Examining the use of Non-Fungible Tokens (NFTs) as a Trading Mechanism for the Metaverse

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Abstract. The notion of a metaverse seems hard to define but encourages the impression that it can be considered as a new virtual metaphysical landscape that somehow goes beyond our geographical locations and understanding (i.e., independent of time and space). Based on virtual reality, augmented reality, and blockchain, it is envisioned as an independent but extended world that is planned to be a digital virtuality entrenched not only in our old habits such as gaming and entertainment but also in virtual asset trade. In particular, trading is a pillar of the virtual economy, and auction houses will be crucial for Metaverse trading. This exploratory study examines the possibility of using an auction environment to improve the trading capabilities in a virtual universe. We investigate the cases of creating a virtual auction house with the potential of social trading of virtual assets with crypto coins and bartering. To this end, we built a virtual auction house and tested it initially using a set of scenarios. Our preliminary findings suggest that creating a virtual trading environment would be beneficial as an environment for buying and selling virtual assets and exploring their consequences.

Keywords: Metaverse, Auction Theory, Virtual Reality, NFT, Trading Mechanism

1 Introduction

Increasingly widespread digitalization and particularly the developments in information technologies caused many activities to take place in digital environments. The process was accelerated with the COVID-19 pandemic and is rapidly reshaping the way people interact with their environment [1]. While many purchase and sale transactions were used to be carried out physically in the past, these transactions can now be realized in digital environments. According to some studies, many traditional purchasing-selling costs could disappear with the increasing pervasiveness of virtual environments [2], one reason for which is the direct communication and trading between private individuals. Within the scope of emerging technologies and the needs arising from the COVID-19 pandemic, new auctions and auction models have started to emerge [3]. For example,

in massively multi-player computer games, in-game purchases can be completed with auction mechanisms [4].

According to Ball [5], such a digital transformation requires fundamental changes in eight components: (i) hardware, (ii) computing, (iii) network structure, (iv) virtual platforms, (v) payment systems, (vi) content, services, (vii) values and (viii) user behavior. One example of a hardware change is the Oculus Quest 3D virtual reality headset. Apart from these types of technological innovations, individuals' shopping habits have been significantly affected by the necessity to avoid physical contact. According to a recent survey in [6], approximately 77 percent of the total participants believed that the pandemic had a significant impact on their purchasing behavior. In this context, the "store comes home" effect is observable among the eight immediate impacts of the COVID-19 pandemic on consumption and consumer behavior [7]. Adopting new technologies to support the experience and effectiveness of direct digital trading, innovations such as the Metaverse can provide infrastructure and interaction opportunities for cultural, intellectual and economic production [8]. A similar extent space was named Metaverse for the first time in a science fiction novel called "Snow Crash" [9].

According to Wang et al. [10], the Metaverse has the potential to transform our society by enabling a variety of immersive social applications such as virtual lives, virtual shopping, virtual dating, virtual chatting, global travel, and even space/time travel. It is also apparent that this structure can bring a new dimension to the users' interaction with cultural content by using the sense of presence effectively. For example, there exists hundreds of permanent galleries and museum spaces in the game Second Life. In this game, which can be considered as a more elementary version of the Metaverse, the artworks can be exchanged between the players, and the players can decorate their homes with these artworks. Similarly, in Digital Palace Museum developed in 2018 by Tencent, tourists were allowed to gain a panoramic and immersive experience of visiting the museum from their homes using virtual reality helmets [10]. As another example, in the game called Fortnite, a concert was given by the electronic music producer named Marshmello, in which players took part as the audience [11]. Yet another example would be the concert delivered by Lil Nas X in 2020 to more than 30 million participants in Roblox, a Metaverse-based gaming environment that has 47 million daily active users globally [12]. As part of this event, it was possible for the game players to shop in aligned digital stores [10].

In this study, we developed a 3D auction system prototype that can be accessed via virtual reality headsets. The software to be developed will enable users with these headsets to participate in a 3D auction environment for Non-Fungible Token (NFT) trading (refer to Section 2.2 for details regarding NFTs). In this way, the auction participants in the virtual environment will be able to interact in a manner similar to traditional physical participation. With this study, we aim to create an auction-based digital market model and develop a trading application for the Metaverse with the following features:

- By participating in the organized auctions, participants will be able to buy and sell NFTs with different shopping models.
- Live Metaverse NFT auctions will allow multiple participants to simultaneously and reliably partake in virtual auctions.
- The planned system will bring different dimensions to NFT trading and make the organization of auction events more accessible.

Due to its scope, content, and applicability to different platforms, the research will be a pioneering application, especially for the NFT-based shopping systems of the future.

In addition, we plan to explore how the NFT trading process can be restructured as a bartering system, without the exchange of money. This trading model benefits from an innovative auction-swap model. In other words, the planned system allows bidders to exchange goods directly rather than purchasing/selling products in exchange for money

RQ1: Will the model and its application enable the participants to successfully exchange NFTs?

RQ2: Will the model and its application facilitate multi-layered transactions, namely complex NFT trading involving both barter and classical exchanges between two or more participants?

This paper has been divided into five parts. The next part contextualizes the research by providing background information about the Metaverse, NFTs and auction mechanisms. In the third part, we summarize the virtual auction house prototype and its preliminary results. The fourth part discusses the limitations and includes a discussion about the implications of the findings on future research. The final section concludes the paper.

2 Background

2.1 The notion of Metaverse

It is suggested that the Metaverse fictional universe, starting with the concept of multiplayer digital games, will evolve into a new generation Internet incorporating virtual reality, augmented reality and blockchain [13]. Mark Zuckerberg, owner of Facebook, describes the Metaverse as "*the concretized Internet in which we are inside of it, instead of watching the content*" and states that it is made up of three-layered architecture consisting of infrastructure (blockchain and storage, communication and network, computing power), intersection (inclusive user experience, digital twins, content creation user interface) and virtual world (user-generated content, economics, artificial intelligence) [14].

This observation converges with the proposition of Lee et al. [13] on the point of describing the components of Metaverse. This structure offers a potential ground for new forms of cultural production, and styles of expression and learning. Kim [15] defines this ground as two different services: user and cultural content management system. The author indicates that while a user management service can address registration and avatar management, a content management service should be responsible for the transfer of the cultural content to individuals. In this case, there is a possibility in the long run that the Metaverse will evolve into a virtual replica of the environments we live in.

Figure 1 shows the key technologies that should be used and the impact areas that need to be focused in order to bring the Metaverse ecosystem to life.

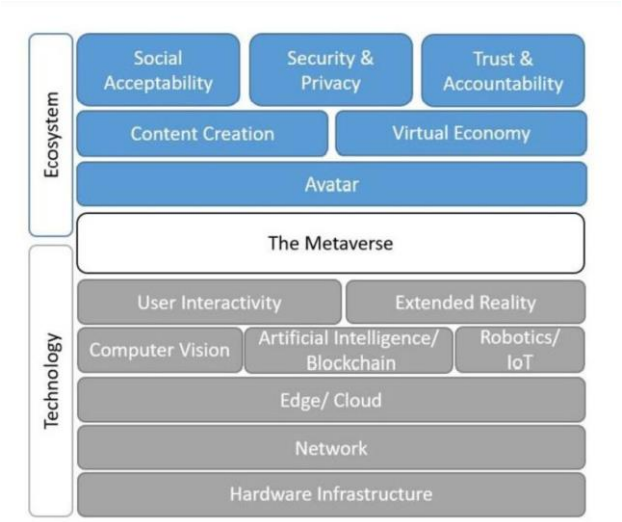

Figure 1 Metaverse Ecosystem (adapted from Lee et al. [13])

2.2 Non-Fungible Tokens (NFT)

An innovative construct in this domain is the Non-Fungible Tokens (NFT), which are the content units in digital platforms that cannot be exchanged by other cryptocurrencies and which approves the uniqueness of a digital asset with the help of blockchain [16]. An evolution of blockchain technology, NFTs exhibit significant growth in business volume such that the total market value of NFT has surpassed $40 billion (USD) in 2021 [17]. There exists different applications of NFTs that find themselves a place in various domains which are summarized in [18] as digital art, fashion, licenses and certifications, collectibles, gaming, domain names, virtual worlds and sports. Trading platforms for NFTs, such as OpenSea and Rarible, make it easy for the NFT holders to trade with one another, just like trading other conventional objects with monetary values [13]. NFT is a cryptographic method of proving the owner of a token linked to a

transaction. A token is a special transaction type supporting the Ethereum cryptocurrency and smart contracts. NFTs allow its users to be the owner of an asset that is unique or limited, just like an artwork or a numbered edition of a custom-made book. The unique characteristics of NFTs differentiate them from the Bitcoin concept in which coins are not different from each other [19]. For example, when Bitcoin is exchanged between two people, they will both have the same asset [20]. However, since it is not possible to exchange NFT in an equivalent way; NFT can be used to describe something in a unique manner [21]. Therefore, it is possible to use NFT to prove the ownership of a unique digital item [22].

Consequently and more specifically, NFTs can provide new opportunities for the art-related businesses which suffer from establishing online markets because of the inability of claiming the exclusive ownership [18], [23]. In fact, GLAM (Galleries, Libraries, Archives and Museums) institutions have already started selling NFTs of their collections, and The British Museum is a recent example of this [24]. Another application of the NFTs is the Foundation app [25] which is designed as an online-auction-based marketplace for NFTs [26]. In this application, several actions related to NFTs can be performed, from its creation until it is owned by a bidder, such as minting, listing, un-listing, bidding, settling and transferring [26].

Some researchers have argued that unlike the basic needs we should have in real life, the value of virtual objects can be evaluated based on their associated social status rather than consumption [13]. This shows that some digital immovables have the potential to form the basis of acquiring new social status indicators in the Metaverse World [27]. Owning an original picture, spending money for your home in the digital environment and shopping can be described as such activities.

In terms of organizing cultural events, Decentraland - known as one of the Metaverse worlds - has organized a four-day festival of music, culture and creativity. To participate in this activity, apart from having a powerful computer and web browser, you also needed a digital wallet to hold your personal belongings such as NFTs, land and crypto [28]. As a further example of the growth in this space, Division Network hosted an augmented reality-based conference. Since there is a mechanism for NFTs that guarantees uniqueness and thus can validate the value of digital assets [15], future Metaverse users will be able to safely collect digital assets, and a new digital content trading marketplace will be created. NFT technologies offer the artists opportunities to protect the value they produce, to transfer it safely and to ensure the rarity of the collected assets. To this extent, artists can earn money without a mediator, which leads to the birth of a new art economy. It is expected that digital galleries, art events and marketplaces to be created will be important components of the art ecosystem in the Metaverse universe. A recent example of this can be the British auction house Sotheby's [29]. As reported in [29], a Metaverse session called "Sotheby's Metaverse" was initiated, and a special auction called "Natively Digital 1.2: The Collectors" has already been organized with 53 pieces from NFT collections. In view of this information, it is anticipated that the developments in NFT technologies will lead to the emergence of new markets and professions such as digital stylists, investment and marketing specialists [30].

To explore the potential of this space, 3D virtual store design principles were outlined in [31], ultimately proposing that entertainment should be an incorporated element. Therefore, this "entertainment factor" is advocated to Metaverse retailers designing 3D stores [31]. Our study aims to highlight the importance of auction systems in the Metaverse. With the help of the auction systems, researchers can investigate new types of sales models and auction mechanisms for selling artworks and virtual lands. In particular, we consider new types of shopping and exchange opportunities integrated into the sales processes of these works. Thus, access to digital works using NFTs will increase. This study creates an auction environment that uses 3D modeling and is designed to work in the Metaverse. The concept can be considered to lie at the intersection of economic mechanism design (auction modeling as a sub-field of game theory) and virtual reality.

2.3 Auction Systems

An auction is a marketplace having a clear set of rules that determines resource allocation and prices based on market participants' bids [32]. Even though the exact origin of the auctions is unknown, the earliest auctions found in the historical records date back to Babylon [33]. Although auctions have a parallel history with human history, important developments in auction theory have emerged in the last two decades. In particular, the developments in information technologies permitted the design of more complex and efficient auction models. Auctions today can take place in the form of multi-product or single-item bargains. In the traditional single item auction model, each item or bundle of indivisible items is auctioned off one by one, and the winner is the highest bidder for each item. Due to its simplicity, this model has been used throughout history and is still in widespread use today.

English Auction. In this well-known classical public sale type, the auctioneer starts the auction with a reserve price (the lowest acceptable price), and the auction continues with the bidders' increasing prices until there is no more increase in the bid prices. The bidder proposing the highest price acquires the possession of the product by paying the amount he/she had proposed. The proposed bids are known by all bidders at the time of auction. In this auction type, the auctioneer has the right to keep the reserve price secret. In this openly competitive context, bids may exceed real value, for example with inexperienced bidders raising the price. However, it is the most widely used form of auction on a global scale [34].

Dutch Auction. Although the English Auction is the most widely used auction type, the Dutch auction is the first known type of auction in history. In contrast to the English auction, this auction type starts with an overbid, and the bid is lowered until a point at which a buyer says "mine" and pays the price [32].

Sealed First Price Auction. Sealed first-price auctions are widely used in government auctions [34]. In this type of auction, the bids are sealed and, therefore, are hidden

from the other bid owners. Generally, each bidder is allowed to submit only a single offer, making the preparation of the bid extremely important. This type of auction has two phases: a bidding phase where bidders submit their bids, and a resolution phase where the auction winner is determined. As with the English auction, the winner pays the full amount they bid.

Sealed Second Price Auction. This auction type is also known as the Vickrey auction. As the sealed first price auction, the bids are closed. However, in this type of auction, the auction winner pays the second-highest bid amount instead of their original final bid. Although this public sale format is rarely used, it is important as it provides a motivation for bidders to offer the real value [32].

Combinatorial Auctions. Single item auctions are suitable when the value of each item is irrelevant to the values of other items for each bidder. However, there can be complementarities and substitutions between items. The parallel auction model, in which all the items are auctioned simultaneously, increases the allocation efficiency by reducing uncertainty, but it does not help to solve the complementarity problem (involving complementarities between items). The combinatorial auction model solves this problem by allowing bundle bidding, that is, bidding on combinations of different items. In this model, all items are available to bidders, and the bidders are free to express their own valuations for any combination of items. The combinatorial auction model is widely used in many areas such as transportation [35] and education [36].

3 Virtual Auction House Prototype

We propose that agent-based modeling can be considered a useful tool when creating a virtual market for multiple auctioneers. We designed three scenarios to test the auction mechanism and the virtual reality-based auctioning application for the Oculus Metaverse (see Figure 2). Three NFTs and a set of three personas with different bidding behaviors were incorporated: (i) a naïve agent with no learning or memory skills, which bids with true costs that are essentially bids until it runs out of money (named as AG1), (ii) a rule-based agent which cannot learn but has a short-term memory and ultimately can bid on three items concurrently (named as AG2), (iii) an agent with the basic skills of reinforced learning which has the skills to track its state and compare it with the auction state (and the collected data to maximize the winning chances) (named as AG3).

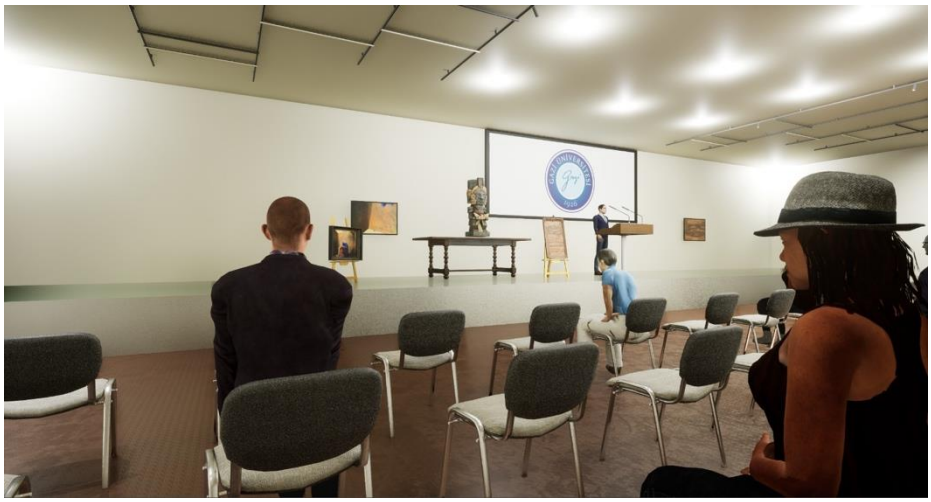

Figure 2 Preliminary prototype of the auction house

The system initiated an auction in a virtual reality environment to create a unique trading experience for human participants. Consequently, we run the test auctions with three human participants with three initial auction scenarios. We generated digital credits for the participants in a random range to explore differences in the bidding. All three NFTs are generated and valued by the system, and a set of scenarios were initiated. The naïve agent was programmed to bid on a single item based on the initial digital money randomly generated for its usage. The rule-based agent was programmed to acquire the two of the three NFTs generated. The agent with learning skills was programmed to aim for all three items based on its initial generated credits (denoted with System Credit - SC).

The first scenario had three NFTs, NFT1 had a value of 3000 SC, NFT2 had a value of 2000 SC, NFT3 had a value of 4500 SC.

Participant Type	Initial Credit	NFT1 Bidding Count	NFT2 Bidding Count	NFT3 Bidding Count	Winner of the asset
Human1	4500SC	9	6	8	NFT2
AG1	3000SC	15	-	1	NFT1
AG2	6000SC	3	10	4	NFT3
AG3	4000SC	7	8	7	-

Table 1. First auction run with one human and three virtual agents

Table 1 shows the initial run with all agents involved. It can be inferred from the table that AG1 has the maximum bid for NFT1, which has a price match that can maximize its benefit, and show the most aggressive bidding behaviour. It only bided once for NFT3 at the commencement of its auction. Not surprisingly, it secured NFT1 and spent all its credits in the process. Human participant won NFT2 while other auctioneers

were concurrently bidding for other items. NFT3 was acquired by AG2 as it had the maximum resources after NFT1 was sold to AG1. AG3 was the loser of the session due to its bidding policy.

In the second scenario, we created a high priced NFT1 with a value of 7500 SC and one low price item. NFT2 had a value of 5000 SC and NFT 3 had a value of 3000 SC. Most importantly, however, NFT2 and NFT3 were randomly given to Human1 and Human2 and both could only use these NFTs complimentarily within an offer.

Participant Type	Initial Credit	NFT1 Bidding Count	NFT2 offer Count	NFT3 offer Count	Owner of the asset at the end of round
Human3	7000SC	9	3	1	NFT1
Human2	7000SC	7	2	3	NFT2, NFT3
Human1	7000SC	5	-	-	-
AG1	7000SC	3	-	-	-

Table 2. Second auction run with one virtual and three human agents

Table 2 illustrates the result of the second auction. In this auction run, initially, Human1 had NFT3, and Human2 had NFT2. In the first round, Human3 made a series of offers to Human2 for NFT3 and ultimately paid 3500 as a winning offer. As a result, this actively changes NFT3's initial price to 3500. Therefore, Human3 was able to raise their total SC to 7500 and won NFT1 at the end of the final round. AG1 was not able to locate a price to synchronize its system credits to any asset. In fact, it was not really programmed for making offers.

In this final scenario for this preliminary part of the research, we built a bartering test and randomly created and assigned 3 NFTs to three human participants. Here, we did not offer any system credits to the players, and they could only request an exchange for the items the other auctioneers owned.

Participant Type	Initial Credit	NFT1 Offer Count	NFT2 Offer Count	NFT3 Offer Count	Owner of the asset at the end of round
Human3	NFT3	1	4	-	NFT2
Human2	NFT2	2	-	3	NFT3
Human1	NFT1	-	1	4	NFT1

Table 3. The third auction run with three human agents

Table 3 shows an interesting kind of auction among the three human agents. Human3 and Human 2 made a series of offers for the items owned by each other. At the end of a series of rounds they exchanged the NFTs as agreed. However, Human1 was not successful in agreeing on any exchanges.

4 Research Limitations & Future Work

We have initially observed that an auction house in a virtual reality setting can potentially improve the interactive experience of trading in the Metaverse. However, the study was limited to the Oculus Quest 2 hardware, and it was not actually tested for more than three participants. At first, bidders found the experience different while experimenting with the system with virtual agents. Although all participants (human and virtual) were using avatars where agents could not be differentiated at first sight, it was observed that the auctions conducted only with humans were more entraining for the human participants.

However, this paper does not attempt to assess the fun factor. To create a more realistic auction house experience, one participant suggested that our virtual environment could benefit from some sounds and perhaps some background noises. In addition, it was also suggested that more scenarios would be essential for investigating the outcomes of the auction mechanism. Further investigations are needed to confirm and validate our findings.

5 Conclusions

This research was undertaken to assess different auction mechanisms in a virtual reality environment and is among the first to investigate the bartering experiences of human participants in a virtual auction. The goal was to create a marketplace where we could assess the feasibility of auctioning mechanisms for NFT-like digital assets in future Metaverse environments. This study has shown that a basic auction mechanism can be implemented with good interaction results. It has also explored the potential of digital trading assets in particular virtual ecosystem. These findings have significant implications for understanding how digital trading assets can change our perception of the next-generation world-wide-web.

Notwithstanding the relatively limited iterations, this work offers valuable insights into trading in the Metaverse. In particular, it has raised important questions about the nature of bartering in digital trading. When considered together, these results suggest that auctions have the potential to be a part of our next-generation trading platforms, especially in the Metaverse.

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References

[1] İ. Arslan and S. Karagül, "Küresel bir tehdit (COVID-19 salgını) ve değişime yolculuk," *Üsküdar Üniversitesi Sos. Bilim. Derg.*, no. 10, pp. 1–36, 2020.

[2] J. D. N. Dionisio, W. G. B. III, and R. Gilbert, "3D virtual worlds and the metaverse: Current status and future possibilities," *ACM Comput. Surv.*, vol. 45, no. 3, pp. 1–38, 2013.

[3] M. Xu, D. Niyato, J. Kang, Z. Xiong, C. Miao, and D. I. Kim, "Wireless Edge-Empowered Metaverse: A Learning-Based Incentive Mechanism for Virtual Reality," *arXiv Prepr. arXiv2111.03776*, 2021.

[4] A. Drachen, J. Riley, S. Baskin, and D. Klabjan, "Going out of business: auction house behavior in the massively multi-player online game glitch," *Entertain. Comput.*, vol. 5, no. 4, pp. 219–232, 2014.

[5] M. Ball, "Framework for the Metaverse," 2021. [Online]. Available: https://www.matthewball.vc/all/forwardtothemetaverseprimer. [Accessed: 11-Apr-2022].

[6] V. Chauhan and M. H. Shah, "An empirical analysis into sentiments, media consumption habits, and consumer behaviour during the Coronavirus (COVID-19) Outbreak," *Purakala UGC Care J.*, vol. 31, no. 20, pp. 353–375, 2020.

[7] J. Sheth, "Impact of Covid-19 on consumer behavior: Will the old habits return or die?," *J. Bus. Res.*, vol. 117, pp. 280–283, 2020.

[8] C. Newton, "Mark in the Metaverse," 2021. [Online]. Available: https://www.theverge.com/22588022/mark-zuckerberg-facebook-ceo-metaverse-interview. [Accessed: 11-Apr-2022].

[9] N. Stephenson, *Snow crash*. New York: Bantam, 1992.

[10] Y. Wang *et al.*, "A Survey on Metaverse: Fundamentals, Security, and Privacy," *arXiv Prepr. arXiv2203.02662*, 2022.

[11] P. Rubin, "Fortnite's Marshmello Concert Is the Future of the Metaverse," 2019. [Online]. Available: https://www.wired.com/story/fortnite-marshmello-concert-vr-ar-multiverse/.

[12] J. McDonald, "Roblox's metaverse is already here, and it's wildly popular," 2021. [Online]. Available: https://www.emergingtechbrew.com/stories/2021/12/10/roblox-s-metaverse-is-already-here-and-it-s-wildly-popular. [Accessed: 12-Apr-2022].

[13] L.-H. Lee *et al.*, "All one needs to know about metaverse: A complete survey on technological singularity, virtual ecosystem, and research agenda," *arXiv Prepr. arXiv2110.05352*, 2021.

[14] M. Zuckerberg, "Founder's Letter, 2021," 2021. [Online]. Available: https://about.fb.com/news/2021/10/founders-letter/.

[15] J.-G. Kim, "A Study on Metaverse Culture Contents Matching Platform," *Int. J. Adv. Cult. Technol.*, vol. 9, no. 3, pp. 232–237, 2021.

[16] L. V. Kiong, *Metaverse Made Easy: A Beginner's Guide to the Metaverse: Everything you need to know about Metaverse, NFT and GameFi*. Liew Voon Kiong, 2022.

[17] A. Vesprille, "NFT Market Surpassed $40 Billion in 2021," 2022. .

[18] W. Rehman, H. e Zainab, J. Imran, and N. Z. Bawany, "NFTs: Applications and Challenges," in *2021 22nd International Arab Conference on Information Technology*

(ACIT), 2021, pp. 1–7.

[19] J. Fairfield, “Tokenized: The law of non-fungible tokens and unique digital property,” *Indiana Law Journal, Forthcom.*, 2021.

[20] L. Kugler, “Non-fungible tokens and the future of art,” *Commun. ACM*, vol. 64, no. 9, pp. 19–20, 2021.

[21] Q. Wang, R. Li, Q. Wang, and S. Chen, “Non-fungible token (NFT): Overview, evaluation, opportunities and challenges,” *arXiv Prepr. arXiv2105.07447*, 2021.

[22] C. Pinto-Gutiérrez, S. Gaitán, D. Jaramillo, and S. Velasquez, “The NFT Hype: What Draws Attention to Non-Fungible Tokens?,” *Mathematics*, vol. 10, no. 3, p. 335, 2022.

[23] A. Mani, “A Comprehensive Study of NFTs,” *nternational J. Res. Appl. Sci. Eng. Technol.*, vol. 9, no. 4, pp. 1656–1660, 2021.

[24] D. Ross, E. Cretu, and V. Lemieux, “NFTs: Tulip Mania or Digital Renaissance?,” in *2021 IEEE International Conference on Big Data (Big Data)*, 2021, pp. 2262–2272.

[25] “Foundation.” 2021.

[26] M. Fazli, A. Owfi, and M. R. Taesiri, “Under the Skin of Foundation NFT Auctions,” *arXiv Prepr. arXiv2109.12321*, 2021.

[27] K. U. Ş. Oğuz, “Metaverse:‘Dijital Büyük Patlamada’Fırsatlar ve Endişelere Yönelik Algılar,” *Intermedia Int. E-journal*, vol. 8, no. 15, pp. 245–266, 2022.

[28] Decentraland, “Metaverse Festival: Frequently Asked Questions.,” 2021. [Online]. Available: https://themetaversefestival.io/MusicFestivalFAQs.pdf. [Accessed: 11-Apr-2022].

[29] H. Ning *et al.*, “A Survey on Metaverse: the State-of-the-art, Technologies, Applications, and Challenges,” *arXiv Prepr. arXiv2111.09673*, 2021.

[30] V. Ma, “5 Futuristic Jobs of The Metaverse,” 2021. [Online]. Available: https://hackernoon.com/5-futuristic-jobs-of-the-metaverse. [Accessed: 11-Apr-2022].

[31] D. Hassouneh and M. Brengman, “Retailing in social virtual worlds: developing a typology of virtual store atmospherics,” 2015.

[32] V. Krishna, *Auction theory*. Academic press, 2009.

[33] M. R. Baye, D. Kovenock, and C. G. De Vries, “The herodotus paradox,” *Games Econ. Behav.*, vol. 74, no. 1, pp. 399–406, 2012.

[34] A. Mochón and Y. Sáez, *Understanding auctions*. Springer, 2015.

[35] Y. Sheffi, “Combinatorial auctions in the procurement of transportation services,” *Interfaces (Providence).*, vol. 34, no. 4, pp. 245–252, 2004.

[36] R. L. Graves, L. Schrage, and J. Sankaran, “An auction method for course registration,” *Interfaces (Providence).*, vol. 23, no. 5, pp. 81–92, 1993.