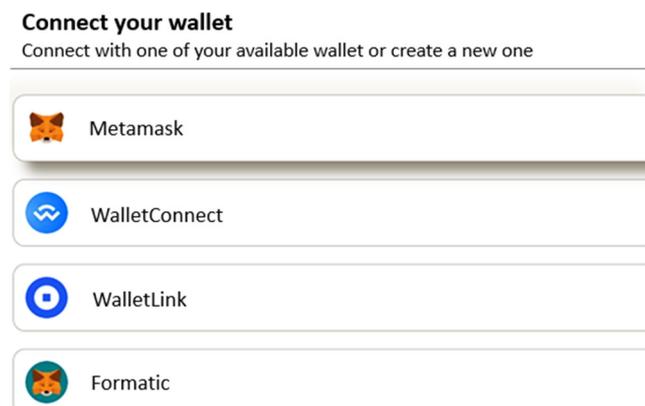
Fig. 3 MetaMask wallet connection

Fig. 4 depicts the design and function for minting an NFT product in the system. The upper half of the graphic Fig. 4(a) represents the function of dragging and dropping an image from your file where the NFT product is located, while the lower portion Fig. 4(a) represents the previews with detailed information about the NFT product you wish to upload. Furthermore, offering a design and capabilities that allow you to enter the relevant information about the NFT product is important. The graphics on the right side of Fig. 4(b) depict the fundamental input information for the NFT item, which includes the name of the NFT website, description category, royalties, picture size, attributes, and price. Then, after verifying the information, you may preview or submit the NFT you prepared.
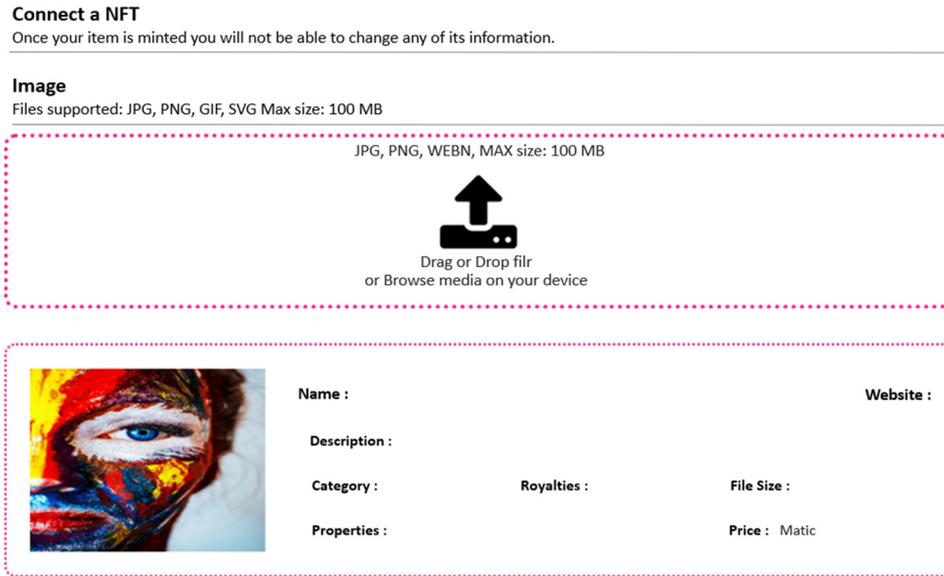
(a) Upload and preview NFT product
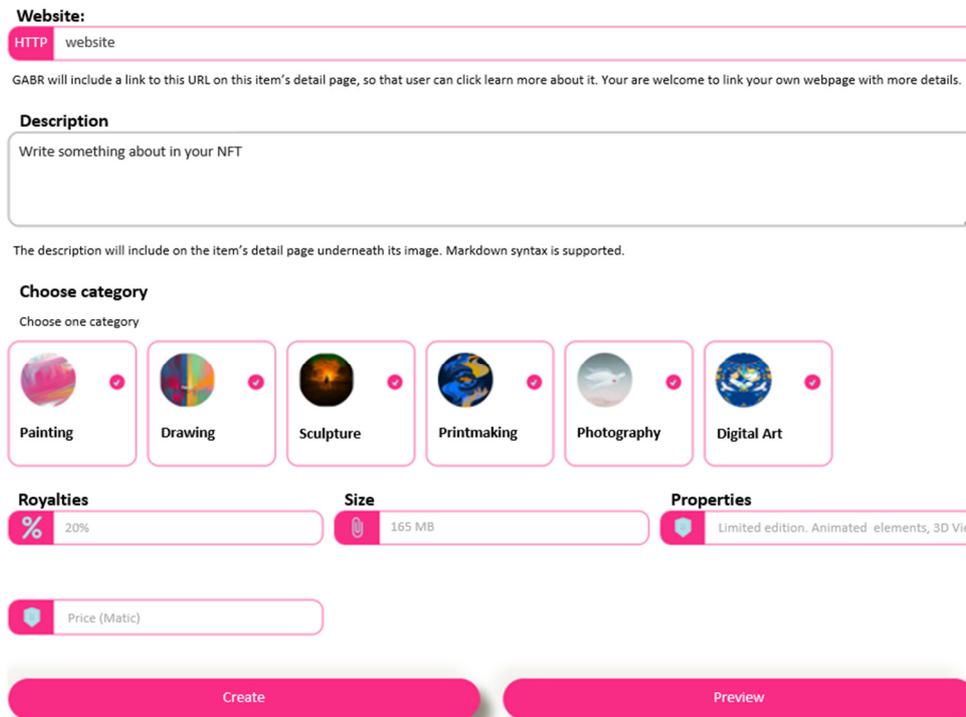
(b) Setting up information on NFT product

Fig. 4 Minting of an NFTs

After the minting process of an NFT, the researchers also created an interface where all NFTs minted and listed are shown. As you can see, it is an NFT artwork uploaded to the system, as illustrated in Fig. 5. All NFTs are offered at a Matic price and may now be purchased by any user. The design also includes a capability that allows users to filter based on the category of an NFT.
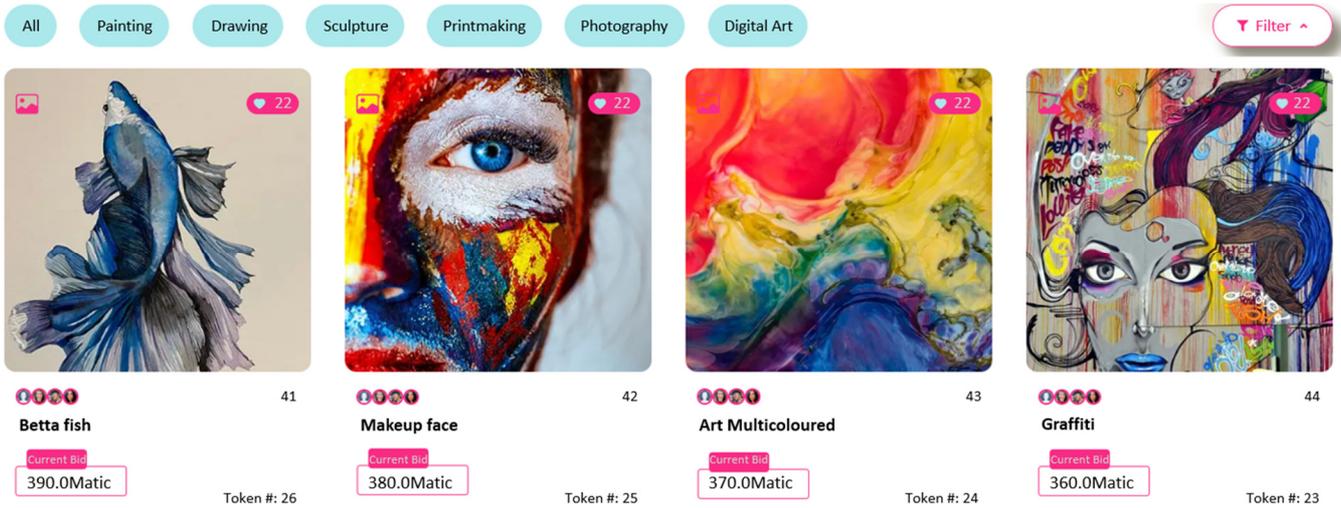
Fig. 5 Uploaded NFT and filter by category

Auctions and bidding are important in the NFT marketplace. That's why the researchers want to develop functions and designs where users can auction and bid on NFT. After the development, auctions and bidding were developed, as shown in Fig. 6. This section also instructs buyers on how to bid on and purchase NFT artwork. Each NFT product comes with these designs, allowing customers to own the NFT of their choice. The buyer can submit an offer (bid) for the NFT based on the price that he or she desires Fig. 6(a), and the seller will select the buyer based on what the seller wants Fig. 6(b). If the NFT product is in the bidding process, the top seven will appear in the lower portion of the buy NFT and make an offer.

However, the purchase NFT button allows you to buy the NFT immediately. Clicking the button will launch a payment procedure in MetaMask. Additionally, if the creator or seller of an NFT is accepting a bid Fig. 6(c), confirmation for payment in MetaMask will be shown. After the confirmation, the NFT will be immediately removed from the list of sellers and transferred to the purchaser of the NFT artwork.
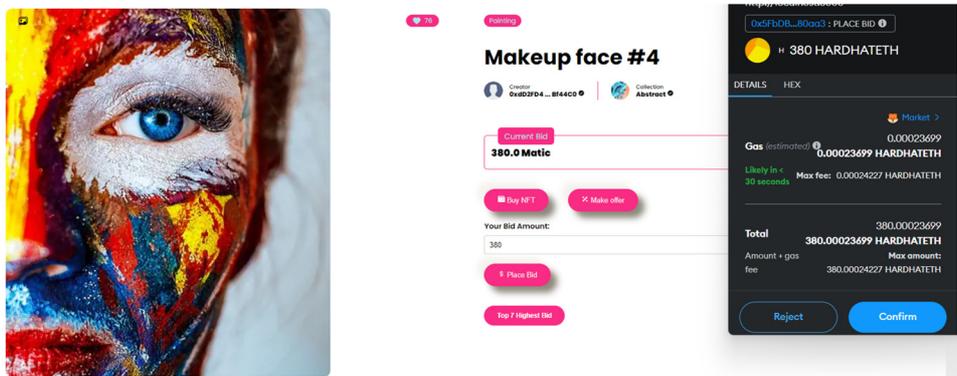
(a) Make an offer (bid) of an NFT
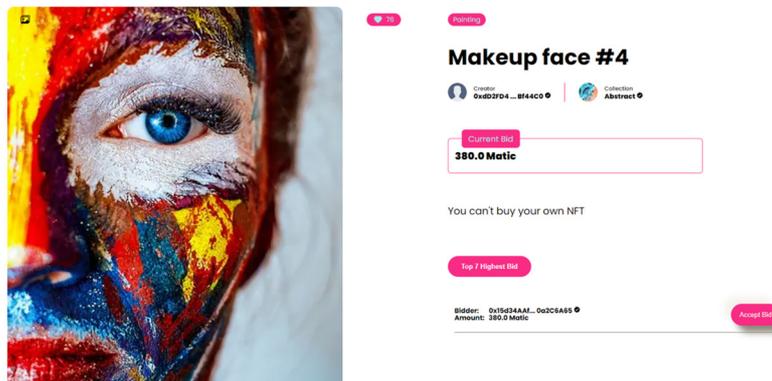
(b) List of a user/s who make an offer (bid) of an NFT

Fig. 6 Bidding of an NFT
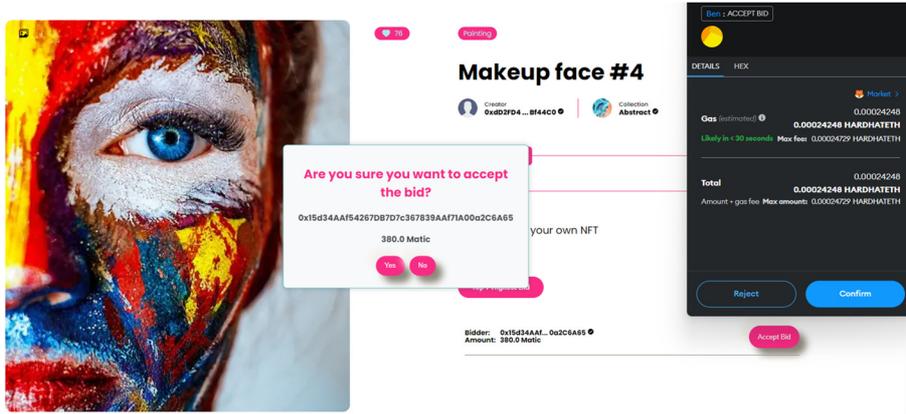
(c) Accepting and confirming an offer (bid) of an NFT

Fig. 6 Bidding of an NFT (continued)

After the purchase or acceptance of the bid, it is also important to have a specific section where the owned NFT of the users can be seen, and that is why the researcher created this interface as shown in Fig. 7 shows the user profile, which includes both the listed and owned NFTs. Simply pressing the button displays the exact NFTs for listed NFTs or owned NFTs. These features enable users to quickly display their NFT artwork on their profile.
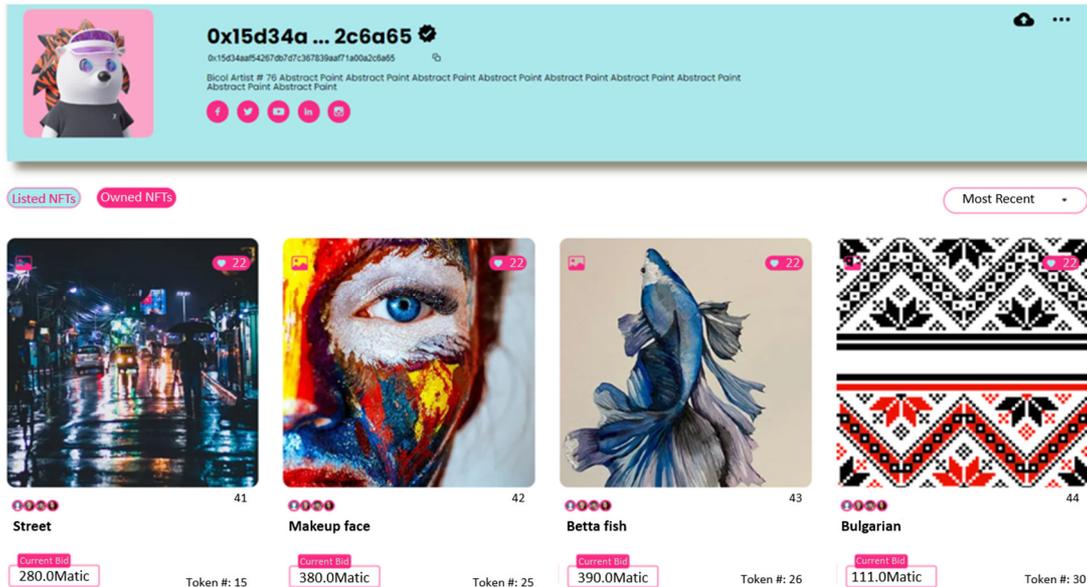
Fig. 7 Owned NFT of the users
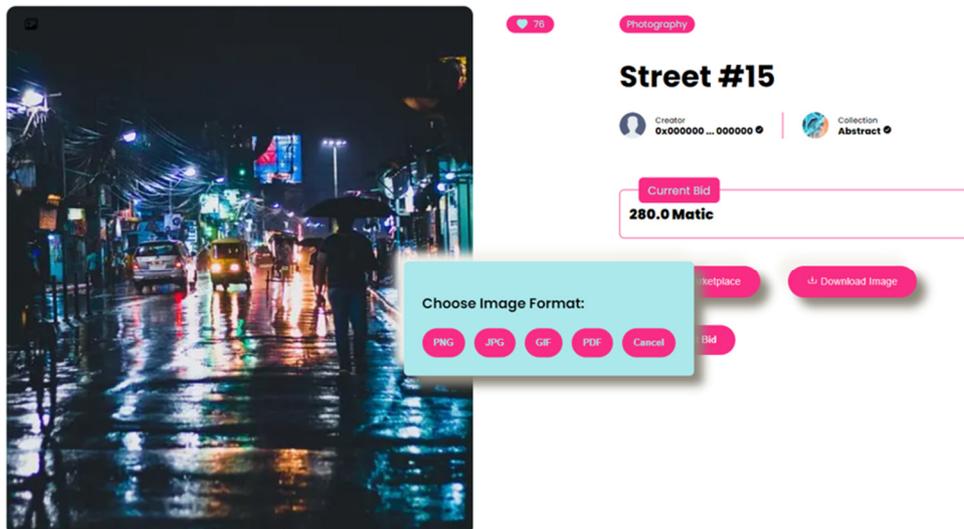
Fig. 8 Download an NFT artwork in multiple formats

The researchers also developed a function to download an NFT artwork by the users as shown in Fig. 8, where customers may pick from a variety of formats including.png,.jpg,.gif, and pdf. The download NFT artwork is particularly developed for users who have already purchased or owned NFT and they can only download it once.

Additionally, the system can resell the NFT that the users have already purchased from the creator while maintaining the original creator of the artwork. The users can select the NFT from their own NFT, and then put a price on the box. The price can increase based on the seller's desires. After providing a price, select the necessary button to proceed with payment through MetaMask. This transaction can be seen in Fig. 9 below.
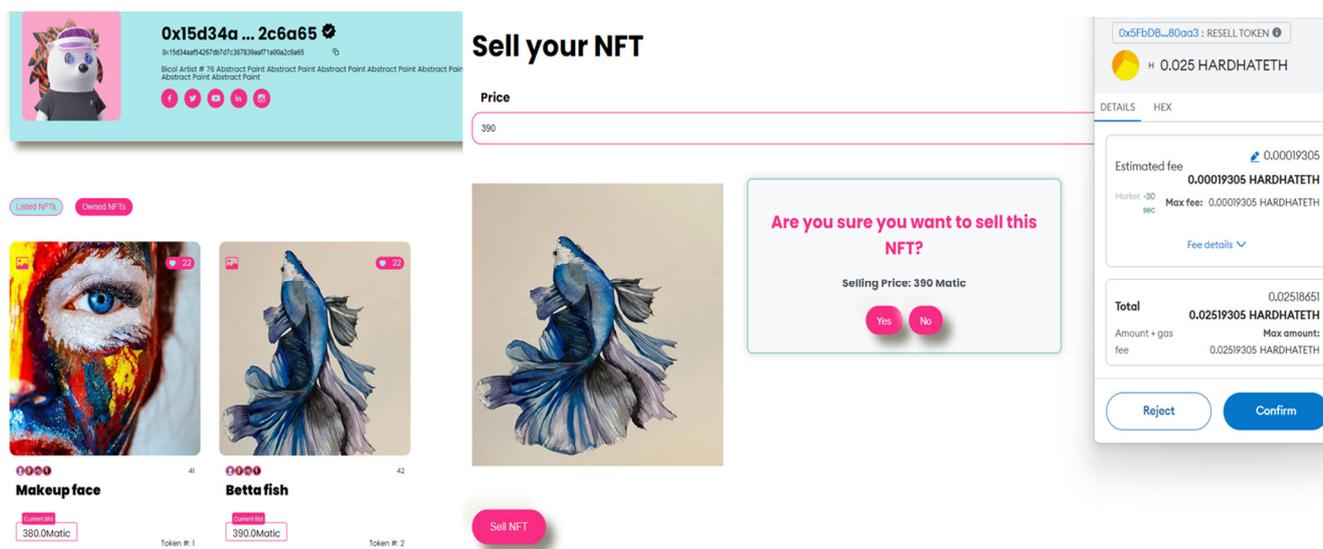
Fig. 9 Resell NFT

3.2. Design thinking process

This section also discusses the design thinking process used by the researcher to construct a viable NFT marketplace for graphic artists in the Bicol Region. The design thinking process is used to understand users, question assumptions, reframe challenges, and develop unique solutions for prototyping and testing. It is particularly beneficial for addressing unclear or unknown challenges and consists of five phases: empathy, definition, ideation, prototyping, and testing.

3.2.1. Empathize

The first step is to empathize, in which the researcher begins to consider the components that will be used to develop a system that assists graphic artists in the Bicol Region. First, engage with an NFT and blockchain specialist to understand the requirements for creating a viable NFT marketplace system. Furthermore, the researcher examined and researched different social media and website platforms related to NFT artwork. In addition, an interview was done to use the respondents' responses in this study.

3.2.2. Define

The defining phase is the second part of the design thinking process, which involves outlining the study's challenges. Local graphic artists, particularly newcomers or aspiring graphic designers, were not acknowledged for the genuine value of their work when they posted it on other social media platforms. Some of the concerns that this research is attempting to address include difficulties in marketability and resource allocation for their artwork, as well as the ability to simply steal or replicate their artwork without the owner's consent. Furthermore, one of the researcher's challenges is selecting the most beneficial features of existing NFT markets that may be applied in the proposed system, as well as the functions and design features that should be integrated into the system.

3.2.3. Ideate

The third step is ideation. The researcher's thoughts lead to the identification of novel solutions to challenges. The researcher identified several features that are extremely useful in the NFT marketplace, including store front, user profile, security, and compliance, NFT minting and listing, NFT discovery and curation, auctions and bidding, user experience and interface, decentralization and transparency, payment and monetization methods, and smart contracts and solidity programming. The researchers recognized and incorporated unique features of the NFT marketplace into the proposed system, including analytics, rewards, ratings, downloading artworks in numerous formats, filtering artworks by category, and multilingual.

3.2.4. Prototype

The prototype phase comes next. This stage illustrates the evolution of the system produced, which is a web system for NFT's product that uses blockchain. It included a variety of designs and features for minting, bidding, listing, and purchasing NFTs, as well as user profiles, blockchain, smart contracts, and analytics, downloading NFTs, filtering artworks by category, and multilingual. These are some of the key features of the proposed system that was developed.

3.2.5. Test

The prototype iteration's major goal is to ensure that the built system is completely functioning. During this phase, all system functionalities are tested many times. Feedback from users of this system was utilized to assess if the produced system had an error.

4. Results

In this study, important transactions are revealed after the designs and functions are developed. Based on the analysis of the researchers, the best features of current NFT markets are required to be integrated into the system to make it function effectively as an NFT marketplace. The unique features are also integrated which serves as an additional feature of the system. This makes the system more secure and user-friendly when users do transactions.

(a) Create token confirmation　　(b) Offer or bidding confirmation　　(c) Buy NFT　　(d) Sell your NFT/Listing
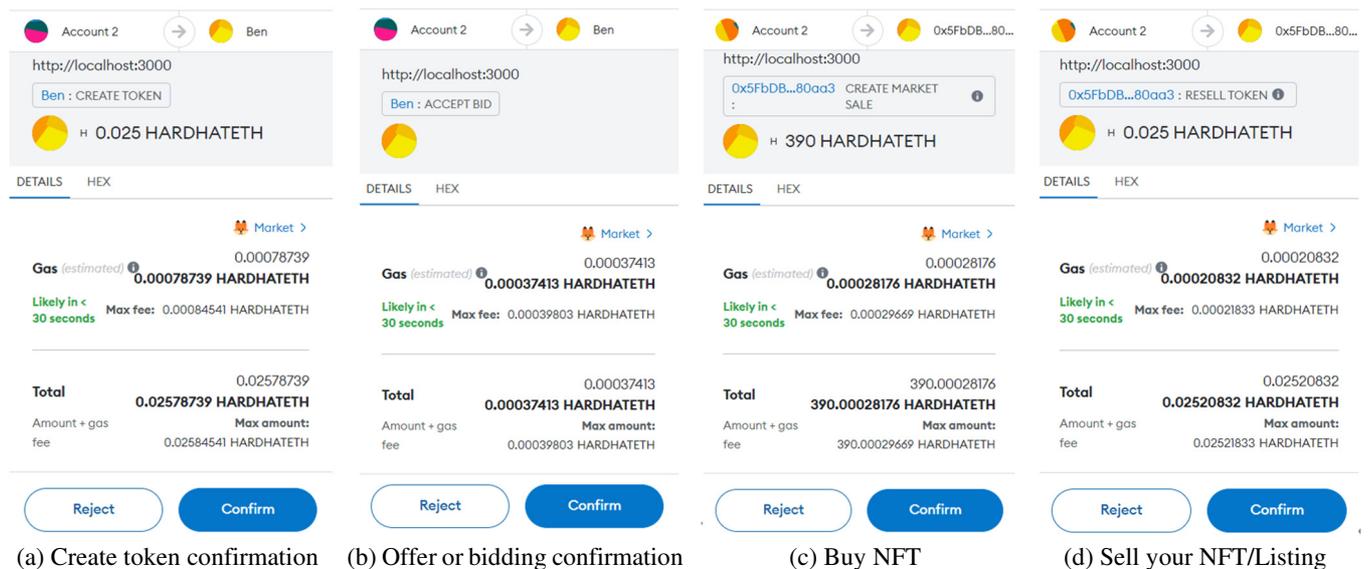
Fig. 10 Transactions for confirmation

When the users mint or list an NFT into the system, important transactions are created, as depicted in Fig. 10(a) generate token confirmation. This might be done once the creator or seller uploads an NFT into the system and creates specific information such as the name, price, category, description, size, royalties, and properties of the NFT. When the seller or creator

chooses from the list of bidders and accepts their bid, Fig. 10(b) is generated. For the NFT already minted or listed in the marketplace, when the buyer directly buys an NFT artwork, Fig. 10(c) is generated as confirmation of buying an NFT. Additionally, when the users decided to resell the NFT artwork they already owned, Fig. 10(d) was generated as confirmation of reselling an NFT or listing an NFT.

Furthermore, to compute the total and max amount of HARDHATETH before the confirmation of the transaction, the equation below was utilized. This equation was originally formed for this study to determine the gas fee for a specific transaction in the NFT marketplace.

$$t = h + g \tag{1}$$

where t is the total fee, h is the HARDHATETH fee, and g is the gas estimated from Fig. 10(a). The max amount can be found by:

$$ma = t - g + mf \tag{2}$$

where ma is the max amount, t is the total fee, g is the gas estimated, and mf is the max fee from Fig. 10(a).

Substitute the values:

Total = 0.025 + 0.00078739; Total = 0.02578739; Max amount = 0.02578739 − 0.00078739 + 0.00084541; Max amount = 0.02584541

So, the gas fee is 0.02584541 HARDHATETH.

In addition, unsuccessful transactions, such as the produced token transaction, are logged in the activity area, as illustrated in Fig. 11. A failed transaction does not affect the user's wallet account token balance. The generated failed transaction may be because of insufficient gas fees, network congestion, nonce mismatch, smart contract errors, out-of-gas transactions, wallet issues, network forks or reorganizations, or contract interactions. To avoid this kind of error or failed transaction in the NFT, the users must ensure gas fee estimation, nonce management, wallet connectivity, double-check transaction details, monitor network conditions, use reputable platforms, use transaction retry mechanisms, or stay informed about blockchain technology updates, best practices, and security considerations.
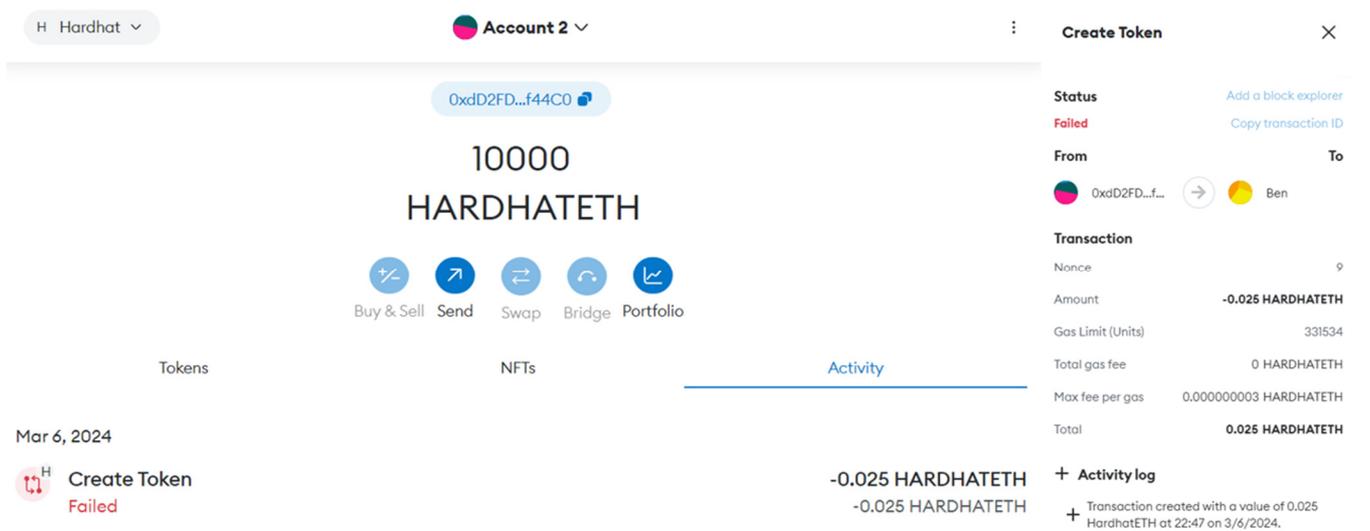

Fig. 11 Failed transaction of an NFT artwork

Furthermore, important transactions are also shown in Fig. 12 such as hex Fig. 12(a), when the users mint, list bid, and by an NFT artwork, this will be automatically generated. Hexes are also composed of function types and hex data. Activity Fig. 12(b), where it is the list of all activities in HARDHATETH. All transactions in the NFT marketplace, such as minting, listing,

bidding, and buying, are recorded in the activity section. Specific activity Fig. 13(c) is a transaction after confirming the bidding, buying, minting, and listing in the system. The contract address Fig. 13(d) is a unique identifier for a smart contract that has been implemented on the blockchain. Smart contracts are self-executing agreements that follow preset rules and automatically impose actions when particular criteria are satisfied.

The contract address also enables users to engage with the smart contract by giving or receiving tokens or activating specified functionalities. This section is also known as decentralized transparency recorded onto a blockchain to make the transaction safe and preserve the uniqueness of an NFT artwork. Every transaction for minting, selling, and bidding, whether approved, rejected, or unsuccessful, has a transaction ID.

| (a) Hex | (b) Activity | (c) Specific activity | (d) Contract address |
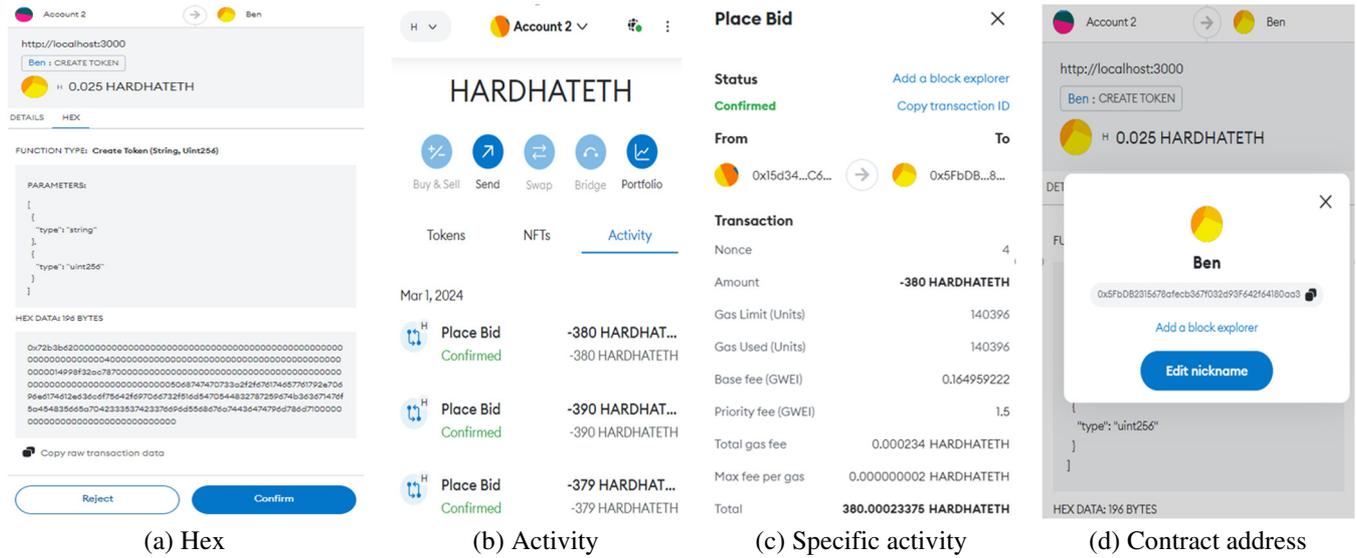
Fig. 12 Important transaction details for minting, listing, bidding, and buying NFT

Fig. 13 depicts the analytic volume of Matic created because of many NFT minting. For every transaction, such as minting, listing, bidding, and buying an NFT in the system, a white dot will be added, and the volume for Matic will increase. It represents the entire cost spent on minting an NFT product for one specific account in MetaMask. The white dot represents the price of each NFT minted in the system, with the lowest mint being 100 Matic, the Polygon token, and the maximum being 400 Matic. This volume of analytics for Matic was carried out between January 28 and January 30, 2024.
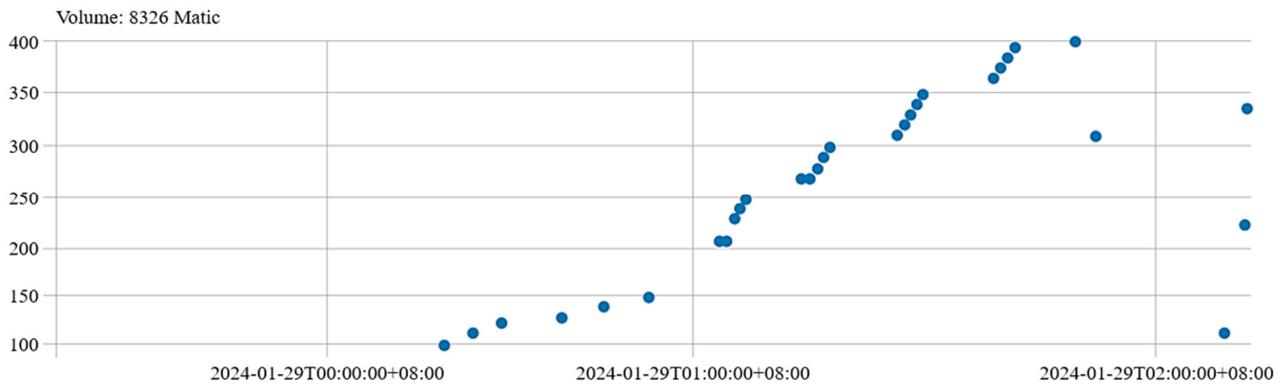

Fig. 13 Analytics for the volume of Matic

Furthermore, a unique transaction ID is always assigned throughout the minting, bidding, buying, and listing of an NFT. This transaction ID may be used to identify a specific transaction from a certain date, as illustrated in Table 3, which depicts an example of transaction identification following the minting, listing, bidding, accepting bid, and purchasing of an NFT. In the system, sellers are unable to buy or bid on their NFTs. These are also the reasons why listed NFTs and owned NFTs are separated to identify the sellers or creators as well as the purchasers of the NFTs that they already possess and have posted in the system.

Table 3 Unique transaction ID

Type of transaction	Transaction ID
Minting	0x349c1d172b175512c14bc6b55504a00f829a24745d7ad49ab879917e9fa1f291
Make an offer or Bid	0x8b214982044984cfe61a0fdefe1a6ca74fb41029025cb880bfad7929f259f92e
Accept Bid	0x6be2b959449f8a911582956912966bdfca4215bd6947fb1f90f5d20b6d72dd2f
Listing	0xb60b5b8aa9d208a3bb2878cdc2bc9da7966c8cbe50b8b07b5d8048943cef7440
Buying	0x72b86048d1dfcc87e989962ad30c07b9973862e36745611466c1dc15f185e6a5
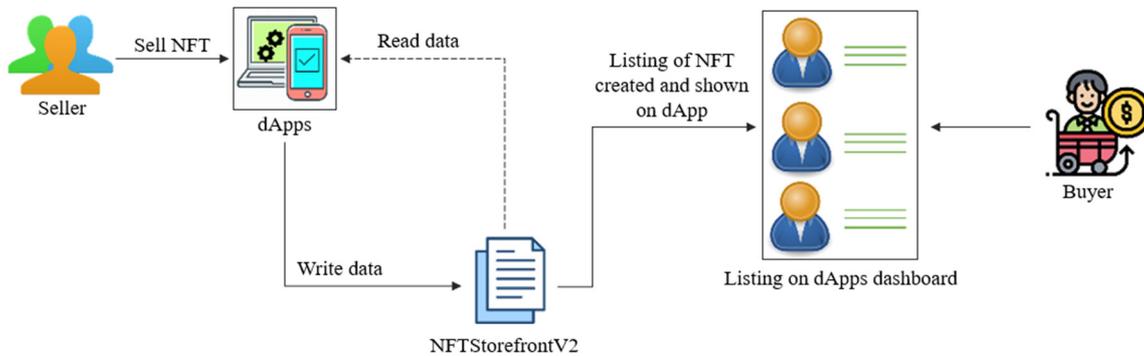
(a) Sellers to list NFTs in dApp
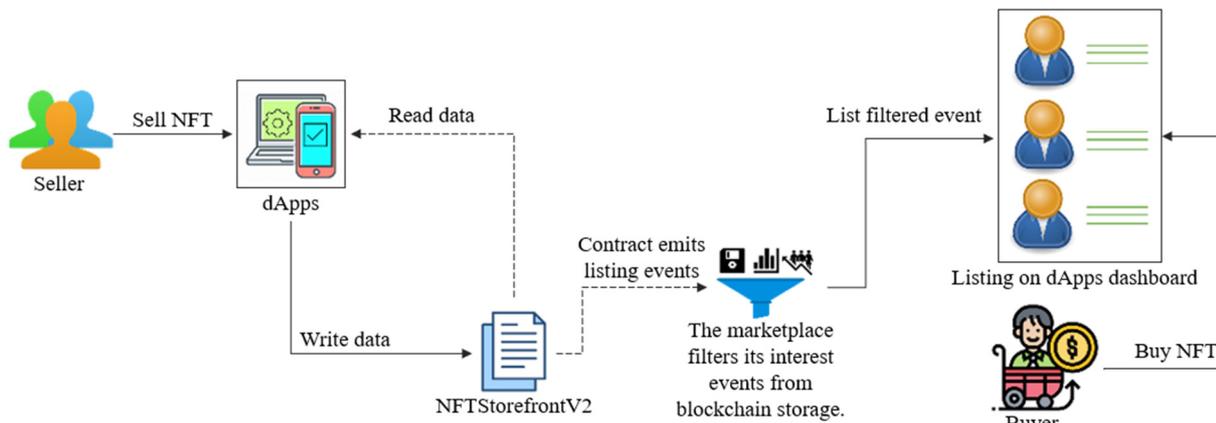
(b) Facilitate the creation of NFT listing
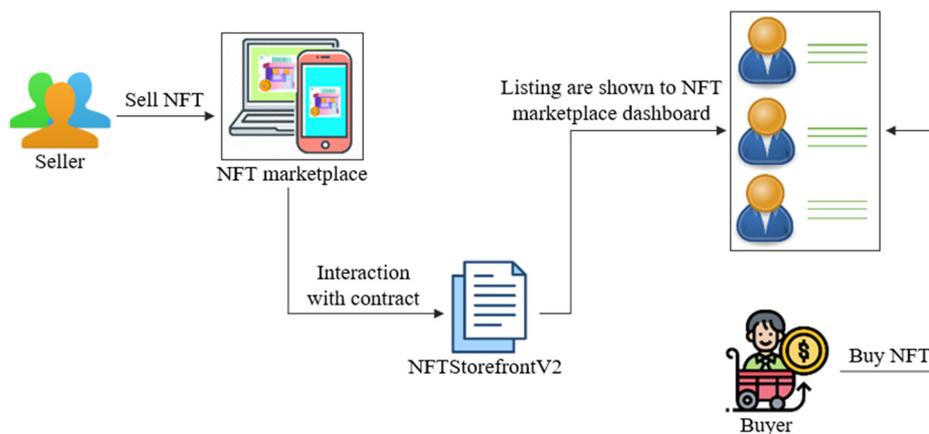
(c) NFT trade by interacting directly with the seller

Fig. 14 NFT marketplace smart contract of the system [21]

Additionally, the NFTStorefrontV2 contract allows you to build a non-custodial resource (NFT) marketplace on the FLOW blockchain. NFTStorefrontV2 makes it easy for vendors to list NFTs in the dApp NFT marketplace. Fig. 14(a) shows how dApp developers utilized the contract's APIs to handle for-sale listings and perform NFT deals. Developers used NFTStorefrontV2 to develop the marketplace and allow peer-to-peer transactions. Fig. 14(b) depicts how dApps may help users create and filter NFT listings. Listings created through a single dApp shop can be featured on several third-party

marketplaces. Well-known third-party markets listen for appropriate NFT listing events, which allows listings to be automated into their dashboards. Using the NFTStorefrontV2, the system can quickly and effectively connect to the active FLOW NFT ecosystem, allowing NFT holders to list their NFTs and enabling creator royalties as shown in Fig. 14(c).

The system then completes an NFT transaction by communicating directly with seller storefronts. Flow's account-based procedure assures that NFTs advertised for sale remain in the seller's account until traded, regardless of how many listings are put across multiple markets for the same NFT.

5. Discussion

To further understand the proposed study of the NFT marketplace and blockchain technology, here are the highlighted discussions of the correlations between NFT and blockchain. The NFT and blockchain technology have a fundamental connection since NFTs rely on blockchain technology for their existence, operation, and security. This illustrates how both are correlated:

5.1. Interoperability

Blockchain technology enables communication across various NFT platforms and ecosystems [22]. Depending on interoperability standards and protocols, NFTs created on one blockchain may be able to be exchanged or used on another. Interoperability broadens NFTs' reach and liquidity, allowing for more widespread adoption and innovation.

5.2. Smart contracts

Smart contracts, which are self-executing contracts with the terms of the agreement put directly into code [23], are critical in NFT transactions. Smart contracts on blockchain platforms support the development, transfer, and execution of NFTs, providing capabilities such as royalty payments for authors, automated resale commissions, and provably scarce digital assets.

5.3. Foundation on blockchain

NFTs are digital assets that are uniquely identifiable and indivisible; they are often represented as blockchain tokens. Blockchain technology offers the foundation for producing, storing, and transferring NFTs [24]. Each NFT is generally created as a unique token on a blockchain, ensuring its legitimacy and ownership.

5.4. Immutability and transparency

Blockchain technology provides immutability and transparency [25], which are critical characteristics of NFTs. Once an NFT is established and recorded on a blockchain, its ownership and transaction history are safe and cannot be changed. This maintains the integrity of NFT ownership records while also providing transparency to all network members.

5.5. Scalability and efficiency

Scalability and efficiency are ongoing difficulties for blockchain technology [26], especially given the enormous demand for NFT transactions and the resulting network congestion. Blockchain scalability innovations, such as layer-2 protocols and sidechains, attempt to overcome these difficulties and assist the rapidly growing NFT ecosystem.

5.6. Decentralization

Blockchain technology is decentralized [27], which means that NFT marketplaces based on blockchain networks do not require middlemen or centralized authority. This decentralization means that NFT ownership is not dependent on any single body, lowering the possibility of restriction or fraud.

After the development of the system, the researchers achieved many things, such as transaction facilitation, which made it easier to buy, sell, and trade NFTs. The NFT marketplace provides a user-friendly interface for creators to mint and sell their NFTs, as well as purchasers to discover and acquire NFTs that interest them.

(1) Ensuring security: safeguarding users' digital assets and personal information. Implement strong security measures, such as encryption, two-factor authentication, and secure payment gateways, to protect users' transactions and data from unwanted access or cyber-attack.

(2) Providing transparency: Make certain that this NFT marketplace provides clear information regarding NFT listings, ownership history, transaction fees, and platform regulations. Transparency enables consumers to make informed decisions and gives credibility to this platform.

(3) Supporting various assets: This will allow for the development and exchange of digital assets other than artwork, such as digital collectibles and virtual real estate. Supporting a varied range of materials draws a larger audience and fosters innovation among artists.

(4) Facilitating royalties: Use smart contract capability to automate royalty payments to creators when their NFTs are resold. Using this feature encourages creators to list their artwork on the site and guarantees that they are compensated fairly for their efforts.

(5) Promoting discoverability: Using search filters, categorization, and trending sections, users may identify NFTs that match their interests, making it simpler to discover new and popular NFTs in the created system.

(6) Scalability: Design the marketplace infrastructure to accommodate increased user activity and transaction volumes as the platform expands. Scalability guarantees that the NFT marketplace remains responsive and dependable, even during times of heavy demand or network congestion.

(7) Continuous improvement: The researchers iterate and develop the NFT marketplace in response to feedback from users, market trends, and technology improvements. Update the NFT marketplace regularly with new features, optimizations, and security updates to ensure customers have the best possible experience.

Blockchain technology plays a crucial role in the development of NFTs. Blockchain technology is based on a decentralized network of nodes, which ensures immutability and security for NFT ownership and transaction histories. It eliminates the need for a central authority to verify transactions, enabling them to take place amongst peers. Consensus techniques like as proof of work and proof of stake validate transactions, increasing security and trust. Smart contracts enable the creation, transfer, and administration of NFTs. Blockchain technology facilitates interoperability across various NFT marketplaces and platforms, which promotes innovation and liquidity. Scalability is critical for NFT marketplaces, which frequently face strong demand and network congestion. Blockchain scaling solutions are being developed to improve network scalability and efficiency while also improving the user experience for NFT transactions.

Furthermore, based on the analysis of the researchers, there are a lot of NFT marketplaces developed all over the world. Studying NFT marketplaces that are already developed is difficult due to the lack of resources to use to understand the logic or algorithm of existing NFT marketplaces. In this study, the researchers developed an NFT marketplace not only for the graphic artists in the Bicol Region but also for the researchers and newcomers who want to understand the algorithm of minting, listing, bidding, and purchasing, including the wallet connection in the NFT marketplace, by sharing a useful source code for a specific transaction of the proposed system. The learners can study the algorithm of specific transactions in the developed system[†]. Minting is for uploadNFT, listing is for reSellToken, bid and purchase are for NFTDetails, and MetaMask wallet is for connectWallet.

[†] https://drive.google.com/drive/folders/1b7Q4uZGvJI7XG0sLtaZTJN1yJkUlN2bn?usp=sharing

Utilizing this study, future researchers as well as the developers will deeply understand the transaction and can also provide recommendations to improve the study and suggest additional features to make it more innovative in the line of NFT artwork and blockchain technology. Additionally, the system is better than the other existing NFT platforms in terms of providing clear instructions for every user on how to transact, being user-friendly, easy to navigate, and providing better visualization of interfaces. Unlike the other NFT marketplaces, based on my observation and analysis as a first-time user of their NFT marketplace, the existing website is hard to understand on how to mint, list, and bid on their NFT artwork. The system also can resell the NFT artwork that the users purchased from the creator maintaining the original owner of the artwork recorded in the blockchain technology.

Using a combination of different source codes [21, 28-29], the researcher successfully created this NFT marketplace. The system now has a better interface visualization, allowing users to easily make transactions in the system, such as minting, listing, bidding, and purchasing. However, the system is operated on localhost (http://localhost:3000/) to obtain data and outcomes when minting, bidding, purchasing, and listing an NFT into the system, but the system requires an internet connection to have a MetaMask account that is used as a payment mechanism for each transaction in the system. The proposed study is intended for educational purposes, enhancing knowledge not just for researchers but also for the institutions to which they are affixed. This study is also intended to help anyone interested in blockchain technology, NFT artwork, and smart contracts who wants to learn more about them.

6. Conclusions

The proposed NFT marketplace system featuring decentralized wallet blockchain technology and cryptocurrency for graphic artists in the Bicol region, has been successfully developed. The proposed study identified existing features from selected websites that serve as a guide to developing a system and unique features that offer a valuable function for better use of the system. The unique features of the proposed system improve the visualization of data in the system, making it more appealing to users due to the increased privileges and rewards, foster communities of creators, collectors, and enthusiasts, foster collaboration and feedback, and make it easier to understand the proposed system due to its user-friendliness. This platform also enables the trading, selling, and buying of NFT artwork, thereby fostering creativity, innovation, and economic activity.

The developed NFTS marketplace empowers artists by encouraging them to showcase and monetize their digital creations, thereby establishing ownership rights and engaging with a global audience. It also unlocks the ownership of digital assets, allowing collectors to invest in and own unique artwork, fostering a new era of digital ownership and cultural expression. Additionally, it also drives innovation and experimentation, pushing the boundaries of digital art, technology, and storytelling. Blockchain technology underpins NFT marketplaces, providing security, immutability, and transparency for transactions. interoperability between NFT marketplaces and blockchain networks expands the market reach and liquidity of NFTs, improving price discovery and innovation. However, NFT marketplaces must navigate regulatory and legal considerations, including intellectual property rights taxation and consumer protection laws, to ensure the long-term viability and legitimacy of these platforms.

Conflicts of Interest

The authors declare no conflict of interest.

Acknowledgment

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