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METHODOLOGY OF CREATING NFT FASHION PROJECTS

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Abstract. *There is a lot of misunderstanding about what non-fungible tokens represent. They are usually associated with some kind of ownership or certification, but it is much more than that. This document aims to inform the readers about different use cases of NFT in the real and virtual world, with applications in the fashion industry. The paper aims to propose a methodology for creating NFT fashion projects. According to the proposed methodology, modelling of the ecosystem for the fashion industry based on NFT is presented. An example of creating an NFT collection, minting and realizing a transaction using a smart contract was also developed. The PyTeal programming language was used to develop the smart contract, and the Algorand platform and market were used to display transactions and minting.*

Key words: *Digital Fashion, Metaverse, NFT, Algorand, Smart Contracts*

1. INTRODUCTION

Fashion designers aim to create visually appealing clothing through creative manipulation of design elements in accordance with design principles [1]. As fashion faces an increasingly complex and digitized work environment, digital technologies are taking on a key role in fashion design. The application of digital technologies allows fashion designers to explore and experiment in an unlimited way. Allowing them to collect ideas, inspiration and knowledge from different sources and then implement them in their creative processes. Digital technologies enable virtual modelling, simulation of materials, colours, movement of clothing items in real-time, and the like, aiming to easily and quickly prototype and test ideas [2]. Based on this, digital fashion can be defined as the visual display of clothing using computer technologies and 3D software. Compared to the traditional fashion industry, digital

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fashion has many advantages, such as environmental sustainability, lower costs, unlimited creativity and no production limitations.

Fashion brands are slowly introducing modern information technologies into their business, and the most noticeable is their interest in non-fungible tokens. NFTs are still a very new topic in today's world. Given the historical facts that the first ever NFT called "*Quantum*" was coined in 2014 by Kevin McCoy and sold only in 2021, it is clear that the use of this technology is still a blue ocean.

One kind of cryptocurrency [3] that is derived from Ethereum smart contracts [4] is called Non-Fungible Token (NFT). Because NFT is distinct and cannot be replaced (equivalent, irreplaceable), it can be used to uniquely identify objects or people. More specifically, the author can simply demonstrate the existence and ownership of digital goods like as photographs, movies, event tickets, and art [5, 6], by utilizing NFTs on smart contracts (in Ethereum [4]). Every time a trade is completed successfully on any NFT market or peer-to-peer exchange, the developer can also profit. Non-Fungible Tokens (NFTs) provide a new form of monetization for fashion brands and ownership of digital assets, enabling fashion brands to keep ownership and control over their property without worrying about theft or piracy.

Since non-fungible tokens create a new experience as well as an innovative digital marketplace, the creation of fashion NFTs allows fashion companies to offer new products to their consumers. They use NFT as a marketing tool to acquire new customers and establish a presence in the Web3 space, i.e. the metaverse.

The structure of the paper first includes the concepts of non-falsifiable tokens, i.e. a closer insight into the general use of NFTs, what they represent and their connection with the metaverse, what are the elements of NFTs, as well as their application and benefits they bring to fashion and fashion design. Then the methodology of creating NFT projects is presented, and the steps that must be taken during the creation itself are included. Then a study example of the application of the methodology of creating NFT projects was presented.

2. LITERATURE REVIEW

2.1. Non-fungible tokens

Non-fungible tokens have unique properties that can make them different from each other, non-fungible units of data stored in a digital ledger in the form of blocks. Their presence on the blockchain is public proof of ownership. Non-fungible tokens cannot be traded on an equivalent scale, unlike fungible tokens. As they are based on the blockchain, non-fungible tokens remove middlemen in transactions, simplifying them and creating new markets [7].

Non-fungible tokens can be represented in two views, as digital or physical assets. As digital assets that are used most often and most today, they can be art, tickets to events, virtual properties, items in games and the like, while from a physical aspect, assets can be ownership contracts, licenses, but also houses, cars and the like. Often, non-fungible tokens can be presented as abstract assets, which can be identity or knowledge [8].

Every NFT project includes details on the digital asset's owner, who minted it or sold it, to whom and in what time frame. In every trade with non-fungible tokens, there is a protocol that is defined and followed. Buying and selling are done using the cryptocurrency Ethereum, and each transaction is recorded within a block on the blockchain.

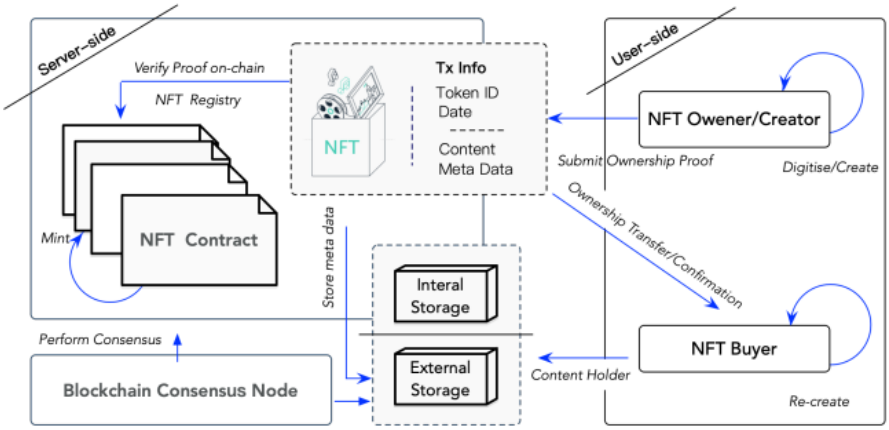

Fig. 1 NFT protocol, adapted from [9]

According to Figure 1, each NFT protocol consists of participants who have two roles, NFT owner and NFT buyer. And the steps of the NFT owner protocol are [9]:

- NFT Creation – The NFT owner creates the file and then confirms that the description, title, and file are accurate. Following the verification, the owner attests to the legitimacy of the ownership and the raw data is digitalized into the proper format;
- NFT Store – The NFT owner keeps raw data off the blockchain in an external database. Additionally, the owner can keep the unprocessed data on the blockchain;
- NFT Token – The smart contract is created and signed by the NFT owner;
- NFT Mint and Trade – The trading process starts when the smart contract is generated using the transaction and NFT data;
- NFT Confirmation – The trading process is finished once the transaction is verified. It suggests that the NFT has a distinct address, is verified to exist, and is kept on the blockchain.

On the other hand, the steps of the NFT buyer protocol are similar, but the actions are different [9]:

- Template creation – The owner of the NFT initiates the template through a smart contract in order to define the basic characteristics;
- NFT offer – the buyer of NFT offers an offer for NFT;
- NFT Mint and Trade – Once the offer is accepted, the trading process begins, and a smart contract is initiated with all the features;
- NFT Confirmation – After validation of authenticity, the buyer buys the NFT and becomes the owner of the NFT.

Each block within the blockchain chain has a limited capacity, with each subsequent transaction of the same NFT project, data will not be stored within that block, but a new block is created that is linked to the address of the original block in the chain. Each transaction stores metadata and ownership details, thus achieving authenticity of ownership, and the history of the NFT is immutable [9].

Non-fungible tokens can be divided into two groups:

- Non-fungible tokens that are based on the real physical world - tickets to events, works of art, etc;
- Non-fungible tokens that are based on the metaverse – digital assets that have no relative connection to actual physical assets or events.

It is known that non-fungible tokens have wider application possibilities and are not only for art, the very principles behind NFTs can revolutionize the concepts of ownership of all types of assets in the metaverse. So, for example, digital art, digital real estate or digital clothing may contain proof of ownership. Indeed, proof of ownership can play a key role in the metaverse, a place where it would otherwise be very difficult to prove that an owner has ownership of any asset [10]. But before that, it is necessary to first define the metaverse and what benefits it contributes to the fashion industry.

The metaverse can be defined as a simulated digital environment using modern technologies, virtual reality, augmented reality and blockchain technology, whose primary task is to imitate the real world, to gather people for socializing, playing, working and the like. As the metaverse is an extension of the physical world, it is logical to feel the need to own virtual clothes, especially those that can be worn [11].

Non-fungible tokens that are based on the metaverse and provide some value to traditional non-fungible tokens but also represent a combination of scarcity, aesthetics and utility. Every metaverse user will need clothes for their 3D avatar [12].

Since NFTs do not degrade or wear out, their authenticity can be easily verified, thus ensuring greater investment value in rare luxury fashion brands and their fashion NFTs, which have a unique value for their owners. The market for non-fungible tokens that yield wearable fashion clothing in the metaverse is still small but has attracted the attention of luxury fashion brands.

The most important benefit that the metaverse provides to fashion brands is to overcome the boundaries of the physical world, providing their customers with a new experience of digital shopping, as well as digital clothing. In this way, fashion brands work to create brand awareness on a global level and achieve greater customer loyalty by providing them with something new and innovative.

However, the most significant benefit that users derive from the metaverse is the opportunity to shop for clothing from "their armchairs"; they may utilize their avatars to visit various stores and try on various outfits before deciding which ones to buy.

2.2. Elements of non-fungible tokens

NFT (Non- fungible token) is a token that cannot be exchanged (meaning irreplaceable) for something else. NFT represents the ability to place an intelligent barcode on an asset. The owner of the NFT owns the intelligent barcode. Property is something useful or valuable, the ownership of which can be transferred to another person or entity through space and time. Assets can be physical (e.g. art, house, contract), digital (e.g. software, image, music) or abstract knowledge, identity. Almost every NFT has a utility. Utility is the physical value gained from owning a particular NFT. The most important thing is the connection between the token that is represented by something (e.g. a picture) and the asset behind it. Tokenization is the process of linking a token to an asset on blockchain technology. The tokenization process represents a promising solution for converting property rights into a unique digital representation - a token [13]. The act of creating digital tokens on a distributed ledger or

blockchain that represent either digital or real assets is known as asset tokenization. Blockchain ensures that if you purchase tokens representing an asset, your ownership of that asset is entirely immutable and cannot be erased or changed by any authority. Tokenization of a digital asset is a process in which ownership rights to an asset are represented as digital tokens and stored on the blockchain [14].

Accordingly, an NFT is a bunch of data stored on the blockchain under a specific address. Elements of NFT:

- Smart contract – a bunch of data represented through code (a set of commands) that defines the use cases of NFTs (creation, transactions, communication with external ecosystems). Contains a link to the asset, but not the asset itself. To make that pile of data more valuable, it needs to be linked to a specific asset. (ERC-721)
- Metadata – represent the link between the token and the asset. It is usually saved as an XML or JSON connection specification file.
- Asset representation – usually a .jpg file. It is important to point out that the whole philosophy lies in the way the technology is applied, not in the presentation itself.
- Assets – intellectual property rights, for example. As mentioned earlier, the types of assets are: physical, digital and abstract.

Of all the elements mentioned above, only the smart contract must be on-chain (on the blockchain), the other elements can be both on-chain and off-chain. Smart contracts follow specific standards that are always present in the blockchain ecosystem. A smart contract works as a decentralized organization – it can run on multiple devices at the same time, but it cannot be changed or stopped once it is running. The programming language Solidity, which is very similar to JavaScript, is typically used to write the code inside Ethereum smart contracts.

2.3. Application of NFT in fashion design

Non-fungible tokens provide a new form of monetization for fashion brands and ownership of digital assets, allowing fashion brands to retain control and ownership of their assets without fear of copying or theft. Therefore, more and more fashion brands are incorporating blockchain and NFT into their business strategies. As non-fungible tokens create a new experience, as well as an innovative digital market, fashion brands are using it to offer their consumers a new higher level of communication, creating better collaboration, and greater customer loyalty. Also, by incorporating modern technologies, fashion brands are slowly turning towards gaining new customers from Generation Z and millennials [15]. Unlike physical products, non-fungible tokens can be sold multiple times while maintaining the same quality. Among other things, the creators of the NFT itself can decide to offer their customers a unique value in addition to the NFT itself and thus make the whole experience better. Based on this, fashion brands can connect virtual fashion with physical, and make the transformation into the metaverse easier. For example, the fashion brand “Chanel” can give its NFT customers access to a limited-edition physical collection. By doing so, the collection becomes much more attractive to consumers, and the fashion brand explores and reaps new revenue streams and remains an acceptable fashion brand for future generations [16].

Traditional fashion brands and non-fungible tokens have one thing in common, that is exclusivity. As the basic definition of NFT is irreplaceability, it makes it very similar to, for example, a fashion piece from one of the “Haute Couture” shows, which is one of the reasons why it can fetch a high price. The NFT market is all about scarcity, and scarcity itself is what

drives the fashion industry. The less there is of an article of clothing, the greater the demand, and thus the price of the given article rises. This is exactly the model that the NFT market follows. For example, the well-known bag of the fashion brand "Hermes", "Birkin" can be compared to the best-selling NFT, precisely because they are highly valued in society and it is a real luxury to have them, and they are very difficult to obtain [16].

The French luxury fashion house "Givenchy" entered the world of non-fungible tokens in an original way. In collaboration with the artist Chito, they created 15 NFT tokens, which they presented on the "OpenSea" market. The purpose of non-fungible tokens is reflected as an online avatar or profile picture. Also, the sale was made in the traditional way, the auction lasted seven days. The Givenchy fashion house donated all proceeds from the sale to a non-profit organization dealing with the elimination of plastic pollution [15].

Unlike the fashion house "Givenchy", the fashion brand "Burberry" dared to experiment, combining the world of games and its non-fungible tokens. In collaboration with the game "Blankos Block Party", "Burberry" launched a limited edition NFT character from the game called "Sharky B", which is covered with the "Burberry" TB monogram [17].

Timberland joins the list of forward-thinking fashion brands staking their claim in the virtual world. In cooperation with "Unreal Engine" and the game "Fortnite", they created shoes from real life and thus connected the physical world with the virtual one. The program "Timberland CONSTRUCT: 10061" included a set of four metaboots, including a replica of the most famous and famous yellow boot of the company "Timberland", as well as three original boots that were inspired and adapted to the ecosystem of the game "Fortnite" [18].

Most fashion brands have successfully implemented the concept of modern technology by introducing non-fungible tokens into their portfolios. The archetypal example is the "MetaBirkins" NFT. "MetaBirkins" is a collection of non-fungible tokens representing the silhouette of the popular "Birkin" bag, decorated with fur coats, cow print, and various motifs and patterns. The NFT collection, which was exhibited at "Art Basel" in Miami, was created by artist Mason Rothschild. As the project itself was not created in collaboration with the fashion brand "Hermes", but independently, the French fashion house filed a lawsuit for trademark infringement and theft. The question arses, of how the fashion house "Hermes" will handle its own protection and enter the metaverse and the very world of non-exchangeable tokens [19].

The fact that companies like "Gucci", "Tommy Hilfiger", and "Dolce & Gabbana" invested millions of dollars to create virtual metaverse storefronts in 2021, selling a combination of digital fashion NFTs and NFTs that could be redeemed for physical goods, shows how important digital fashion has become.

2.4. Benefits of NFT in fashion and fashion design

The benefits of using non-fungible tokens in fashion and fashion design are reflected in the opportunities they provide to fashion designers. As just creating and making a fashion collection is very expensive, fashion designers and even the most talented ones find themselves trapped in the cage of costs required to realize their ideas. Digital fashion in the form of non-fungible tokens allows fashion designers to fully express their talent, with little compensation. Sustainability. The fashion industry is one of the largest producers of waste, and the implementation of modern technologies would reduce waste. In addition to lower production costs, NFTs provide a new economic model and greater financial benefits. Fashion brands could benefit from secondary copyrights implemented in a smart contract [20]. Among other things, the benefits of using non-fungible tokens in fashion provide the

power to refresh the very image of a fashion brand. Consumer demands are changing, and NFT provides a chance for fashion designers to create something new, and innovative, but also to expand their collections, on the contrary, in physical form this is not possible to a large extent [16].

Since NFT is a relatively new innovation, there are also some drawbacks that fashion brands should consider before introducing non-fungible tokens. NFT stands in direct contrast to everything fashion stands for, feel and touch. As the use of quality materials in the manufacture of fashion garments is a key factor in the consumer's purchasing choice and trust, non-fungible tokens will hardly succeed in imitating the distinction between non-luxury and luxury brands through quality. Fashionable non-deceptive tokens can be bought on a number of different NFT markets, which implies that most users are or can be confused when purchasing. Although they exist and are not sufficiently adopted, it is necessary to create a fashion market for non-deceptive tokens that will stand out from the rest. Countering the uncertainty of use brought about by non-deceptive tokens, as well as addressing potential legal challenges are still under development [16].

"Nike" and "Dolce&Gabbana" are the fashion brands that have generated the most income from the introduction of NFT in their portfolios. Sports giant Nike had their best year in terms of NFT sales, earning $185 million in sales alone. Then, in second place is the fashion brand "Dolce&Gabbana", which managed to earn 25.6 million dollars through NFT sales. As "Collezione Genesi" was one of the biggest events in the history of fashion NFT, which included nine pieces of fashion NFT and the physical garments themselves, it sold for almost 5.7 million dollars. Also, the fashion house "Gucci" reaps the benefits of well-implemented modern technology in its business, with sales revenue of 11.56 million dollars [21].

3. Methodology of Creating NFT Projects

Details on who owns the digital asset, who sold it, and when are all included in the NFT project. They are kept on the blockchain and are purchased and traded online with cryptocurrencies. Each NFT project is a unique token on the blockchain [22]. This original work is limited to one owner and one verifiable version. NFT projects can be saved and shared, but NFT's content can only be replicated with access to its password-protected, blockchain-stored unique identification. Regardless of location, NFT projects are the way of the future for the collectible art market [20].

The necessary steps to be taken are:

1. Defining the concepts and strategies - defines how NFTs solve problems, why people should buy them, what makes them unique, how to generate revenue, the project's vision, risk mitigation, and the distinction between strategy and implementation plans;
2. Creation tools and NFT platform - includes coming up with an attractive concept, using software like "Adobe Illustrator" or "Photoshop" to create the token, and considering blockchain technology, digital wallets, and smart contracts for the market;
3. Preparation of works of art and NFT collection - includes planning the project, developing a smart contract, creating a minting page, designing the artwork, minting the NFTs, disclosing the collection, and implementing the roadmap;
4. Designing and implementing smart contracts - Smart contracts are computer protocols that enforce agreements by storing ownership and transaction data for NFTs, requiring

thorough testing before deployment on a blockchain platform, enabling NFT availability and facilitating trading and ownership transfer.;

5. Property testing - testing strategies encompass automated methods, utilizing software for repeated tests and comparing expected outcomes with actual results, as well as manual approaches involving human-assisted steps like code audits to thoroughly examine each line of contract code.;
6. Selling on the market - involves two stages: the phase before minting, where the NFT is prepared, and the phase after minting, where the NFT is published on the blockchain and becomes available for buying, selling, and trading.

3.1. Defining the concept and strategies

When formulating a strategy for NFTs, it is essential to address key questions that shape the direction of the project. It begins by identifying the problem that the NFTs aim to solve, understanding the unique value proposition that attracts potential buyers. Emphasizing what sets the project apart is crucial in a competitive landscape. Developing revenue generation plans for both pre-mint and post-mint phases ensures financial sustainability. Envisioning the project's trajectory in the next 2-3 years provides a clear vision and direction. Evaluating and minimizing risks helps safeguard the project's success, promoting stability and growth.

Demand in the market must exist again and again. It can also affect (limit) the supply process. The key thing is not to confuse strategy and plan, and a plan can be defined as a concrete implementation of a defined strategy.

3.2. Tools for creating NFT collection

Creating non-fungible tokens is an extremely simple and easy process, while on the other hand, coming up with the very concept and idea is an exciting process because it is necessary to create NFT that will attract digital art enthusiasts. After the concept is designed, the next step involves the creation of the NFT. There are various software that can be used during the creation itself, and the most commonly used are "Adobe Illustrator", "Photoshop", "NFT Creator", "SketchAR", "Corel" and similar [23].

In addition to the various software used when creating the non-falsifiable tokens themselves, in the performance market, it is necessary to use and choose blockchain technology, a digital wallet, as well as certain software for the development of smart contracts according to the choice of blockchain technology.

3.3. Creating NFT collection

Steps required to create an NFT collection:

1. Project planning
2. Development of a smart contract
3. Development of the minting page
4. A work of art
5. Mint
6. Disclosure
7. Implementation of the road map

The steps of smart contract development, minting page development and the artwork itself can be parallelized.

3.3.1. Project planning

The roadmap is a product of the NFT project. It represents the idea that will be delivered during the roadmap. NFT is an enabler that provides access to the roadmap. Therefore, the roadmap is unique, must cover at least one year of the project strategy and be simple (2-3 milestones per year) and realistic (according to the skills of the team members).

In this step, a good business plan must be made, which in NFT projects is called a white paper. In addition, as already mentioned, marketing strategy is crucial. A good practice here is to define the user persona, engage influencers and stay focused on the content and delivered value, not on the sale itself. The key to success is a good team consisting of artists, someone taking care of the artwork, as in, for example, the translator between the artist and the rest of his team called the art director. Then Community Manager, Developer (Page Forging, Smart Contract) and "Founder". The best places to find a team are "Twitter" and "Discord".

3.3.2. Development of a smart contract

To create a smart contract, the logic behind its terms is most important. Tools needed for smart contract development:

1. Algorand - Development of smart contracts using the PyTeal programming language;
2. IDE (Integrated Development Environment): IDE: REMIX – a browser-based application used for development, testing and deployment;
3. Etherscan.io – used for application and process control, e.g. inflict, reveal, pause, payout, etc. It is used to analyze, publish, interact and access, read and use blockchain smart contracts.

3.3.3. Development of the minting page

It is a frontend page whose code contains the conditions for defining a smart contract. The most commonly used libraries are web3.js and inter.js.

3.3.4. Work of art

It is a representation of an NFT and the connection between the token and the asset it represents. This is usually an image called a TFT (Profile Picture/Avatar), created using. "Adobe Photoshop" or "Adobe Illustrator".

3.3.5. Mint

Minting represents the moment when an NFT is published on the blockchain, and from then on it can be bought, sold and traded. The minting process can be seen in Figure 2. NFT platforms are websites, or crypto exchanges, that offer a one-stop marketplace to mint, list and sell NFTs. The most popular are: "OpenSea", "Solanart", "CNFT", and "Binance NFT".

The NFT minting process includes opening a crypto wallet and connecting it to the NFT marketplace. Then, the digital file should be uploaded to the NFT marketplace, and a name should be given to the NFT, along with providing the royalty payout rate and other parameters. Finally, the NFT is minted [24].

3.3.6. Discovery

Every NFT market has exact instructions on how to set up NFT properly, so it is possible to generate a market NFT from a digital file. Choosing the NFT monetization method itself is the last step. Some markets allow a stock or fixed price to be listed. But for an NFT to be resold on secondary markets, the owner of the non-fungible token must set a minimum price, royalties and the length of the auction.

After all these steps, only non-fungible token market trading can begin.

3.4. Designing and implementing smart contracts

A smart contract is a computer protocol that makes it easier for two or more parties to negotiate or carry out an agreement by facilitating, validating, or enforcing it. Important data is stored in it, including ownership rights and NFT transaction data. Code must be thoroughly tested before being deployed on the blockchain. A smart contract can be implemented on a selected development platform after it has been designed. Users will be able to exchange or transfer ownership of tokens and access NFTs on the blockchain as a result.

3.5. Property testing

The following reasons the importance of testing smart contracts. First of all, smart contracts are high-value applications. They are also immutable and can, and frequently do, result in significant, irreversible losses for customers.

There are two main types of strategies for testing smart contracts:

- Automated testing – automated testing tools that may run numerous tests to identify vulnerabilities in smart contracts. Additionally, test data can be used to configure automated testing tools so they can compare expected and actual outcomes;
- Manual testing – manual and requiring the assistance of a person to carry out the testing procedures. One type of manual testing for smart contracts is code audits, in which developers and/or auditors review every line of the contract code.

3.6. Selling on the market

Generally speaking, there are two main stages of creating NFT project before actually selling it on the market:

1. Phase before minting
2. Phase after minting

Minting represents the moment when NFT is published on the blockchain, and from then on, it can be bought, sold and traded.

3.6.1. Phase before minting

For a successful NFT project, the NFT creator must make good use of the period before the actual public announcement. It needs to tell the whole story behind the created NFT, why customers should buy that particular NFT, what makes it specific compared to others, what value it gives to its customers, how exclusive it is and so on. That is, it is necessary to create hype, the part when a good marketing strategy is the key to the success of the project. It consists of encouraging the audience for the project. It also includes whitelisting and giveaways. Considering that NFTs that manage to create a viral effect usually end up

being sold out, it is necessary to take the time to create a good strategy and learn how to create peaks. Therefore, the greater the hype, the greater the opportunity to sell NFTs. This phase has a positive effect on the price of NFTs. Also, in this phase, the success of the entire NFT project is evaluated—Tokenomics – NFT project economics. There is a rule in the NFT market: low supply, high demand.

After that, it is necessary to determine in which market the NFT owner will offer his digital asset, "Algorand", "OpenSea", "Foundation", "Rarible", etc. This is followed by the creation of a smart contract, as well as all the characteristics of the digital asset that is published for proof of authenticity. Then you need to create a community before publishing. The best social network for creating a community, but the sheer excitement surrounding an NFT announcement, is Twitter. Each creator of NFTs must define the target group of their customers, get to know them, what they want from NFTs, and what value they value [25]. At the very end comes the disclosure of NFT.

3.6.2. Phase after minting

Later, after the discovery of the NFT, the owner of the NFT enters the second phase, the post-mint phase. It is up to the owner to define a new way to stimulate their customers to keep buying. This phase represents the execution of the roadmap and consists of two elements, the first is when the excitement dies down after the release itself, and the second element is about adding new features to the project, such as collaborations, metaverse, games and the like. Also, at this stage, the owner can see if he has chosen good strategies when publishing NFT, the way customers behave, but also use them for further work and creation [26].

4. NFT FASHION DESIGN PROJECT

4.1. Blockchain-based ecosystem for the fashion industry

In this section, we have provided the system design architecture and sequence diagram. Figure 1 shows a model of the proposed NFT ownership tracking and management system for digital fashion apparel, the stakeholders involved, and their interaction with smart contracts. For example, an individual fashion designer who does not have the technical knowledge to create 3D models can hire a company that provides 3D modelling. After that, the smart contract is launched, as it represents a single transaction. After the transaction and the 3D digital fashion design are complete, the fashion designer can place the NFT on the market for sale. Before the release, the fashion designer can hire a marketing company to create hype around his non-fungible fashion token. If this situation is decided upon, the smart contract is also triggered. After the hype is raised, the NFT minting is done; the next step is the sale itself. The sale is based on the auction system. After the auction is over, the buyer who offered the highest price checks the data and buys the NFT and becomes the new owner of the NFT. In further documentation, one part of the solution from the proposed ecosystem is presented. A detailed description of the components is in the continuation of the documentation.

The main stakeholders in the proposed ecosystem are (Figure 2):

1. An independent fashion designer (not working for any fashion company) prepares their product for placement on a platform or marketplace. Company that makes software for 3D fashion modelling, fashion designers who do not have technical

knowledge can hire 3D modelling companies to create fashion designs. If the fashion designer is well-known, companies can offer them various benefits in exchange for advertising their software.

2. Company that makes video games (Unity, UnrealEngine) allows products to be available in the game and provides a link to purchase them on the marketplace. The fashion designer pays a fee to the company to represent their collections in their game.

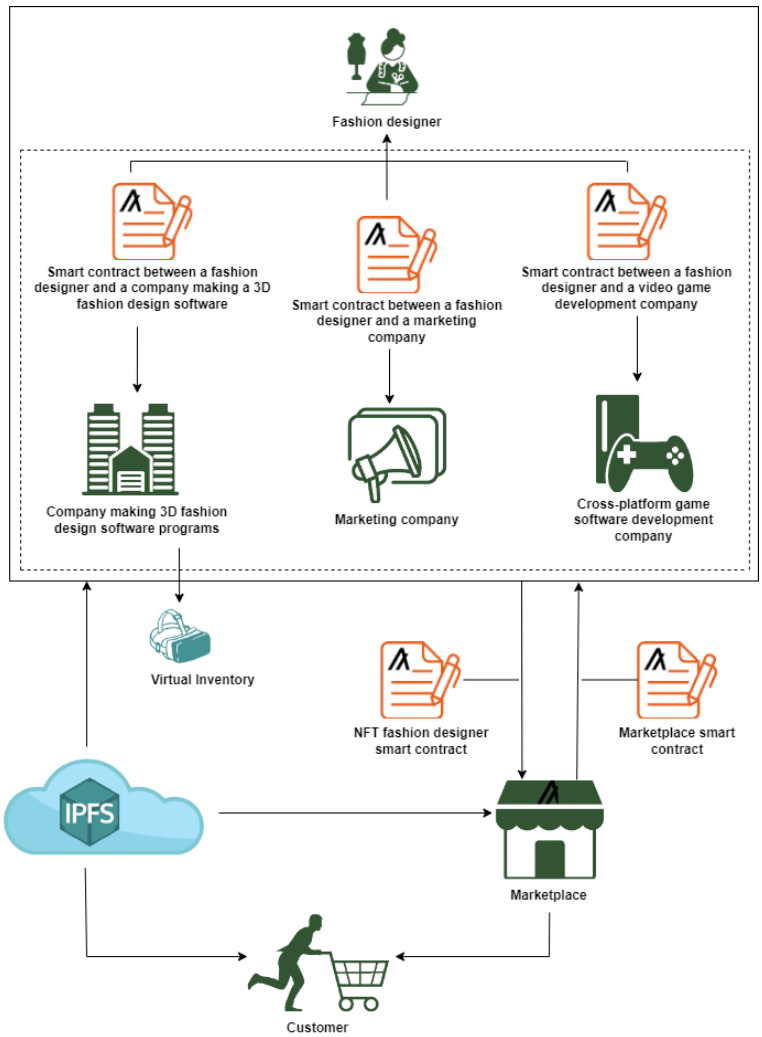

Fig. 2 Blockchain-based ecosystem for the fashion industry

3. Marketing company helps fashion designer better market their product and generate hype before the reveal. The best outcome is creating a viral effect. Social media is used, and a digital campaign is created to attract the attention of as many people as possible. Fashion items from the fashion designer's NFT collections are promoted.

4. Customer views and purchases fashion items on the marketplace or platform. The buyer can use NFTs in the Metaverse, as well as in video games. The entire purchasing process is covered by a smart contract. Milestones of the road trip are clearly defined, so the customer knows exactly what benefits they will gain within a certain timestamp by purchasing the specific NFT.

Platform/Marketplace - where independent fashion designers place their products and where buyers view and purchase products. All financial transactions among all participants in the blockchain system are carried out using smart contracts, digital wallets, and electronic banking services. All transaction data is stored in the blockchain ledger within the chosen platform. The platform provides fashion designers with the ability to place their 3D fashion creations as NFT collections. There is also a case where the designer does not create 3D models but traditional ones. In that case, the platform can connect the fashion designer with a 3D designer who will create their existing designs in 3D.

In Figure 3, the sequence diagram is a more detailed representation of the relationships and interactions between stakeholders and smart contracts in the NFT-based fashion ecosystem.

As a first step, it is necessary to register all participants and interested parties, i.e. fashion designer and buyer. Then, a fashion designer with no technical knowledge requests a quote from a 3D modelling company and a smart contract is launched. The 3D modelling company checks if the fashion design is in VirtualInventory; if it is, it uploads it to IPFS and asks for approval from the fashion designer; also, in this case, a smart contract is launched. The fashion designer approves the digital fashion design, and the smart contract is launched.

As a next step, the fashion designer may or may not seek bids from marketing campaigns to create hype around the NFT before the actual minting. In case he chooses to cooperate with the company, a smart contract is also launched. After that, the fashion designer puts the digital fashion design in NFT format on the market, with the sale via auction. The auction has started, and the buyer sets his price.

After the auction is over, a smart contract is launched, and Algos is transferred from the buyer’s account to Algorand's account as revised funds to guarantee the fashion designer that he will be paid for the purchased digital fashion item. After checking all the data, a smart contract is launched, and the state of ownership is changed from the fashion designer to the customer. Also, the customer can rate the fashion designer and thus increase the reputation of both the fashion designer and himself.

In case when developing a video game, a video game company needs an item of clothing for a character in the game, they can ask a fashion designer for a design. In that case, the fashion designer checks if he already has a design. It creates a given design and uploads it to IPFS as hashed so that the video game company can see the design and approve it. In this case, a smart contract between a fashion designer and a video game company is triggered. In this sequence diagram, only one flow of steps that can be formed is represented.

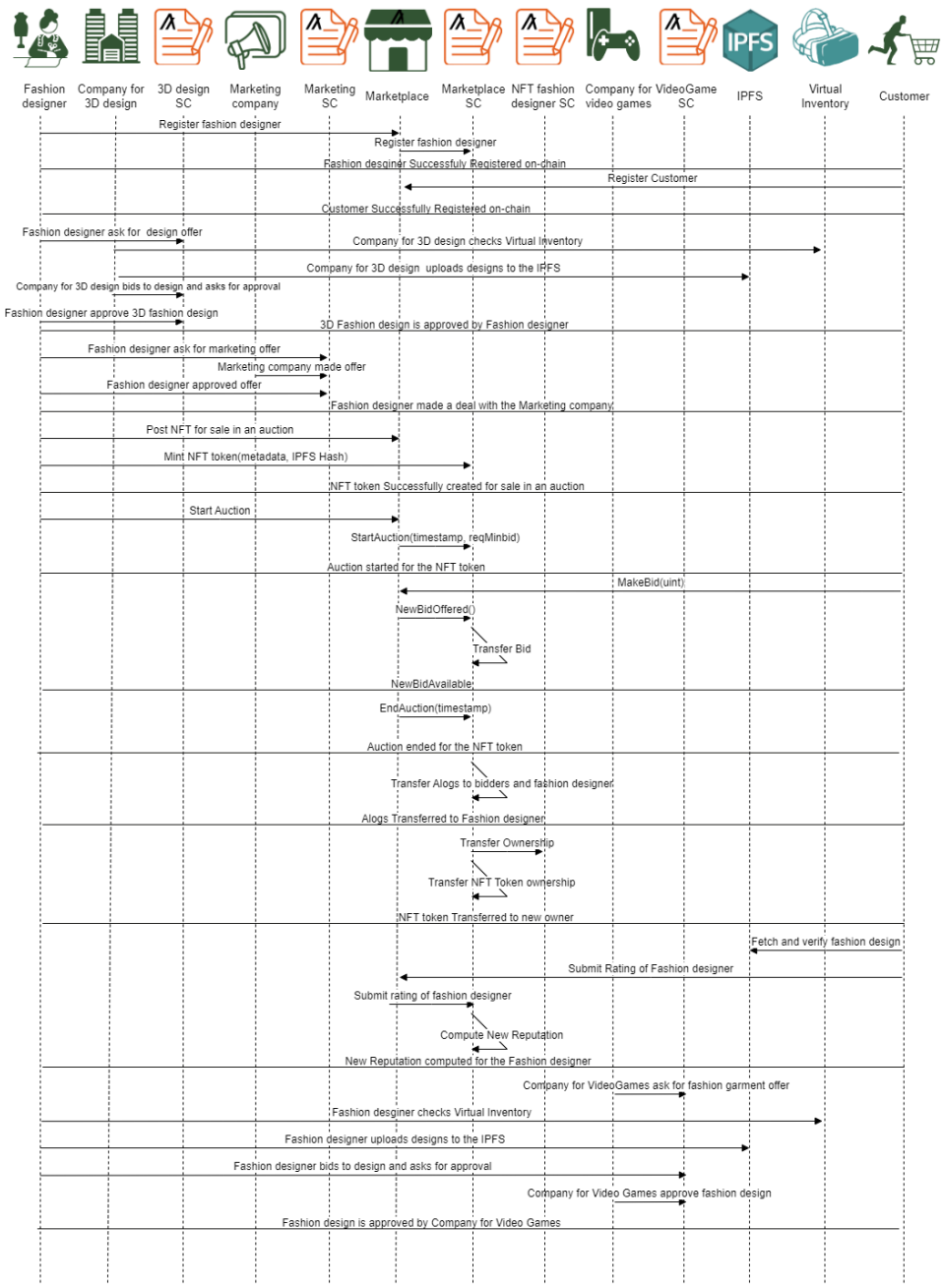

Fig. 3 Sequence diagram

4.2. Business Model for fashion NFTs

The main purpose of Business Model Canvas is to show how a company operates, to whom it sells its products or provides a service, and how it does it. It also shows how value is created and delivered to customers. It also serves to attract the attention of investors and investment partners. Figure 4 shows the Business Model for fashion NFTs. The goal of the model is to show an innovative way of applying NFT and blockchain technology in the business of the fashion industry.

Business idea: *One place for all fashion NFTs, a direct connection between fashion designers and customers and the application of Blockchain in the fashion industry*
Products and services: *Minting NFTs on the Algorand Blockchain, connecting fashion designers with 3D Modelling and Video Games companies*

Key Partners	***Key activities***	***Value propositions***	***Relationship with users***	***Customer segments***
Investors Fashion designers Algorand Companies that create software for 3D modelling Nifty Getaway Marketing companies Decentraland Metaverse	Processing the entire buying and selling process "P2P" trading of digital assets Exhibiting collections in a showroom KYC protection Connecting fashion designers with companies to create digital clothing	Marketplace with a large number of fashion NFTs Marketplace that provides exhibition space for 3D avatars in the Metaverse Source platform for transactions and preserving integrity Platform that brings together a large number of fashion enthusiasts, creating an NFT community	Social media presence Discounts on Metaverse clothing purchases Benefits while playing video games Decentraland Fashion Week	People who buy NFTs In the case of popular NFTs, buyers who participate in auctions to outbid others Customers who play video games Collectors People for Metaverse Influencers Fashion enthusiasts
	Key resources Active customers Digital assets Physical space Computers Technical support Fashion designers Human resources		***Channels*** Websites Android and IOS applications Video games Metaverse Social media platforms	

Cost structure	***Revenue Streams***
Electricity costs NFT trading costs Marketing costs Smart contract costs Creator royalties costs Legal expenses costs Platform maintenance costs Salary, depreciation and space maintenance costs Costs of employee skills development	Revenue from services for showcasing fashion collections Revenue from in-game purchases of fashion items in video games Revenue from NFT sales Revenue from listings Revenue from initial fees Revenue from NFT minting Revenue from renting exhibition space

Fig. 4 Business Model for fashion NFTs, adapted from [27]

4.3. Marketing strategy

The marketing industry is increasingly embracing the potential of blockchain technology and slowly implementing it into their activities. Also, merchants see the benefits of using blockchain technologies because they can offer a new type of value to their customers. As technology is still emerging, marketing managers, as well as marketers, are reluctant to completely surrender to modern technologies precisely because of the lack of technical understanding and large advertisements, and they decide to adopt a "wait and see" attitude [28].

Fashion brands are increasingly faced with the fact that it is difficult to maintain a relationship with customers as a sales item and prolong their stay in a loyalty program, and as a marketing strategy is one of the key components of a successful business, innovation must be introduced.

Although we live in the 21st century, in the year 2022, in a world where the Internet is a normal thing and forms an integral part of our lives, consumers still have an aversion when shopping on the Internet. The two crucial factors that prevent consumers from making an online purchase and are taken into consideration are trust and risk. Traditionally, the foundation of online shopping is based on convincing consumers that their transactions are secure, reliable and risk-free. But still, the percentage of uncompleted purchases is very high. As NFTs, i.e. non-fungible tokens, are decentralized on the blockchain, there is a noticeable difference compared to traditional, centrally-based online purchases. The marketing implications unique to NFT as a decentralized application are reflected through the provision of authentication, proof of ownership, non-fungibility, royalty, direct infrastructure distribution and the like [29].

As NFTs can be stand-alone components of fashion brands, three sessions describe how fashion brands can use marketing tricks to influence consumers. The first session covers the pre-purchase phase. In the pre-purchase phase, fashion brands must make efforts to create attitudes, that is, focus and develop their NFT collections that will strive to create brand awareness. The second session covers the purchase phase. Consumers decide whether to place their trust in one fashion brand or another, after which they develop a purchase. As fashion brands face competition, it is necessary to develop an NFT collection that will create a positive impact on customers, emphasizing attractive features and elements. The third and final session involves the post-purchase phase. After the purchase, consumers compare their pre-purchase expectations with the post-purchase experience and potentially develop loyalty towards the chosen fashion brand. The last session is the least sensitive to marketing targeting [30].

4.4. Smart contract

A smart contract is a self-executing program that makes the tasks specified in a contract or agreement automatic. The transactions are irreversible and traceable once they are finished. To put it simply, smart contracts are blockchain programs that enable each party to a transaction to fulfill its portion. They make it possible for reliable agreements and transactions to be conducted out amongst dispersed, anonymous persons without requiring a centralized authority, a legal framework, or outside enforcement mechanisms [31].

There are quite a few popular blockchain networks, like Ethereum, Bitcoin and Algorand. In the practical example in this document, Algorand was precisely used. With a

two-tiered structure and a special version of the Proof-of-Stake (PoS) consensus process, Algorand is an open-source, decentralized blockchain network that aims to speed up transactions and achieve finality. All ALGO coin holders have the potential to get benefits through Algorand's block rewards, which are awarded to all ALGO holders rather than simply block creators [32].

There are a few languages that are used for writing smart contracts. Some of them are Solidity, Reach and PyTeal. In the practical example shown in this document, PyTeal programming language was used specifically.

PyTeal is a Python language binding for Algorand Smart Contracts (ASC1s).

Algorand Smart Contracts are implemented using a new language that is stack-based, called Transaction Execution Approval Language (TEAL).

But TEAL is really simply an assembly language. PyTeal allows programmers to use only Python to express smart contract logic. Using type checking at construction time, PyTeal offers high-level abstractions in the style of functional programming over TEAL.

In this section, examples are shown for modelling smart contracts between a fashion designer and a 3D digital fashion garment modelling company, for example, Clo3D. Also, between a fashion designer and a marketing company. Then a real example of a smart contract between a fashion designer and a customer for a minted fashion NFT. A smart contract is created in the PyTeal programming language.

Figure 5 shows a smart contract where a fashion designer without technical knowledge requests a certain design from a company for 3D fashion design. The input includes the ID of the fashion designer and the ID of the design of the fashion garment. The smart contract verifies the data and publishes an event.

Algorithm 1: *Fashion designer seeks 3D fashion design*

```
Input     : fashionDesigner ID, fashionGarment ID
If     Caller == fashionDesigner then
           fashionGarment(fashionDesigner ID) == fashionDesigner ID
else
    return error
```

Fig. 5 Algorithm for fashion designers seeks 3D fashion design

Once the design is completed, Clo3D uploads the file and simulations to IPFS and creates a hash so that the fashion designer can access the uploaded files. Then, Clo3D requests approval from the fashion designer for the created digital garment. The input includes the Clo3D ID, fashion garment ID, and the IPFS hash of the design, Figure 6. The hash allows the fashion designer to access the necessary data, verify and examine it, and ultimately make a decision.

```
Algorithm 2: Clo3D requests a decision from the fashion designer for the
3D fashion design
Input     : Clo3D ID, fashionGarment ID, Design-IPFS-Hash
If    Caller == Clo3D then
          fashionGarmentI ID Specifications = Design-IPFS-Hash
      Issue an announcement(Event) that the Clo3D is asking for Design Approval.
else
      return error
```

Fig. 6 Algorithm for Clo3D requests approval from a fashion designer

After the 3D design of the requested clothing item is created, the fashion designer accepts or rejects the offer, and an event is triggered accordingly. In case the created design is part of a Virtual Inventory, the ID of Clo3D is replaced with the ID of the Virtual Inventory. The input includes the ID of the fashion designer, the ID of the fashion garment, and the decision of the fashion designer. The smart contract first verifies the identity of the fashion designer and then his decision regarding the 3D fashion clothing design (Figure 7).

```
Algorithm 3: Fashion designer makes a decision about the 3D fashion design
Input     : fashionDesigner ID, Clo3D ID  fashionGarment ID, fashionDesignerDecision
If    Caller == fashionDesigner then
          fashionGarment(fashionDesignerDecision) = fashionDesignerDecision.
          if fashionDesignerDecision == True then
              if Clo3D owner == Virtual Inventory then
                  -
                  Issue an announcement(Event) that the fashionGarment is On Virutal Inventory
              else
                  Issue an announcement(Event) that fashionGarment is Approved
          else
              fashionGarment is Rejected.
else
      return error
```

Fig. 7 Algorithm for the fashion designer's decision

In Figure 8, after accepting the 3D fashion design from Clo3D, the next step for the fashion designer is to seek proposals from marketing companies for the best placement of the 3D design on the platform. The input includes the ID of the fashion designer and the ID of the marketing company. The smart contract verifies the data and publishes the event.

```
Algorithm 4:Fashion designer is requesting proposals from marketing agencies
Input     : fashionDesigner ID, marketingCompany ID
If    Caller == fashionDesigner then
          marketingCompany(fashionDesigner ID) == fashionDesigner ID.
          Issue an announcement(Event) that the fashion designer is asking for marketing offer
else
      return error
```

Fig. 8 Algorithm for fashion designers requesting proposals from marketing agencies

After receiving a notification that the fashion designer is seeking offers for a campaign, the marketing company submits their proposal, including marketing strategy, campaign start time, and similar information, directly to the fashion designer. The input includes the ID of the marketing company, the ID of the campaign, and the price (Figure 9).

```
Algorithm 5: Marketing company offers a campaign proposal to the fashion designer

Input     :marketingCompany ID, campaign ID
If        Caller == marketingCompany ID then
              compaign(Price) = Price
              Issue an announcement that the marketingCompany's offer is ready.
else
          return error
```

Fig. 9 Algorithm for Marketing company's offers

The last one, Figure 10, shows after the marketing company has created an offer for the marketing strategy, the fashion designer accepts or rejects the offer. If the fashion designer approves, an event is triggered, announcing that the fashion designer has accepted the offer. Otherwise, a notification is received that the fashion designer has rejected the offer. The input includes the ID of the fashion designer, the ID of the campaign, and the fashion designer's decision about the campaign.

```
Algorithm 6: Fashion designer makes a decision about t a marketing company's offer

Input     : fashionDesigner ID, campaign ID, campaignDecision
If        Caller == fashionDesigner then
          if campaing(fashionDesigner ID) == fashionDesigner ID then
                fashionDesignerDecision == campaignDecision
                if fashionDesignerDecision == True
                      then
                      -
                      Issue an announcement(Event) that the fashionDesigner accepted Marketing company's
                      offer, Start campaign
                else  Issue an announcement(Event) that fashionDesigner rejected Marketing
                      company's offer
else      return error
```

Fig. 10 Algorithm for fashion designer's decision

5. IMPLEMENTATION OF NFT FASHION PROJECT

5.1. Methodology of creating NFT fashion collection

The development of the following study example is based on certain steps that need to be taken when creating an NFT collection in fashion design. The steps for creating an NFT fashion collection [33, 34] are:

1. *First step: Choosing a fashion garment*. As irreplaceable tokens represent digital art in the form of images, audio productions, and even video, the goal is to create unique content [35]. Therefore, the first step includes the idea itself, determining what the designer wants to present as a non-exchangeable token, which is the garment. Rarity is something that brings and determines the value of the NFT itself, and the very verification of ownership of intellectual property rights contributes to that rarity. Also, the designer can offer his customers a physical product in addition to the digital garment. For this project, we decided that the digital fashion garment should be a bag.
2. *Second step: Choosing blockchain technology*. Several types of blockchain technologies can permanently store immutable tokens. Ethereum, the most popular NFT blockchain, stores thousands of non-fungible tokens. The Ethereum NFT that was created supports the ERC-721 standard, which stores metadata on the Ethereum blockchain. Ethereum operates on a proof-of-stake (PoS) consensus. Then, Solana is a faster and cheaper variant of the Ethereum blockchain, providing a list of supported applications for non-fungible tokens. Solana works on proof of history (PoH) and consensus mechanism (PoS). The difference with Ethereum is in fast transactions [35]. Algorand is a new-generation blockchain technology which also provides its users with scalability and a consensus mechanism based on PoS. Its goal is to lower the security risk associated with smart contracts, among other things [36]. For this project, we chose the Algorand blockchain.
3. *Third step: Setting up a digital wallet.* Once blockchain technology is chosen, it is necessary to choose a digital wallet that supports that blockchain. Creating a digital wallet requires downloading a crypto wallet app, logging into an account and saving private keys for offline recovery, and among other things, requires purchasing a specific cryptocurrency. Several popular digital wallet applications are distinguished, such as “MetaMask”, “PeraAlgo Wallet”, “Coinbase Wallet”, “Ledger Nano X”, and the like. Since we chose the Algorand blockchain for the project, the logical step is to use “Pera Algo Wallet” for the digital wallet.
4. *Fourth step: Selection of NFT markets*. The creation process itself can begin when the designer has a digital wallet and some cryptocurrency. The next fourth step refers to the selection of the market where the non-deceptive token will be traded. As already mentioned, there are various NFT markets such as: “Algorand”, “OpenSea”, “Larva”, “Rarible”, “SuperRare” and others. After choosing a market, the next step involves connecting to a digital wallet. In this way, it is possible to create the non-fungible token itself, and therefore it is possible to retain the income from the sale. We have chosen to mint our NFT on the Rand Gallery market, Algorand platform. This is presented in Figure 11.

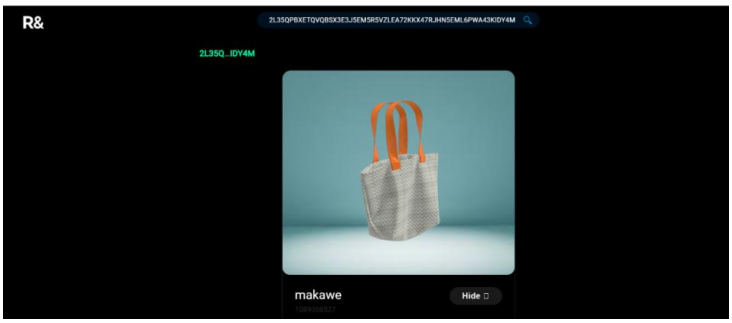

Fig. 11 Minted NFT

5. *Fifth step: Creation of the NFT.* After the idea is conceived, the blockchain technology is chosen, the digital wallet is chosen, and then the market in which the non-fungible tokens will be traded is chosen, and then the associated market with the digital wallet; the next step involves the creation of the NFT itself. The idea is to create a digital fashion clothing collection that can be presented as an NFT. Figure 12 shows an example of how a fashion designer can display his fashion garments.

Fig. 12 Makawe collection

6. *Sixth step: Launch the NFT.* In each NFT market, there are exact instructions on how to set up the NFT in a proper way, and in this way, it is possible to generate a marketable NFT from a digital file. Choosing the NFT monetization method itself is the last step. Some markets allow a stock or fixed price to be specified. But for the NFT to be resold on the secondary markets, the owner of the non-fungible token himself must set the minimum price, royalties and auction length. After all these steps, only trading on the non-fungible token market can begin.

5.2. dApp for the fashionblock platform

In this section, the frontend of the application represents only one part of the proposed overall solution. The application was created using React js. It shows the interaction between a fashion designer and a customer. According to Figure 13a, the user first needs to select a role. In case the fashion designer is applying, he needs to choose the role of fashion designer, and in case he is a customer, he needs to choose the role of customer. The first use case involves the customer. After the customer has chosen his role, and to ensure that the customer will pay the fashion designer for the digital fashion garment, he needs to connect his digital wallet, Figure 13b. The customer must have Pera Algo Wallet installed on his mobile phone, and he needs to scan the QR code. Then it needs to accept the connection with the "fashionblock" platform. Figure 13c shows a situation where the customer selects the material he wants and applies it to buy NFT.

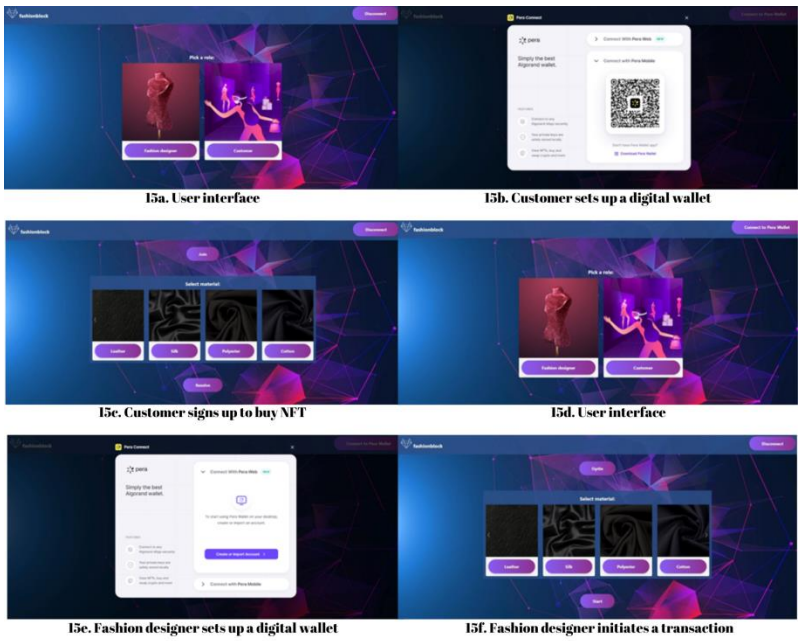

Fig. 13 dApp for the fashionblock platform

Another use case involves a fashion designer. The fashion designer also needs to choose a role, in this case, the fashion designer, Figure 13d. A fashion designer needs to connect his digital wallet to complete the transaction and transfer the funds. This is shown in Figure 13e. After that, it is necessary to select the material used in the creation of the digital garment, i.e. the bag, and start the transaction, Figure 13f. In case the customer's material is searched for, it matches the material used, and after the customer has reviewed the data and accepted the NFT, the transaction is executed. And therefore, the transfer of ownership from the fashion designer to the customer.

6. CONCLUSION

Introducing modern technologies into fashion and fashion design has potential and, so far, has proven to be a smart decision. Just by implementing non-fungible tokens in their business models, fashion brands keep pace with the development of technology. They are moving forward and securing their position in the Web 3.0 space. This is exactly what can be defined as a characteristic of fashion itself. Fashion brands provide their customers with a new shopping experience and new forms of the products themselves but also ensure greater loyalty. With digital fashion, there are no boundaries; the only limit is human imagination. The fashion NFT market is still underdeveloped, implying that there is scope for some new and better things. Among other things, the ecosystem of non-fungible tokens provides an opportunity for young designers to establish cooperation with more experienced designers. As it is still developing, there is a place for everyone, and the market itself is not overloaded; you just need to stay consistent, creative and persistent.

A new world of digital fashion is created by combining software settings for 3D clothing modeling with virtual reality and augmented reality. This allows users to make and sell NFTs as well as wear digital fashion items in the Metaverse. There is a lot of misunderstanding about what NFT represents. It is usually associated with some kind of ownership or certificate, but it is indeed much more than just that.

This project represents the application of the methodology for creating NFT fashion projects, covering each step-in detail. The steps involved include minting a collection of 3D fashion items and selecting appropriate target groups, as well as the elements necessary for the appropriate market to launch NFT collections. The created NFT collection was minted in the “Rand Gallery”, and a smart contract was developed to purchase NFTs. The PyTeal programming language was used to develop the smart contract. The transaction is presented using the “Algorand” platform and “AlgoExplorer”.

In future research directions, the development of NFT marketplaces is planned, with a focus on enhancing user experience, ensuring transparency, and exploring innovative features to propel the evolution of the NFT fashion ecosystem.

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