TOKENS NO FUNGIBLES: UNA REVISIÓN SISTEMATIZADA SOBRE EL PANORAMA DESDE LA EVIDENCIA CIENTÍFICA

NON-FUNGIBLE TOKENS: A SYSTEMATIC REVIEW OF THE PANORAMA FROM SCIENTIFIC EVIDENCE

MSc. Javier Alfonso Ramírez Duran[*], **Jose Ignacio Ramírez**[*], **PhD. Leonardo Niebles Núñez**[*]

[*] **Corporación Universitaria Latinoamericana**
Calle 58 # 55 - 24A Barranquilla - Colombia
[*]**Universidad del Atlántico,** Facultad de Ingeniería,
Calle 68 Número 53- 45 Barranquilla- Atlántico.
Tel.: (57) (5) 3162666.
E-mail: {hugohernandezp, daironovoa, danielmendoza}@mail.uniatlantico.edu.co

Abstract: Non-fungible tokens are one of the topics that have been most popular in recent months due to the high sums of money that their transactions have represented; However, there are many questions about what non-fungible tokens are and how they work. In this way, this study is developed in order to analyze the benefits of non-fungible Tokens and their application within the various markets. For the development of the study, a systematized bibliographic review carried out in the WoS and Scopus databases is presented, accompanied by a bibliometric analysis of the results of the search equation before carrying out the process of filtering the results. The results obtained show an important level of application of non-fungible tokens in various sectors, based on the qualities of providing verifiable and unclonable information to various assets; which can range from physical devices based on the IOT to digital art, music or collectibles within video games. It is concluded that the panorama of non-fungible tokens, although very uncertain, shows a trend towards growth and permanence as a type of asset to be considered in the development of the 4.0 era.

Keywords: Non-fungible tokens, Blockchain, smart contracts, Ethereum

Resumen: Los tokens no fungibles son uno de los temas que han tenido más popularidad en los últimos meses por las elevadas sumas de dinero que las transacciones de estos han representado; no obstante, existen muchas preguntas sobre que son y cómo funcionan los tokens no fungibles. De esta forma, el presente estudio ser desarrolla con el objeto de analizar los beneficios de los Tokens no fungibles y su aplicación dentro de los diversos mercados. Para el desarrollo del estudio se presenta una revisión bibliográfica sistematizada realizada en las bases de datos de WoS y Scopus, acompañada de un análisis bibliométrico de los resultados de la ecuación de búsqueda antes de realizar el proceso de filtraje de los

resultados. Los resultados obtenidos permiten mostrar un importante nivel de aplicación de los tokens no fungibles en diversos sectores, basándose en las cualidades de la dotación de información verificable e inclonable a diversos activos; los cuales pueden ir desde dispositivos físicos basados en el IOT hasta arte digital, música o coleccionables dentro de los juegos de video. Se concluye que el panorama de los tokens no fungibles, si bien es muy incierto, muestra una tendencia hacia el crecimiento y permanencia como un tipo de activo a ser considerado en el desarrollo de la era 4.0.

Palabras clave: Tokens no fungibles, Blockchain, contratos inteligentes, Ethereum

1. INTRODUCTION

Since the rise of cryptocurrencies in recent years, there has been a radical change in the way in which transactions are carried out in the digital environment (Sahoo, 2017), becoming the fundamental basis of one of the most remarkable and fastest growing markets in the history of mankind (Goel & Mittal, 2020). In this way, it should be noted that the cryptocurrency market has stood out not only for the great growth and relevance it has presented, but that such recognition is also associated with the fact that these, not being traceable, tend to be used for various illicit activities such as money laundering (Vassallo, Vella & Ellul, 2021). However, with this type of digital assets appears the blockchain technology as a new transaction architecture or process which represents a radical change in the credibility of the information; being considered as one of the inventions with the greatest impact in the history of mankind; which is comparable to the internet (Tapscott & Tapscott, 2016; Zhou, et al., 2020). Blockchain technology is based on a series of digital records that keep track of information through a group of blocks that are connected to each other and record the process of the various transactions and the data related to these (Seebacher, & Schüritz, 2017; Pesserl, 2021).

Several experts consider that blockchain technology has been the fundamental tool to provide decentralization and reliability to the cryptocurrency market at the international level (Kher, Terjesen & Liu, 2021); highlighting how certainly such technology today is applied to various environments such as healthcare, logistics, among others (Shahnaz, Qamar & Khalid, 2019; Bodkhe et al., 2020).

This is where the emergence of the so-called NFTs or, by their acronym in Spanish, Non-Fungible Tokens occurs; which means that these digital assets are characterized by not being homogeneous among themselves and having the quality of being unique in their type (Fairfield, 2021); unlike the various cryptocurrencies that were certainly designed not to be different among these, giving them a quality of being equally valuable among their peers (Baur, Hong & Lee, 2018; Shirole, Darisi & Bhirud, 2020). Nowadays, non-fungible tokens have gained an important relevance within the international market of digital art transactions and within other markets such as music or e-sports where they already have an important degree of maturity that allows evidencing the significant growth of this type of digital asset as an investment opportunity (Vermibus, 2021; Franceschet, et al., 2020; Kupferman, 2021).

It is essential to understand how non-fungible tokens are closely related to cryptocurrencies and blockchain technology; with the first such relationship is given as NFTs arise from the so called Etherium smart contracts and with the second they are related thanks to the use of blockchains to ensure the transparency and traceability of transactions made with this type of digital asset; allowing to verify the originality of this (Pesserl, 2021; Raman & Raj, 2021).

In this way, through a transaction in Etherium by means of a digital contract the owner of the asset can prove the existence and ownership of such digital asset, where the creator of the asset can generate income from each transaction made with this type of token, making it extremely attractive for the protection and profitability of intellectual properties (Serada, Sihvonen & Harviainen, 2021). Non-fungible tokens can be any type of digital asset that is unique, such as a musical composition, a work of art, a component related to a video game or even a Twitter post (Vanherpe & Janssens, 2021; Rae, 2021). Certainly this opportunity to monetize digital assets in a transparent way makes the market of collectors and investors see in NFTs an opportunity to earn income in a considerable way (Crow & Ostroff, 2021). Below is an example of CryptoPunk Ⓒ #9023, whose last transaction totals USD

133

39,740.90 (Larvalabs, 2021): This is certainly demonstrated by the numbers reported in the first months of 2021, where the market volume exceeds two billion dollars, which is ten times greater than the entire trading market volume during the whole of 2020. Its application has also migrated to the sports arena, where around 7.6 million dollars have been generated in video transactions on NBA plays (Nadini, 2021). In turn, this market has shown an extremely important growth since the beginning of 2021, since this year more than 550 million dollars in transactions have been reported by the end of March, of which 36.4% was reported only in the month of March (Dowling, 2021).

However, it should be noted that within the scientific field there are very few studies that address the description of non-fungible tokens and analyze their growth and application within the markets today; especially within the Spanish speaking research field where such information is much scarcer. Thus, this study is developed in order to describe through a theoretical review the non-fungible tokens as a booming digital asset. Based on this phenomenon under study, this article is developed with the purpose of analyzing the benefits of non-fungible tokens and their application in different markets. This premise gives rise to the research question which is directed to know what are the benefits of non-fungible tokens and their applicability within the various markets?

2. METHODOLOGY

With the premise of solving the objective set out in the document, a systematized search is developed which focuses on the scientific evidence that addresses the application of the so-called non fungible tokens within the various markets and sectors at the international level. This systematized review responds to the latent lack of academic information that supports the concepts and evidence found in relation to this type of digital asset; being this study the opening of an analytical framework built from the reliability and validity provided by this type of review process (Díaz-Jiménez, Yerga Míguez & Serrato-Calero, 2021). It is essential to understand that, as stated by Gama & Gómez-Conesa (2008), a systematized review is a study with a design denominated as secondary sources whose nature is retrospective, observational and analytical. For the implementation of the systematized review presented, the keywords taken from the IEEE 2021 thesaurus "Blockchain" and "token network" were used as a basis.

From this process, the results obtained in the two databases selected for the review were processed by means of the Histcite software, which allowed a bibliometric review of the sources consulted based on the process proposed by studies such as that of George and Avello (2021), where prior to a systematic mapping analysis of the literature, it is essential to perform a bibliometric analysis of the results obtained. In this case, it should be noted that the bibliometric analysis is not performed with the aim of constructing clusters due to the novelty of the phenomenon under study, but to understand the characteristics of the results yielded by the thesauri applied in the search process.

Thus, the platforms selected for the review were Scopus and Web Of Science because they are the two most internationally renowned databases, and some documents from information sources such as Google Scholar were selected intentionally to reinforce certain elements of the study. The collection of information is carried out on June 24, 2021. In this sense, the searches are carried out with the following inclusion criteria:

1. The research should have developed some study directly related to non-fungible tokens.
2. This includes studies that directly or indirectly analyze their application or possible applications of non-fungible tokens in any sector.
3. That the research be published in scientific journals, book series, Conference Proceedings or dissertations.
4. The observation window for the review runs from 2018 to 2021.

The selected studies were analyzed by means of a matrix in which the key points of each study were placed, such as concepts, materials and methods, results and contributions to the research. A dichotomous scale of "yes" and "no" was used as a basis for determining which studies would be included in the final review.

3. RESULTS

3.1 Bibliometric analysis in databases

From the search of the thesauri within the databases, a total of 303 publications were found, distributed in 234 in Scopus and 69 in Web of Science. With these

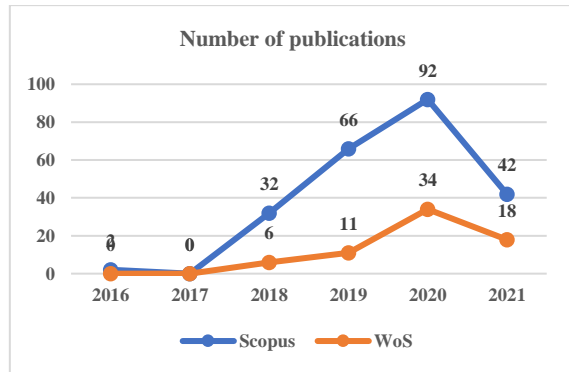data, the following comparative bibliometric analysis is developed:

Fig. 1. Publications in Scopus and WoS

Starting from the number of articles published by each of the databases, it is observed how in Scopus publications on the subject of study occur since 2016, but it is not until 2018 when a significant growth is evidenced with 32 published papers; a trend that continued to rise in 2020 with 92 publications. With respect to Web of Science, it is noteworthy that, although the frequency of publications on the area is lower, a clear increase in the area is observed from the year 2018.

In this sense, we proceeded to investigate the distribution of publications on the topics by countries through a coupling study. This analysis shows that the country with the highest frequency of publication is the United States with a total of 43 documents published in Scopus, followed by countries with a remarkable frequency such as China with 40, India with 24, Germany and the United Kingdom with 12 in each country, Australia and Singapore with 9 and Hong Kong, Italy, South Korea and Spain with 8.

A review of the Web of Science database shows that the highest concentration of publications within the search equation formulated are from the United States with a total of 17, followed by China with 13, India and Italy with 6 each and Germany with a frequency of five localized publications. This is shown in the following table:

Table 1: Countries with the highest frequency of publication in the area in the Scopus and WoS databases.

Scopus		Web of Science	
Country	**Frecuency**	**Country**	**Frecuency**
United States	43	Usa	17
China	40	China	13
India	24	India	6
Germany	12	Italy	6
United Kingdom	12	Germany	5
Australia	9	Australia	3
Singapore	9	England	3
Hong Kong	8	Finlandia	3
Italy	8	U Arab Emirates	3
South Korea	8		
Spain	8		

Based on this, it is important to note that in both databases the United States is the country with the highest frequency of publication in the area under study, followed by China and India, which are in second and third place in the weighting of the databases; at the same time, within this same coupling analysis, countries such as Germany, Australia, Italy or the United Kingdom are mentioned with an outstanding production.

On the other hand, with respect to the co-occurrence of the localized keywords, it is observed that the Web of Science database (Figure 1) shows that the keywords with the greatest impact are Blockchain, Cryptocurrency, Smartcontract, Etherium, Security and Bitcoin; showing how this topic is associated with digital transactions supported by Blockchain technology and digital assets such as Etherium or Bitcoin. Similarly, when reviewing the co-occurrence within the Scopus database, it is observed that those that have a greater impact are

135

Blockchain, Internet of things, network security, Ethereum, smart contract and Access control showing how there is a relationship with computer systems or cryptography:
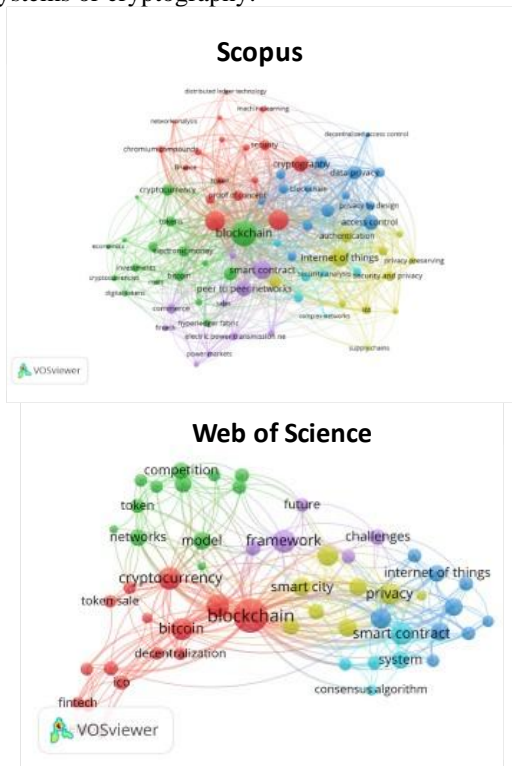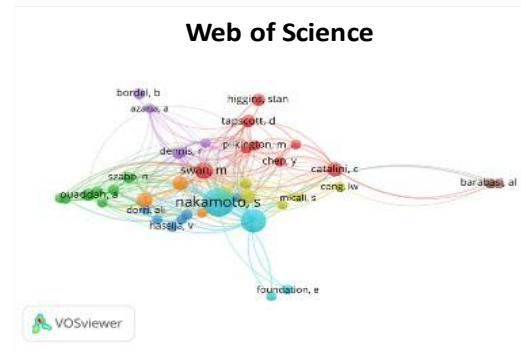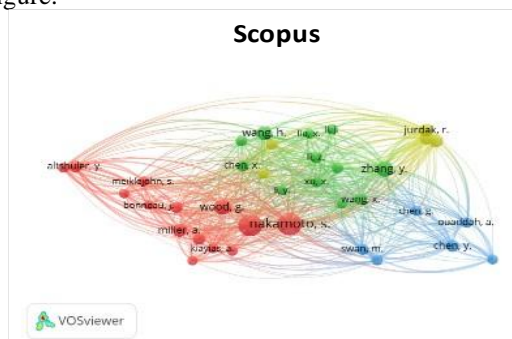

Scopus

Web of Science

Fig. 2. Cooccurrence of keywords in Scopus and Wos.

Next, with respect to the coupling by cited author, it is highlighted how in both databases there are important similarities in the most important references in the area. Within this group of authors we can mention Nakamoto, S. (reference used for the pseudonym attributed to the creation of the Bitcoin protocol), Chen, Y.; Swan, M. or Quaddah, A., who appear in both databases as some of the most cited authors; this can be seen in the following figure:

Scopus

Web of Science

Fig. 3. Most cited authors in Scopus and Wos.

3.2. Filtering and review

The publications were filtered based on the established criteria, from this process 303 documents were filtered to a total of 11 documents, to which were added 10 documents that were manually selected in the Google Scholar platform based on the quality of content and scientific quality located in the studies. This process yielded a total of 21 documents, the filtering of which is shown below:

Fig. 4. Filtering process performed
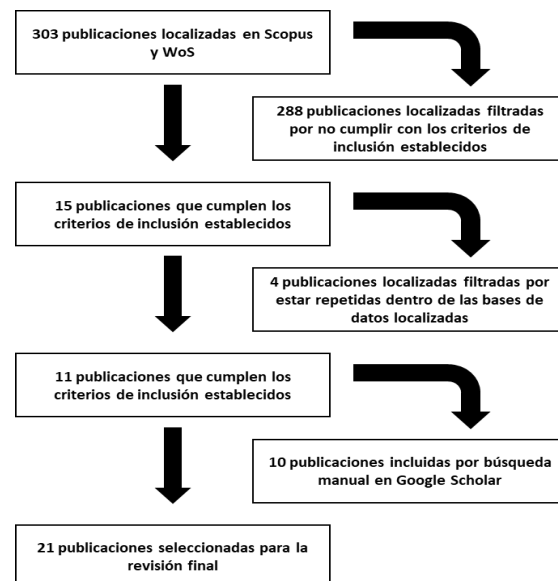
Based on the filtering performed, the following table shows the most relevant points found in the 21 studies selected for the review, where a series of categories are established to describe the benefit of NFTs and the application sectors mentioned in each of the studies submitted for the final review:

Table 2: Relevant points of the publications analyzed for final review

136

Title of publication	Authors -Year	Benefit of the NFTs	Sectors of application mentioned
A Blockchain Based Decentralized Computing and NFT Infrastructure for Game Networks	Muthe, K. B., Sharma, K., & Sri, K. E. N. (2020).	Creation of digital assets with unique features and decentralized systems	Construction of decentralized digital systems applied to the video game industry.
A Study on the elements of business model innovation of non-fungible token blockchain game: based on 'PlayDapp'case, an in-game digital asset distribution platform	Choi, S. W., Lee, S. M., Koh, J. E., Kim, H. J., & Kim, J. S. (2021).	To provide unique, independent and decentralized digital assets.	In the video games industry as a fundamental element of a blockchain that allows to be a differential factor for companies in the video games sector or other field.
Barter machine: An autonomous, distributed barter exchange on the ethereum blockchain	Ozturan, C. (2020).	Ability to demonstrate transparency and security of transactions.	Support of a swap system based on Blockchain and smart contracts.
Blockchain based car-sharing platform	Valaštín, V., Košťál, K., Bencel, R., & Kotuliak, I. (2019).	Representation of digital assets within a blockchain.	Automotive sector for the identification of data in secure and decentralized databases.
Blockchain based transaction system with fungible and non-fungible tokens for a community-based energy infrastructure	Karandikar, N., Chakravorty, A., & Rong, C. (2021).	Ability to provide a unique identifier to an asset.	Electricity sector Creation, transfer, exchange, return and reading of assets
Decentralized cloud manufacturing-as-a-service (CMaaS) platform architecture with configurable digital assets	Hasan, M., & Starly, B. (2020).	Opportunity to develop decentralized processes	Development of manufacturing systems in the cloud.
Fertile LAND: Pricing non-fungible tokens	Dowling, M. (2021).	Creation of digital assets with unique features and decentralized systems	In the market for digital assets in the form of virtual reality real estate.
Is non-fungible token pricing driven by cryptocurrencies?	Dowling, M. (2021).	Ability to provide a unique and uniquely identifiable identification of assets	Collectibles and artwork, objects in virtual worlds and digitized characters from sports and other games and cryptocurrency-based digital asset transactions.
Leverage from Blockchain in Commodity Exchange: Asset-Backed Token with Ethereum Blockchain Network and Smart Contract	Heryadi, Y., & Trisetyarso, A. (2021).	Opportunity to develop decentralized processes	Crypto-token-backed asset investment or project investment.
Non-fungible token (NFT): Overview, evaluation, opportunities and challenges	Wang, Q., Li, R., Wang, Q., & Chen, S. (2021).	Ability to provide a unique identifier to an asset.	Implementation in the market through the strengthening of digital assets.
Non-Fungible Tokens: Blockchains, Scarcity, and Value	Chohan, U. W. (2021).	Ability to provide a unique and uniquely identifiable identification of assets	Transactions of digital assets in all cryptocurrency-based systems (Ethereum)
Potential use cases for non-fungible tokens in combination with physical art	Vinnari, M. (2021).	Ability to provide a unique and uniquely identifiable identification of assets	Application in the creative industry sector providing the ability to demonstrate the authenticity of the pieces.
Scavenger hunt: Utilization of blockchain and iot for a location-based game	Manzoor, A., Samarin, M., Mason, D., & Ylianttila, M. (2020).	Creation of digital assets with unique features and decentralized systems	Application of digital assets as rewards in the video game industry.
Secure Combination of IoT and Blockchain by Physically Binding IoT Devices to Smart Non-fungible Tokens Using PUFs	Arcenegui, J., Arjona, R., Román, R., & Baturone, I. (2021).	Ability to provide unique and uniquely identifiable assets.	Application of non-fungible tokens for the identification of physical assets that are connected via the internet of things
Secure management of IoT devices based on blockchain non-fungible tokens and physical unclonable functions	Arcenegui, J., Arjona, R., & Baturone, I. (2020).	Articulation of devices based on the internet of things.	Device security systems based on the internet of things using non-fungible tokens.
Smart Collectibles: Unlocking The Value of Non-Fungible Tokens (NFTs)	Fai, A. (2021).	Creation of digital assets with unique features and decentralized systems	Transactions of digital assets in all cryptocurrency-based systems (Ethereum)
The non-fungible token (NFT) market and its relationship with Bitcoin and Ethereum	Ante, L. (2021).	Ability to provide unique and uniquely identifiable assets.	Collectibles and artwork, objects in virtual worlds and digitized characters from sports and other games and cryptocurrency-based digital asset transactions.
Tracing manufacturing processes using blockchain-based token compositions	Westerkamp, M., Victor, F., & Küpper, A. (2020).	Ability to provide a unique and uniquely identifiable identification of assets	In the manufacturing sector through the provision of a unique and traceable identification to assets.
Transactions Process in Advanced Applications on Ethereum Blockchain Network	Goyal, S., Sanjith, K., Sisodia, A., Suhaas, N. M., & Akram, S. (2020).	Ability to provide a unique identifier for an asset	Transactions of digital assets in cryptocurrency-based systems (Ethereum)
Velink - A Blockchain-based Shared Mobility Platform for Private and Commercial	Pirker, D., Fischer, T., Witschnig, H., & Steger, C. (2021).	Ability to demonstrate transparency and security of transactions.	Automotive transactions for public and private transportation in one App.
VGO, NFT, OMG! Commentary on continued developments in skins wagering	Abarbanel, B., & Macey, J. (2019).	Ability to provide a unique and uniquely identifiable identification of assets	In the video game industry as one-of-a kind assets that acquire exchange or collection value through their own characteristics.

137

From the findings found in the 21 publications reviewed, a theoretical framework can be established based on the systematized review; based on this process, the following basic fundamentals to be taken into account to understand non-fungible tokens are shown below, as well as an analysis of their benefits and their various areas of application:

3.3. Basic fundamentals for the study of non-fungible tokens

From the systematized theoretical review process carried out, it is possible to understand in the first instance that a non-fungible token is a type of digital asset with unique and uncountable characteristics which is based on blockchain technology to verify and maintain its transparency and credibility in transactions carried out in Ethereum in the ERC721 and ERC1115 standards through the so-called smart contracts (Fai, 2021); which allow the registration and access of the information carried out in each transaction with this type of asset (Heryadi & Trisetyarso, 2021).

This key concept is addressed by the various studies conducted and the approach is given with respect to the characteristic of each study and the applications given to the non-fungible tokens. In the same way, the following key elements are identified at a conceptual level, whose description is fundamental to understand the variable under study:

- Blockchain: It is a database which is deposited in a series of attached server nodes which are interconnected within a decentralized system, creating a chain between them to back up and protect the information deposited in them based on cryptographic protocols.
- Ethereum: Digital platform based on blockchain where a series of processes are carried out within the various standards of tokens that are handled in it; such as fungible and non-fungible tokens.
- Smart contract: Smart contracts made in Ethereum are a type of digital contract which is based on blockchain technology; providing the parties to it the ability to perform processes and transactions without the need for a third party so that a decentralized system is created.

Once the basic elements involved in non-fungible tokens have been understood, the programming standards on which they are based are presented:

- ERC721 standard: It is a token standard which is characterized for being unique and unclonable; unlike the ERC20 standard which is constituted with the purpose of being fungible and working as a currency. It has a uaint256 variable represented in the TokenId; this Id can be endowed with certain characteristics according to the needs of the creator of the asset registry (Goyal et al., 2021).
- ERC1155 Standard: Also called Multi Token Standard; it is a mixed standard between ERC20 and ERC721; which is characterized in that each TokenID can have the ability to be fungible and non-fungible independently of the others, as well as being fungible in each transaction or process (Wang et al., 2021).

Using them as a reference, a comparative table is presented between the fungible standards and the standards mentioned above:

Table 3: Comparison between fungible, non-fungible and mixed standards

Expendable standard (e.g. ERC20)	Standard ERC721	Standard ERC721
All assets are uniform among themselves. It is commonly used to represent coins.	It is characterized by the fact that each asset is unique in its type. It is used to represent an asset that is intended to be unique (property or goods).	This is characterized by its mixed nature. It can represent both fungible assets such as currencies and non-fungible assets that require verification of their unique characteristics.

Once the basic elements of non-fungible tokens are understood, the following graph shows the process that summarizes how transactions based on Nfts work according to the various contributions of the studies reviewed:
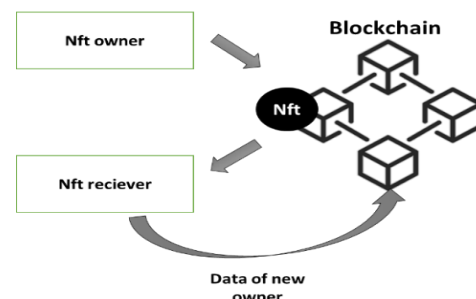
Fig. 5. NFT transaction

The process shown above shows that everything starts with the owner (who may be the creator) of the non-fungible token, who performs the transaction process of such asset through the blockchain (digitization, validation, etc.) so that the asset is transferred to the receiver, who in turn deposits the information of the ownership of the asset to the blockchain. It is important to emphasize that all this process to be done through smart contracts does not need any type of intermediaries to perform the process, since the contract itself is configured so that it deposits the information and characteristics of the process in an automated manner within the blockchain.

In turn, these characteristics, which are part of the processes with Nfts, allow revealing a series of benefits that are in turn shown by the researches taken into account for the review carried out. Thus, the benefits of non-fungible tokens are as follows (Karandikar, Chakravorty & Ron, 2021; Wang et al., 2021; Choi et al., 2021):

- Verifiability: according to the literature reviewed, it is possible to determine that one of the most outstanding qualities is the verifiability of the information; by means of blockchain-based systems, the information deposited in smart contracts can be quickly verified, and the traceability of the asset can be checked.
- Originality: Originality refers to the fact that non-fungible tokens are unique in their type at the level of the record they have within the smart contract; so that the smart contract is unclonable based on the characteristics deposited in the blockchain.
- Decentralization: Non-fungible tokens by relying on distributed blockchain systems on a series of server nodes allows it to be fully decentralized from an outsourced server service that may affect the processes performed therein.
- Interchangeability: The transaction system of the non-fungible tokens allows them to be easily transferable for any transaction made with this type of asset.
- Adaptability: Such a system can be practically adaptable to various uses, such as the relationship with unique digital assets, process identifiers or to provide

identification to physical assets connected to digital systems.

- Non-manipulable: By depositing the information of the non-fungible tokens in a decentralized blockchain, a protection against manipulation of the information is created, since each node deposits the information subscribed in the smart contract once the process is initiated.

In turn, this review process allows us to unveil the proposal formulated by Wang, Li, Wang & Chen (2021), who carried out an analysis based on the STRIDE methodology on the situation of non-fungible token systems, taking as a reference the vulnerability to security threats:

Table 4: STRIDE vulnerability analysis of the Nfts

THREAT	DETECTED PROBLEMS
Spoofing - Authenticity	Exploitation of system vulnerabilities and could test the user's password and gain access to the system.
Tampering - Integrity	Information outside the blockchain can be manipulated.
Repudiation - Non repudiation	The hash data information can be attached with an attacker's information.
Information disclosure - Confidentiality	The buyer's or seller's information may be exposed to possible exploits.
Denial of service - Availability	The asset may lose availability if the asset is deposited outside the blockchain.
Elevation of Privilege - Authorization	Smart contract design issues can negatively affect the properties and benefits of non-fungible tokens.

Applications of non-fungible tokens in various industries

3.4. Video Game Industry

Within the video game industry it is reported that one of the first studies of a scientific nature referring to non-fungible tokens is developed by Abarbanel, & Macey (2019) who make a review of the behavior of the so-called VGO Skins as digital assets. In this case, allusion is made to how companies such as Valve created a group of rewards to players which were based on blockchain to provide them with unique features; creating an ecosystem similar to that of gambling within the industry where some assets were endowed with a special value based on their characteristics, accessibility and the same dynamics of consumers.

show a reward system after completing a series of activities proposed by the game which are represented by non-fungible tokens; this system is integrated through devices based on the IOT (internet of things) and a hybrid architecture between Amazon's NoSQL systems (DynamoDB), Amazon Web Services Lambda and Hyperledger's open blockchain (Manzoor, Samarin, Mason & Ylianttila, 2020). On the other hand, Muthe, Sharma & Sri (2020) present a digital infrastructure based on blockchain; which seeks to be decentralized and not depend on third parties so that developers in the video game industry do not have to depend on a third party that may have access to confidential information and transactions that they develop on such platforms.

Thus, it is considered that the implementation of non-fungible token systems based on blockchain become an important differential factor for companies in the sector, through the use of the various Marketplace platforms where such Nfts are an asset that can generate significant income for developers and thus establish sustainable business models (Choi, et al., 2021). This process is then based on the creation of a group of assets such as collectibles that can acquire different levels of value based on their characteristics and the same dynamics established by the market based on the scarcity system as a focal point.

An example of this is Decentraland (virtual reality platform based on the Ethereum blockchain) where a large number of large-scale transactions have taken place, ranging from pieces of art in the video game, users' collectibles or the same houses and land found within the space of said digital world.

3.5. Automotive sector

The application of non-fungible tokens within the automotive sector is directed towards the use of blockchain-based systems, where assets are registered as Nfts by means of smart contracts, thus seeking to generate decentralized information systems (Valaštín, et al. 2019; Pirker, et al., 2021). The functionalities of the application of smart contracts within the transportation sector effectively allow the development of an effective process of tokenization of assets, so as to improve traceability and security of information and also to reduce intermediation and reduce the costs of such intermediaries.

3.6. Electricity sector

Within the electricity sector, Karandikar, Chakravorty & Ron (2021) show the application of digital assets based on non-fungible tokens for a decentralized system for renewable energy microgeneration transactions. Such a system is based on a blockchain system where there is a tokenization process of the various assets by means of Hyperledger Fabric, which are assigned a unique identifier and information. Similarly, non-fungible tokens are used for those assets that represent only values. The model proposed by the authors within sector allows showing the opportunities of empowering and decentralizing the transactions carried out between the various actors of the generation systems and renewable energy microgeneration transactions Chakravorty & Ron, 2021).

3.7. Manofacturing

Westerkamp, Victor & Küpper (2020) show the functioning of a supply chain which records manufacturing processes as token recipes, which are the set of tokenized goods required to mine a new token or good. Within this system, products are represented as non-fungible tokens that are part of a blockchain, which through smart contracts allows for better clarity and understanding of the goods that are part of the manufacturing process.

On the other hand, the application of a decentralized system based on the Contemporary Cloud Manufacturing-as-a-Service (Contemporary Cloud Manofacturing Service) allows demonstrating the applicability of a blockchain-based architecture that allows decentralizing the manofacturing processes in the cloud; achieving to improve the transparency, provenance and integrity of the information allowing to demonstrate and maintain the possession of the information by the creators through a smart contract (Hasan & Starly, 2020).

3.8. Safety systems

Within the security systems, the application of non fungible tokens is directed towards devices based on the Internet of Things (IOT) because these are those that are interconnected with the network and through the physical unclonable function (PUF) or physical unclonable functions. In this way, a system based on Nfts allows the construction of security infrastructures where through these PUFs are linked to a unique and unclonable record that is part of a blockchain account, so that a link can be established between the asset and its identification that is traceable throughout the useful life of the asset

(Arcenegui, Arjona & Baturone, 2020; Arcenegui, et al., 2021).

3.9. Art

Within the field of art, it can be noted that there are two aspects; the first is directed towards digital art in its various presentations and the second towards physical works (Wang et al., 2021; Vinnari, 2021). In this sense, it is explained that the artwork itself is not the Nfts but the information contained in it is recorded in a smart contract by means of a non fungible token, allowing to check all the characteristics of the asset such as authorship, ownership or the chain that it has passed between different owners (Wang et al., 2021).

The application of non-fungible tokens in digital art has been one of the most discussed points at present, because this brings a lot of benefits to the artist and the consumer of this type of works; because this type of systems allow to protect and expand the scope of intellectual property and also allows that through various characteristics of the Nft the artist can receive recognition for each time that such asset is exchanged; opening opportunities for new business models for artists (Nadini et al., 2021). In turn, there are studies that propose systems in which a combination of non-fungible token systems with quick response codes (QR) is used to integrate this technology with physical art, so that the benefits of Nft, such as the verification of authenticity and provenance, can be enjoyed (Vinnari, 2021).

3.10. Financial systems

The application of non-fungible tokens within financial systems is not different from its application in other environments, as it basically involves the entry of non-fungible assets within the exchange processes that occur within blockchain based systems (Ante, 2021). In this way Nfts are an investment alternative, which although it has existed for a couple of years, it was not until recently that it showed significant growth to thus open the opportunity for both the creators of such assets and those engaged in their exchange to create an enabling space for investment in the medium and long term (Chohan, 2021; Dowling, 2021a; Dowling, 2021b). Some of the examples of assets based on non-fungible tokens that are currently relevant are cryptokitties or cryptopunks; the following graph shows the growth in sales of the latter from January 2021 to June 2021:
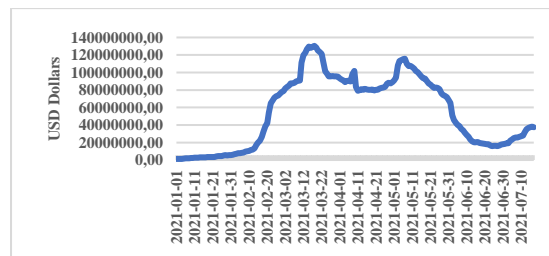

Fig. 6. Sales volume of Cryptopunks in US Dollars

In this way, new platforms have also been expanded and created for the exchange processes of this type of assets, based on the benefits of transparency and decentralization that make this type of assets attractive to generate trust in the parties involved in such transactions (Ozturan, 2020).

3.11. Challenges and opportunities of non-fungible tokens

Once the analysis of the fundamental elements and the sectors of application of non-fungible tokens has been carried out, it is mentioned that they certainly have a great amount of growth opportunities according to their sector of application. In this way, it is possible to visualize that the market for non fungible tokens is becoming increasingly relevant for all those who seek to offer and/or access various systems that are characterized by being decentralized and that provide an important level of transparency and protection of information (Westerkamp, Victor & Küpper, 2020; Karandikar, Chakravorty & Rong, 2021). In turn, within the market of digital transactions of commercial indoles in video games, digital art or any other asset, there has been an important level of recognition; empowering the various parties involved in making a profit from such transactions (Goyal, et al., 2020; Choi et al., 2021). The growth and constant evolution of the digital environment makes it increasingly plausible to give tangible value to what happens within digital spaces such as virtual reality (Dowling, 2021). New markets are opening up for all those who, within the digital world, find a space for both work and social life. However, it must be recognized that such non fungible tokens possess a number of challenges that must be overcome if they are to remain the standard for non-fungible assets within the digital and physical realm:

- In the first instance, it is considered fundamental that such a long-term market proves to be durable and reliable and not just a media boom that resulted in transactions for large sums of money.

- It is essential to align the non-fungible token with the value of the asset it represents, so that it is not just a speculative market based on scarcity and a sense of urgency.
- Next, the various gaps mentioned by several of the authors cited in the review need to be improved so that greater confidence can be generated within the various application sectors.

In turn, it is essential that the growth of nfts goes hand in hand with the implementation of IOT-based assets so that the benefits that can be brought by the entry of information through smart contracts on a blockchain are increasingly closer to the everyday life of human beings.

4. CONCLUSIONS

Once the bibliometric analysis process has been carried out on the search equation developed in the WoS and Scopus databases and the bibliographic review systematized from the proposed filtering and inclusion process, the following final considerations are presented:

In the first instance, the process of bibliometric analysis shows how there has been a significant growth in the research developed in large-scale databases on token networks and the application of blockchain technology in various contexts. However, it should be noted that at the same time it is a branch of knowledge still very young as the first registered studies date back to 2016 so there are not currently a high number of studies on the subject. According to the bibliometric review carried out, it is expected that there will continue to be a growth of related empirical studies. This element constitutes a limitation at the statistical level of the study because, since it is not a large database, the possible predictions or more rigorous statistical processing are limited.

Similarly, it is concluded that studies on this type of technology tend to focus on countries such as the United States, China and India, which are recognized as world leaders in terms of technological innovation, especially from the point of view of information technology. Next, the systematized review allowed the establishment of a rigorous filtering and inclusion process in which a total of 21 studies were taken into consideration for the final review; these could certainly be considered a low number of research studies, which would make the elaboration of clusters for a subsequent documentary analysis difficult. Thus, the documentary analysis is elaborated in the form of a review of the most relevant aspects and is analyzed based on the qualities and characteristics presented in each of the studies.

The systematized review carried out allows to clarify several concepts around non-fungible tokens as a digital asset that is part of a financial ecosystem that is evolving faster and faster, seeking transparency and decentralization of conventional systems; both in financial terms and in computer terms such as servers. Thus, it is concluded that this type of digital asset has an important variety of applications in various sectors, since its power lies in the ability to provide any element with a series of unclonable characteristics that can be verifiable and whose origin can be easily traced. Leveraging blockchain technology opens the door to a myriad of systems based on fungible or non-fungible elements that can provide transparency and control to any process that a programming team can locate (Kakarlapudi, & Mahmoud, 2021).

At this point, it is considered that non-fungible tokens should not only be seen as the new digital asset available to make investments or establish trade, but that it can be applied to various sectors where it can be found useful to its powers; because in these powers lies the real reason for its current recognition and great growth in recent months. In short, it could be said that the value does not lie in the non-fungible token but in what it can represent and how this representation can be traceable and demonstrable (Quirion, 2021).

On the other hand, although research related to non fungible tokens is still scarce, it is possible to observe how studies related to digital assets supported by blockchain technology, both fungible and non-fungible, continue to expand, which allows supporting the growth and consolidation of this type of assets as part of the development of society towards digital environments (Dowling, 2021). Non-fungible tokens are then a great opportunity to further evolve and decentralize the various processes in the digital environment or also for those that are developed as hybrids between the virtual and physical environment; where certainly, the entry of blockchain technology has meant an important change in the way business models are established (Morkunas, Vaschen & Boon, 2019).

5. REFERENCES

Abarbanel, B., & Macey, J. (2019). VGO, NFT, OMG! Commentary on continued developments in skins wagering. Gaming Law Review, 23(1), 23-25.

Ante, L. (2021). The non-fungible token (NFT) market and its relationship with Bitcoin and Ethereum. Available at SSRN 3861106.

Arcenegui, J., Arjona, R., & Baturone, I. (2020). Secure management of IoT devices based on blockchain non-fungible tokens and physical unclonable functions. In International Conference on Applied Cryptography and Network Security (pp. 24-40). Springer, Cham.

Arcenegui, J., Arjona, R., Román, R., & Baturone, I. (2021). Secure Combination of IoT and Blockchain by Physically Binding IoT Devices to Smart Non-Fungible Tokens Using PUFs. Sensors, 21(9), 3119.

Chohan, U. W. (2021). Non-Fungible Tokens: Blockchains, Scarcity, and Value. Critical Blockchain Research Initiative (CBRI) Working Papers.

Choi, S. W., Lee, S. M., Koh, J. E., Kim, H. J., & Kim, J. S. (2021). A Study on the elements of business model innovation of non-fungible token blockchain game: based on'PlayDapp'case, an in-game digital asset distribution platform. Journal of Korea Game Society, 21(2), 123-138.

Dowling, M. (2021a). Fertile LAND: Pricing non-fungible tokens. Finance Research Letters, 102096.

Dowling, M. (2021b). Is non-fungible token pricing driven by cryptocurrencies?. Finance Research Letters, 102097.

Fai, A. (2021). Smart Collectibles: Unlocking The Value of Non-Fungible Tokens (NFTs).

Goyal, S., Sanjith, K., Sisodia, A., Suhaas, N. M., & Akram, S. (2020). Transactions Process in Advanced Applications on Ethereum Blockchain Network. In 2020 International Conference on Recent Trends on Electronics, Information, Communication & Technology (RTEICT) (pp. 275-281). IEEE.

Hasan, M., & Starly, B. (2020). Decentralized cloud manufacturing-as-a-service (CMaaS) platform architecture with configurable digital assets. Journal of Manufacturing Systems, 56, 157-174.

Heryadi, Y., & Trisetyarso, A. (2021). Leverage from Blockchain in Commodity Exchange: Asset-Backed Token with Ethereum Blockchain Network and Smart Contract. In Smart Trends in Computing and Communications: Proceedings of SmartCom 2020 (pp. 301-309). Springer, Singapore.

Karandikar, N., Chakravorty, A., & Rong, C. (2021). Blockchain Based Transaction System with Fungible and Non-Fungible Tokens for a Community-Based Energy Infrastructure. Sensors, 21(11), 3822.

Manzoor, A., Samarin, M., Mason, D., & Ylianttila, M. (2020). Scavenger Hunt: Utilization of Blockchain and IoT for a location-based Game. IEEE Access, 8, 204863-204879.

Muthe, K. B., Sharma, K., & Sri, K. E. N. (2020). A Blockchain Based Decentralized Computing And NFT Infrastructure For Game Networks. In 2020 Second International Conference on Blockchain Computing and Applications (BCCA) (pp. 73-77). IEEE.

Ozturan, C. (2020). Barter Machine: An Autonomous, Distributed Barter Exchange on the Ethereum Blockchain. Ledger, 5.

Pirker, D., Fischer, T., Witschnig, H., & Steger, C. (2021). velink-A Blockchain-based Shared Mobility Platform for Private and Commercial Vehicles utilizing ERC-721 Tokens. In 2021 IEEE 5th International Conference on Cryptography, Security and Privacy (CSP) (pp. 62-67). IEEE.

Valaštín, V., Košt'ál, K., Bencel, R., & Kotuliak, I. (2019, September). Blockchain based car-sharing platform. In 2019 International Symposium ELMAR (pp. 5-8). IEEE.

Vinnari, M. (2021). Potential use cases for non-fungible tokens in combination with physical art.

Wang, Q., Li, R., Wang, Q., & Chen, S. (2021). Non-fungible token (NFT): Overview, evaluation, opportunities and challenges. arXiv preprint arXiv:2105.07447.

Westerkamp, M., Victor, F., & Küpper, A. (2020). Tracing manufacturing processes using blockchain-based token compositions. Digital Communications and Networks, 6(2), 167-176.

Tapscott, D., & Tapscott, A. (2016). The impact of the blockchain goes beyond financial services. Harvard business review, 10(7).

Seebacher, S., & Schüritz, R. (2017, May). Blockchain technology as an enabler of service systems: A structured literature review. In International Conference on Exploring Services Science (pp. 12-23). Springer, Cham.

Pesserl, A. (2021). NFT 2.0: blockchains, mercado fonográfico e distribuição direta de direitos

autorais. Revista Rede de Direito Digital, Intelectual & Sociedade, 1(1), 255-294.

Goel, S., & Mittal, H. (2020). Economic, legal and financial perspectives on cryptocurrencies: a review on cryptocurrency growth, opportunities and future prospects. World Review of Entrepreneurship, Management and Sustainable Development, 16(6), 611-623.

Vassallo, D., Vella, V., & Ellul, J. (2021). Application of gradient boosting algorithms for anti-money laundering in cryptocurrencies. SN Computer Science, 2(3), 1-15.

Zhou, Q., Huang, H., Zheng, Z., & Bian, J. (2020). Solutions to scalability of blockchain: A survey. IEEE Access, 8, 16440-16455.

Kher, R., Terjesen, S., & Liu, C. (2021). Blockchain, Bitcoin, and ICOs: a review and research agenda. Small Business Economics, 56(4), 1699-1720.

Bodkhe, U., Tanwar, S., Parekh, K., Khanpara, P., Tyagi, S., Kumar, N., & Alazab, M. (2020). Blockchain for industry 4.0: A comprehensive review. IEEE Access, 8, 79764-79800.

Fairfield, J. (2021). Tokenized: The Law of Non-Fungible Tokens and Unique Digital Property. Indiana Law Journal, Forthcoming.

Vermibus, V. (2021). Arte urbano, como token no fungible, y patrimonio cultural. PH: Boletín del Instituto Andaluz del Patrimonio Histórico, 29(103), 184-186.

Franceschet, M., Colavizza, G., Finucane, B., Ostachowski, M. L., Scalet, S., Perkins, J., ... & Hernández, S. (2020). Crypto art: A decentralized view. Leonardo, 1-8.

Kupferman, D. W. (2021). Educational Futures and Postdigital Science. Postdigital Science and Education, 1-8.

Baur, D. G., Hong, K., & Lee, A. D. (2018). Bitcoin: Medium of exchange or speculative assets?. Journal of International Financial Markets, Institutions and Money, 54, 177-189.

Baur, D. G., Hong, K., & Lee, A. D. (2018). Bitcoin: Medium of exchange or speculative assets?. Journal of International Financial Markets, Institutions and Money, 54, 177-189.

Nonfungible. (2021). https://nonfungible.com/market/history/cryptopunks

Serada, A., Sihvonen, T., & Harviainen, J. T. (2021). CryptoKitties and the new ludic economy: how blockchain introduces value, ownership, and scarcity in digital gaming. Games and Culture, 16(4), 457-480.

Vanherpe, J., & Janssens, M. C. (2021). Non-Fungible Tokens and Copyright: crypto-buyer beware….

Rae, M. (2021). Analyzing the NFT Mania: Is a JPG Worth Millions?. SAGE Publications: SAGE Business Cases Originals.

Crow, K., & Ostroff, C. (2021). Beeple NFT fetches record-breaking $69 million in Christie's sale. Wall Street Journal.

Raman, R., & Raj, B. E. (2021). The World of NFTs (Non-Fungible Tokens): The Future of Blockchain and Asset Ownership. In Enabling Blockchain Technology for Secure Networking and Communications (pp. 89-108). IGI Global.

Díaz-Jiménez, R. M., Yerga-Míguez, M. D., & Serrato-Calero, M. D. L. M. (2021). Mediación, discapacidad y Trabajo Social: una revisión sistematizada.

George Reyes, C. E., & Avello-Martínez, R. (2021). Alfabetización digital en la educación. Revisión sistemática de la producción científica en SCOPUS.

Kakarlapudi, P. V., & Mahmoud, Q. H. (2021, February). A Systematic Review of Blockchain for Consent Management. In Healthcare (Vol. 9, No. 2, p. 137). Multidisciplinary Digital Publishing Institute.

Nadini, M., Alessandretti, L., Di Giacinto, F., Martino, M., Aiello, L. M., & Baronchelli, A. (2021). Mapping the NFT revolution: market trends, trade networks and visual features. arXiv preprint arXiv:2106.00647.

Quirion, A. (2021). What Is an NFT and Why Should Archivists Pay Attention?. archeota, 11.

Morkunas, V. J., Paschen, J., & Boon, E. (2019). How blockchain technologies impact your business model. Business Horizons, 62(3), 295-306.

Larvalabs. (2021). Cryptopunks 9023. https://www.larvalabs.com/cryptopunks/details/9023

Shahnaz, A., Qamar, U., & Khalid, A. (2019). Using blockchain for electronic health records. IEEE Access, 7, 147782-147795.

Shirole, M., Darisi, M., & Bhirud, S. (2020). Cryptocurrency Token: An Overview. IC-BCT 2019, 133-140.