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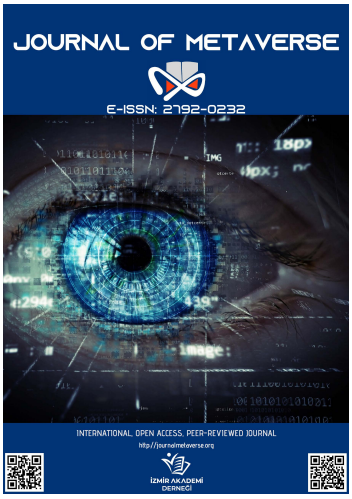

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Metaleisure: Leisure Time Habits to be Changed with Metaverse

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***Abstract*— New habits that will come into our lives with a metaverse will create the concept of Metaleisure. With the introduction of virtual platforms into our lives, the mass of people spending their leisure time on the Internet grew. This group participates in many leisure time activities on virtual platforms, defined as the concept of electronic leisure (e-leisure). The metaverse has taken this electronic participation to a whole different dimension. The metaverse has initiated the process of being involved in leisure time activities in three-dimensional environments through avatars. The purpose of this article was to conceptualize the concept of metaleisure as a new leisure time habit that enters our lives with the metaverse and discuss this theory. This study provides researchers, who conduct studies on metaverse and leisure time, with the characteristics to understand the time frame spent with the metaverse. Leisure time users are an important resource for the metaverse industry. Games, museums, and concerts are the leading examples. E-idle stands out as an important factor pointing to the consumption of leisure time participants in the game industry. The concept of metaleisure will become important for leisure time research as well. In order to understand leisure time behavior, it is necessary to be able to interpret changing habits and technological development. As a result, the concept of metaleisure is defined as leisure time activities that individuals perform in three-dimensional universes through avatars. With the development of wearable technology, the interest of metaleisure participants in this new universe will grow. With the spread of metaleisure, traditional leisure time activities will gradually become retro leisure time activities.**

Keywords*— *Metaverse, metaleisure, leisure, recreation, world of avatars.

I. INTRODUCTION

In order to understand the different leisure time trends that have entered into our lives with the metaverse, it is necessary to first understand the concept of leisure time. We can say that leisure time habits have existed since the time of primitive man. If the first man explored his surroundings after completing the activities he had to do for a living, it means that leisure time also existed in the life of early man. If the written history is to be taken as the starting point, considering that history began with the Sumerians [1], it can be said that the history of leisure time also began with the Sumerians. Poetry and art [2, 3] in the Sumerians corroborates the existence of leisure time habits. Apart from written history, we can relate leisure time habits with the first work of art; From the habits of the first man, Sumerians carving their works of art and poems on stones in ways that could be called primitive, to the million-dollar non-fungible token (NFT) artwork created in the metaverse. From artwork carved on walls to virtual artwork kept in space. It can be said that metaleisure, which we can ascribe beyond spare time, offers a different experience from the habitual leisure time events and activities. The metaverse will bring a new dimension to the traditional recreational activity or event style.

The transformation of leisure time into social activity, being placed in a recreational (also defined as recreational activity [4]) or limited time frame, has made it marketable in the capitalist order as well as feasible for commercial concerns [5]. Leisure time is the time that an individual spares, except for the activities that he has to do to live [6, 7] and the time he spares for work [8], for the activities he does through voluntary participation [9] and taking pleasure [10]. Why would this big time frame not whet the appetite of investors who consider it as a commercial marketing tool via the metaverse? Playing games, taking trips, visiting museums, and going to concerts in the fictional universe will turn into the income channel for companies with commercial concerns, and will lead to a large marketing area. The metaverse, as well as its economic framework, is a synthetic universe that creates new dimensions and spaces for gaming platforms, social and leisure time activities [11]. What whets the industry's appetite is the leisure time habits of individuals and the budget they allocate to it. According to the Gaming in Turkey 2020 report, the main target of the sector, which has reached a revenue of USD $880 million with 36 million players in Turkey, is leisure time users. Questions about the utilitarian and correct use of leisure time may arise at this point. The same question should also apply to the entire time period spent in the metaverse. It should be also mentioned that the game playing period has increased by 30% when compared to last year [12] according to the same report. Games are just one of the metaverse contents. Metaverse users have the opportunity to spend their leisure time in many different areas, such as concerts, museums, and touristic trips.

As well as changing many habits of society, the metaverse will also make radical changes in their leisure time habits. Leisure time researchers should follow-up this process starting from its early stage. Society and Leisure magazine published a special e-leisure issue in 2013. In the article she wrote for this issue, Linda [13] emphasized that leisure time researchers do not do enough research on e-leisure and drew attention to the existence of many leisure-themed subjects, such as watching movies and playing games, in the world of e-leisure. Leisure time activities, reviewed within the scope of

e-leisure, appear in the metaverse by developing in a different dimension. The proliferation of leisure time research in the metaverse, which will become the universe of the avatars, will shed light on the understanding of leisure time behavior and will contribute to this newly developed universe.

The activities in the metaverse, such as the concerts, NFT exhibitions, museums, as well as games (fortine, Pubg, LOL, etc.), that have existed in the metaverse environment for years are mostly leisure time activities. These participations, if not a job or an obligation, stand out as subjects of leisure time research. Being shaped by the technology, the universe of the metaverse promised to us will change our habits and give a different perspective to the concept of leisure time. The one-to-one existence in the fictional universe with an avatar without physical participation is a harbinger of a whole different experience and process. Gamers have already been meeting and interacting with avatars on a fictional plane for years. However, now, there are many more innovations, such as concerts, museums, and business meetings that their avatars will attend, and the anticipation is that life will shift there. Many business meetings and activities have already shifted to the virtual environment with the COVID-19 outbreak. It will also be possible to reflect body language on avatars through the use of wearable technologies. The perception of reality will increase in line with the progress of this technology. At this point, it would be right to ask whether participation via avatars will cause physical inactivity. Moreover, there will be some extra leisure time since the waiting periods and the time spent in transportation for participation in work or leisure time activities will be eliminated. This will raise new research questions, such as “Will the leisure time opportunity, which has increased with the industrial revolution, increase even more with the metaverse?” Future research will shed light on the extra leisure time that will arise with the Metaverse, and the advancement of this leisure time period.

In a world of changing work and life habits, the leisure habits will also change: Just the way our habits of game, movies, etc., have changed as the virtual world has entered our lives, and although the retro leisure trend will always exist, we cannot ignore the fact that, with the introduction of the internet into our lives, some of the audience watch movies over the internet rather than cinemas and theaters. Traditional leisure time activities with physical participation can turn into retro leisure time activities in the world of avatars. The future has focused on the possibility of existing in the metaverse environment, by directly processing thoughts, without the need for physical activity [14]. In other words, it is a process that starts from where we sit at our homes and participate in shopping, examination, and leisure time activities through avatars. Netflix, and its popularity, is the most realistic example of the habits that have changed with e-leisure. Among the traditional leisure time habits, people would go to the cinema or theaters to exhibit some form of physical activity. With virtual platforms, we now enjoy the comfort of watching the movie we want with remotes in our hands from where we sit. In this case, we can say that traditional leisure time activities can turn into retro activities through technology.

With the metaverse and avatars, we will be able to exist in the phenomenon that takes place in many different geographies, such as movies, the game world, and museums, whenever we want. In other words, we will be able to visit Göbekli Tepe with our avatar from where we sit, without making any flight or hotel reservations. Hence, with the metaverse, avatars will substitute the leisure time habits of physical participation. Bodies meeting during a traditional leisure time activity in a movie theater, stadium, or cafe will be replaced by a fictional plane where avatars will come together, meet, and socialize somewhere in that space. The changing leisure time activity habits will accompany many psychological and sociological research questions. It is worth emphasizing the existence of an audience that has already been doing these meetings in many games for years. Research on this population will also shed light on the future.

In this article, the leisure time spent in the metaverse is defined as metaleisure. This is the first academic study made between the leisure workspace and the metaverse. The claim that "the world of the metaverse may lead to a radical change in leisure time habits and perceptions", which is still very new and at an early stage, is at the center of the study. The concept of the metaverse is derived from the words Meta ‘beyond’ and ‘Universe’, and takes its meaning from the mixture of the two. This concept first appeared in Neal Stephenson's book Snow Crash, published in 1992 [15]. The word metaverse was also used as a fictional universe beyond or parallel to the Universe. In fact, the ground is being prepared where this concept will be constructed as an endless series of universes and galaxies. Stephenson's dream of the universe beyond was reworked as Oasis in the movie Ready Player One. People who transition into the parallel and virtual universe using virtual reality (VR) glasses (a device that provides virtual and augmented reality) spend time traveling and fighting with people they have never met in real life, and buy clothes and weapons for the avatar that they have created. Duan et al. [16], who defined the metaverse as the new generation of Internet, where users can interact in three dimensions through avatars, stated that there is a 30-year improvement behind this progress. Microsoft defined the metaverse as a digital environment in which digital representations of people and objects live, and has stated that it is possible to participate in interviews (doctor's examination, meeting, etc.) while sitting at home [17]. Facebook, on the other hand, announced that it would step into the virtual reality world by acquiring the 2014 VR glasses manufacturer, Oculus, for USD $2 billion [18]. It changed its name by giving the name Meta to its parent organization. Interest has increased with the announcement of the metaverse as the future of the Internet by social media giants [19]. Zuckerberg stated that in this fictional universe, it is possible to teleport to where your family is using a hologram, in addition to attending concerts, meeting with celebrities, and many other leisure time activities [20]. In fact, the subject of a holiday advertisement published by Netflix in 2019 was the family meeting in a fictional universe as if it were real [21]. There are also studies claiming that the metaverse “meets our social needs at a lower cost and with higher security” [16]. The Horizon Home and Horizon Work rooms are currently available under the Horizon umbrella, which was declared as the meta universe of the Facebook Meta. Metaleisure activities can be carried out using your avatar to invite your friends' avatars to Horizon Home, or you can attend business meetings where your avatars meet in Horizon Work rooms. Moreover, the gaming world is already accustomed to spaces where avatars meet, play games, and chat. Games such as Fortnite

and Pubg are examples of this. It has been observed that some government structures also show interest in the metaverse. The Seoul Municipality, the capital of South Korea, announced that it opened a Metaverse Office [22] and announced that, taking its place as the first metaverse city, it would offer municipal services over the metaverse. The Mayor of Ankara, the capital of Turkey, Mansur Yavaş, announced on his social media account that Ankara is the test city for the Open Air Cloud Association [23]. Additionally, the Democracy and Progress (DEVA) Party, a political party in Turkey, announced that they bought land in the metaverse and that they will carry out election activities there [24]. No academic studies or commentaries have been conducted regarding the channels where industry and government organizations have already begun to gain profit from their leisure time habits. In the limited available research about the metaverse, it was realized that its connection with leisure time has not been discussed. The new leisure time habits that come with metaverse will become a new field that scientists will try to understand and include in the research process. Currently, many different disciplines related to leisure time in the metaverse, such as tourism, sports, the game world, and creating meta-universes of cities, are waiting to be researched and interpreted.

II. Notion Of Metaleisure

Metaleisure is defined as the leisure time spent in the metaverse, and "meta recreational activities" is defined as the recreational activities participated in. Leisure time activities in the metaverse consist of museum visits, concerts, touristic city tours, games, and similar activities, in which the individual participates in accordance with his/her concept of leisure time. Metaleisure has been categorized under the following three headings:

1. Participation through avatars
2. Spending time on three-dimensional fictional platforms
3. The time spent is not a necessity, but leisure time

The most basic feature that distinguishes the concept of metaleisure from the concept of e-leisure is the one-to-one existence of avatars in the metaverse via the three-dimensional and augmented reality technologies. The emergence of technology with many innovations, such as wearable gloves, vests, and taste buds, will transform the concept of metaleisure into an indispensable part of our lives. Thus, it will enter our lives as a fictional universe where we spend most of our free time, as the technology develops more.

In the Fortnite game, 12.3 million people, all at the same time, watched the concert Travis Scott gave with an avatar that looked exactly like him. The audience participated using their own avatars from their homes or offices in different countries of the world. A frame from Travis Scott's concert is available in Image 1. This concert was planned to be given within the Fortnite game after being postponed due to the pandemic. It can be said that the COVID-19 pandemic process has had an effect on the rapid introduction of metaleisure into our lives and our ability to get used to it. Metaverse is being frequently used as an alternative space to leisure life since COVID-19 [25]. Games played with avatars, such as Fortnite and Pubg, are defined in the same category as games such as backgammon, okey, mancala, and taboo, namely indoor recreational activities [26]. Although our avatars interact with the world in the metaverse, our body is in a closed space. Our mental world being in nature, in a concert, or in a fictional store via the metaverse when our body is indoors may present a different perspective. If we take a look at the definition of indoor and outdoor recreation, indoor recreation is a leisure time activity created by man and is usually done in an unnatural indoor area with a roof [27], while outdoor recreation consists of all kinds of leisure time activities that can be done outdoors or in nature [26]. While playing taboo with our friend at home, we are physically and mentally engaged in indoor recreation. However, in the metaverse, while our avatar is part of an outdoor recreation, our body is on our sofa in the living room. This situation may trigger a recreational perception process that is split into two. In this case, the sense of reality given by the avatar and the proximity of the outdoor recreation activity to the perception of reality come to the forefront. The perceptions of the individual may stand out in such case. If he/she is satisfied and feels as if they are outdoors, it cannot be imposed on him/her otherwise. This will be one of the areas that will be open to changes, or at least discussed in terms of leisure time activities.

Image 1. A frame from the Travis Scott concert

Source: Shot by the researcher on December 29th, 2021, while watching a concert on his official YouTube account.

In the image, an avatar that looks identical to Travis Scott, while he is facing the stage, is seen. The people having fun with their backs turned are the avatars of the people who attended the online concert. Considering that a concert is a leisure time activity, is a concert that is attended using an avatar, sitting at home, any different than a usual concert? Does metaleisure then help to understand the changing leisure time habits? The effort we spend physically going to the concert venue is replaced by sitting at home and waiting for the concert to begin. Dancing and interacting in the concert area will perhaps leave its place to the concerts that our avatars participate in and watch while physically lying down. We will be able to attend the concert and dance via the integration of

wearable vest and glove technologies, meanwhile our avatar will detect and mimic our movements. Although not widespread, this technology is now available. We can say that many big companies also enter this universe. Samsung is one of the companies that announced entering the Decentraland Metaverse through its store known as Samsung 837X. In its statement, Samsung announced that it would express technology in an artistic language, and that it opened a virtual store with a movie theater and DJ performance in Decentraland. Samsung also announced that special collection clothes of its own design would be given to those selected among the visitors of its store who participated in the draw [28]. We will do all of this using our avatars while sitting at home. We will take part in the activity by sitting at home, dancing, and watching the brand's advertisements. This can be interpreted as a theme outside of the traditional mode of activity. This is the exact point that separates the concept of metaleisure from the traditional understanding of leisure time. If Samsung does not open more stores on other platforms, we will only be able to access this store in Decentraland. The existence of many fictional universes raises the question, "Will identities such as Turks, Americans, and Russians be replaced by concepts such as Sandboxers and Decartlanders?" over time. At this point, criticism arises as to whether it will be on different platforms, rather than all humanity uniting in the metaverse on a platform.

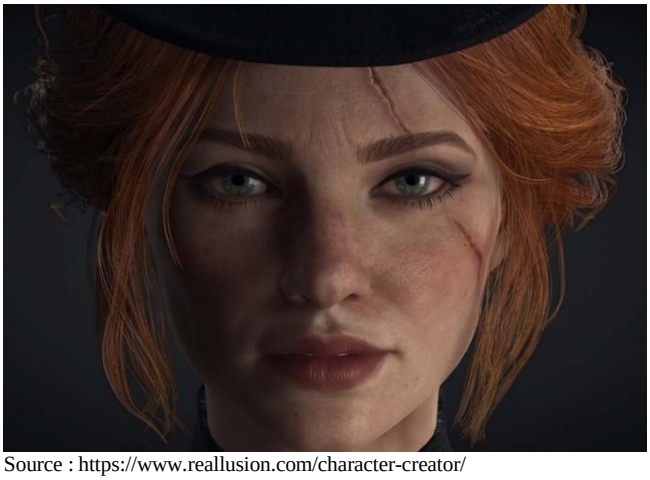
TABLE I. SOME CURRENT LEISURE TIME ACTIVITIES IN THE META UNIVERSE

Metaverse	Leisure Time Activity
Sandbox www.sandbox.game/	Playing games, creating your own game, shaping avatars, and navigating the fictional universe.
Axie Infinity axieinfinity.com/	War game and avatar shaping.
Decentraland decentraland.org/	Being able to participate in events, start the event you want on your own land and earn game currency by digging.
OVR www.ovr.ai/blog/ovr-competition-powered-by-chainlink/	Being able to participate in events (museum, concert, etc.), organize events on your own land and win gifts by walking around the city (if your avatar is a participant on the device and also on the move in the city).
Second Life secondlife.com/	You can do all the free time activities you can do in real life in this virtual world through your avatar.

On platforms such as Sandbox, Decentraland, and OVR, it is possible to buy land, spend time with our friends, open museums on our own land, give concerts or visit concerts and museums with avatars that look like us by uploading our own virtual avatars or photos. Here, we can visit the people or organizations that open stores and be a participant in their activities. In OVR, unlike the other two meta-universes, we can buy plots from the real world map, and explore areas, as in Pokemon Go, by walking and winning gift packages and candy canes. In Table 1, the meta-universes, and the leisure time activities they consist of are classified. In addition to these, there is a game world that has existed in this fictional universe with avatars for years. In games such as Pubg, Fortnite, and Second Life, users are represented by their avatars and buy imaginary items (clothes, weapons, or apparatuses) for these avatars. Keskin and Bayram [29], based on Veblen's Idleness theory, defined individuals who conspicuously consume in the virtual world as e-iddle. The extent of consumption, which will reach a different extent with the metaverse, will result in this concept being scrutinized even more. As this consumption and advertising opportunity attracts the attention of companies, a new market share will emerge in the metaverse. Metaverse marketing, on the other hand, may be one of the areas dominated by leisure time users.

There are many more games and applications in this three-dimensional universe where users can take part using their avatars. It is dreamed of entering this world, where VR glasses and wearable technology are integrated, through implants as well. This is also becoming the subject of movies and TV series. In this world, which will be the planet of the avatars, we can recreate ourselves as we are or as we want to be. Metahuman Creator and Character Creator 3 are groundbreaking with their new avatars, as they produce avatars that resemble real people by reflecting every detail. The metahuman examples of these companies' avatars can be seen in Images 2 and 3.

IMAGE 2. EXAMPLE OF CHARACTER CREATOR 3'S AVATAR



Source : https://www.reallusion.com/character-creator/

IMAGE 3. EXAMPLE OF METAHUMAN CREATOR'S AVATAR.

Source: https://quixel.com/bridge

The metahuman examples of the two companies' avatars above are quite realistic, which will provide a high level of satisfaction during interaction. If we specify these phases as the initial phase, we anticipate a more unpredictable future. Ready Player Me is an area where we can easily produce our avatar. We can create our avatar representation, although it is not as realistic as other examples. In Image 4, the avatar

inspired by my photo can be seen, which was created by Ready Player Me.

IMAGE 4. AN EXAMPLE OF AN AVATAR, INSPIRED BY MY PHOTO, CREATED BY READY PLAYER ME

Source : https://d1a370nemizbjq.cloudfront.net/18b3dd7d-129f-4a61-8dcc-a3895c9f6cf6.glb

Although it does not look very much like me, still it is an avatar that I can prefer for my leisure activities in the metaverse. In metaverses such as Sandbox and OVR, we can create a game-specific avatar. A parallel universe is the subject of the USS Callister episode of the Black Mirror series, which discusses the subject of the metaverse from a futuristic perspective. In the series, holographic images, which are identically the same as real personalities, obtained from DNA samples, are transferred to another fictional universe. This futuristic episode also handles a retro spirit. It opens doors to the retro leisure spirit that are completely different than those that can be experienced in the metaverse. The lead actor is a fan of the 1966 series Star Trek. Being influenced by this sequence, he created a similar metaverse. He brought the holographic images and personalities of his friends into this universe by obtaining the DNA of his colleagues. The metaverse, being the final point of the modern age, can pave the way for us to perform our old games or activities, through our avatars, as a free-time activity. We can say that retro leisure can skip to a different phase with the metaverse. It seems highly likely that we will relive our old street games, childhood games, or games played before us via our avatars or holograms. A mother (Jang Ji-sung) who lost her daughter in 2016 met with her daughter's hologram using virtual reality in 2021 [30]. A technology that took her back to the past and allowed her to spend time with her daughter (the sense of reality is open to question) can also make our old leisure time activities livable again. This will bring a different dimension to retro leisure.

III. METAVERSE MARKETING

Nike acquired RTFKT (pronounced ‘artifact’) Studios, a virtual shoe company making NFTs and sneakers for the metaverse [31]. Adidas stepped into the metaverse world with the companies Bored Ape Yacht Club, PUNKS Comic, and gmoney, and its first NFT works were sold out [32]. This has been the sign that brand perception will exist in the clothes of the avatars. Bourlakis, Papagiannidis, and Li [33] described this new marketing world, where leisure time users will be the main target, as a unique experience opportunity. They emphasized that the consumer prefers not only to consume a product or service, but also to interact with it and experience it in the three-dimensional metaverse.

Metaverse marketing can come to the forefront in two aspects. The first is that brands use this medium as an advertising and promotional tool, and the second is that they sell their products as virtual products in the metaverse. In this case, the cost spent on production and fabric will be replaced by original designs because the products can be owned virtually. Although we cannot deny the existence of the mass in the metaverse, except for leisure users, considering the gaming platforms and their economic values, we can say that the target audience of the market is leisure time users. The NFT market OpenSea, announcing that it reached a value of $13.3 billion [28], provides an idea of the size of the market. Although not very popular yet, stores like Walmart are also in the metaverse. The transition from traditional retailing to e-retailing and then to a new medium, metaverse retailing, offers a different experience [33]. We can interpret metaverse retailing as the avatars of individuals sitting at home, shopping. Although this situation offers an opportunity for a different experience, it can be interpreted as a transformation from a person who goes to the market in traditional ways and is part of a physical activity, to a metahuman who sits at home and shops. The lack of activity, reduced socialization, and increased leisure time will be separate research topics. Turning towards consumption for fear of losing the developments in social platforms, fomsumerism [34], will gain a new aspect with the metaverse. Is this going to turn into the competition of “My avatar is prettier than yours, I'm wearing fancier and brand name clothes”? There are also researchers who have emphasized that, in the face of these new habitats, some individuals are as uneasy as children who are afraid of losing their toys [31]. The look or spectacular appearance of the avatar will introduce us to other users. The effort to reflect oneself as we are or with more features, being the source of fear, will also be the ground for new research topics. Leisure time, which is our main subject, is at the center of all these concerns and developments.

A. E-IDLE: WORLD OF AVATARS

According to a popular joke in Turkey, Nasrettin Hodja is invited to a dinner party, which he goes to in his old clothes and is not respected. Then, he goes home and puts on his new clothes. When he goes to the dinner party again, they show Nasrettin Hodja respect. Hodja dips his fur coat into the food and says, “This reputation is yours, eat my fur coat, eat” [35]. A lesson can be drawn from this myth that it is the inner beauty that matters, but not the clothes of a person. With the metaverse, is it going to be the turn of the avatars to eat instead of the fur coats? The metaverse, which will be represented by avatars, will turn into an avatarverse; thus, the universe of avatars. The era of avatars and the virtual clothing brands the avatars are wearing will begin. The money spent on virtual clothing in current games [36] is proof of this. This consumption may also evolve in a pretentious way.

Veblen used the term leisure idleness for conspicuous consumption [37]. Based on Veblen's theory, Keskin and Bayram [29] defined people who buy virtual products to show off in the metaverses, such as PubG and Second Life, as e-idle.

This definition, referring to the conspicuous consumption of leisure time users, explains that the main target of the metaverse is leisure time users. In a different study on purchasing behaviors with online players, Marder et al. [36] defined 2 themes and 7 sub-aspects: Hedonistic Motivations (innovation, aesthetics, self-satisfaction, and character dedication) and Social Motivation (gift, social distinction, and visual authority). The user's self-satisfaction, aesthetic appearance of the avatar, and the effort to establish authority with its image are among the remarkable details in this study, which explains the reason for the behavior of individuals who buy virtual products. The metaverse will be another platform with pretentious consumption for the avatars.

IV. Discussion and Result

This study comprises pioneering work that reveals the leisure time habits that will change with the metaverse and the three-dimensional world of avatars replacing physical leisure time participation. The aim of the article was to conceptualize metaleisure in terms of leisure time participants. In the study, it was attempted to define the changing leisure time perception in the metaverse for leisure time researchers. Moreover, it was also intended to provide the necessary information for scientists doing research on the metaverse to understand and recognize leisure time users. Additionally, the findings that demonstrated that the leisure time habits are at the center of this new fictional universe were shared. In this study, which was based on the metaverse literature with limited research, the metaleisure participants were defined as individuals who participate in any leisure time activity in three-dimensional fictional universes through their avatars or holograms. In case the concept is used in different languages, it is recommended to translate it into the relevant language as metaleisure, keeping it consistent with the original. In addition to complying with the spirit of metaverse, which will unite people from different cultures and geographies, it is also important in terms of concept integrity in international literature.

We do not know whether leisure time habits with physical participation will be completely replaced by avatars, as only time will tell. However, many metaleisure activities are currently done in the metaverse via avatars. From a futuristic point of view, we can state that the physical participation of leisure time will be a field of study of Retro Leisure in the future. Metaleisure, also expressing the radical changes in leisure time habits, points to a phenomenon beyond the usual leisure time behaviors. It can be stated that especially the new generation will adapt and turn it into a means of self-expression. It is anticipated that the traditional leisure time consumer, who meets his friends in a cafe and gets prepared for this, will be replaced by people meeting through their avatars in a cafe in the metaverse. It is not necessary to be in the same city for this. Concerns such as getting into areas that would be a sign of social status and dressing our avatars in virtual clothes with brand names will be new research topics. Moreover, worries such as missing the bus that will take us to the meeting place will be replaced by buying more technological devices or the latest version products.

Some leisure-related concepts, such as digital leisure time and e-idle, have been discussed by researchers in the literature. Digital leisure time can be used as an umbrella concept, including metaleisure and e-leisure. However, it should not be forgotten that there will be differences between the leisure time spent in the metaverse and the e-leisure time spent over the internet. Based on Veblen's Idleness theory, the concept of e-idle, which refers to leisure time users who consume conspicuously on virtual platforms, is a concept that also covers leisure time users who consume conspicuous consumption in the metaverse. There will be individuals who care about the appearance of avatars and come out as part of conspicuous consumption. Furthermore, some negative effects due to inactivity and being a leisure participant by staying indoors may also arise. As well as this, some other factors will arise, such as the decrease in appearance concerns, the disappearance of the concept of distance, and the absence of long preparation processes for participation in an activity. The positive aspects that may reflect as gains in terms of socialization and all of the benefits of the new universe will pave the way for new research topics.

Metaleisure is not just a concept that only researchers will be involved in. It also needs to be examined as a concept that the industry, marketers, and spatial and clothing designers will also concentrate on. Investigation of the reasons for the participation of leisure time participants will guide the whole sector. Researching many subjects, such as the consumption habits of metaleisure participants, the places they will enjoy being a part of, and the designs of these spaces, will reveal the tendencies of the target audience. The results will also guide the industry. Consequently, this research emphasized that revealing the concept of metaleisure is important both for researchers and the industry. Some suggestions for further research include: a) multidimensional research of leisure time activity areas in different metaverses, b) revealing leisure time experience using avatars, c) the place of leisure time participants in the market, and d) the positive and negative achievements of metaleisure participants.

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Applying Digital Twins in Metaverse: User Interface, Security and Privacy Challenges

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***Abstract*— Digital Twins (DTs) are a conventional and well known concept, proposed in 70s, that are popular in a broad spectrum of sciences, industry innovations, and consortium alliances. However, in the last few years, the growth of digital assets and online communications has attracted attention to DTs as highly accurate twins of physical objects. Metaverse, as a digital world, is a concept proposed in 1992 and has also become a popular paradigm and hot topic in public where DTs can play critical roles. This study first presents definitions, applications, and general challenges of DT and Metaverse. It then offers a three-layer architecture linking the physical world to the Metaverse through a user interface. Further, it investigates the security and privacy challenges of using DTs in Metaverse. Finally, a conclusion, including possible solutions for mentioned challenges and future works, will be provided.**

Keywords*— *Metaverse, Blockchain, Digital Twins, Digital World, Non- fungible Token, Real and Digital World Interface.

I. INTRODUCTION

Recently, the rapid growth of the internet and digital communications has increased the popularity of digital home based and remote jobs. Consequently, and also as a result of increased internet-based communications, hackers and malicious users are motivated to commit fraud against regular users [1]. Therefore, the demand for security and privacy on the internet has increased in the last two decades.

Visual effects in internet-based communication have made them more attractive and efficient. Online shops and virtual meetings allow people to do their outdoor businesses in their homes efficiently, fast, and with lower expenses [2]. Designing user-friendly and easy-to-use services attracts customers. Therefore, service providers try to improve their services to provide better visual effects and user-friendly designs.

High-level and accurate simulation create natural feelings for users and greatly assists technology [3], and enables designers to predict future effects of products and prevent possible risks. Digital twins (DTs) provide the most realistic simulation of physical objects in a way that they can accurately indicate and predict all the physical output of the computer [4]. Highly accurate DTs greatly help the industry and protect physical objects (for more details, refer to Section II-D).

Creating DTs has been a state-of-the-art field of science and technology for many years (and will be in the future).

Metaverse, as a concept proposed in 1992, has become a popular blockchain-based concept/technology in public after renaming Facebook to Meta (for more detail about blockchain and Metaverse, refer to Sections II-A and II-C and [5], [6], [7], [8]). However, it has many regulatory, security, and privacy gaps that should be solved. It is believed that applying DT designing ideas in Metaverse can create natural/actual fillings in Metaverse-based digital things for users and make Metaverse more attractive and user-friendly. Virtual Reality (VR) headsets and Augmented Reality (AR) are two well-known instruments and technologies linking users to the digital world [9]. In addition to VR and AR, Artificial Intelligence (AI) and Machine Learning (ML) are two fields of science and technology that greatly develop Metaverse and virtual spaces [10].

A. Contribution

This paper consists of some parts as below:

- *Review:* This study presents a review of the Metaverse and related concepts.
- *Contribution:* This study presents a three-layer architecture containing a user interface layer for linking the physical world to the digital one (Metaverse).
- *Discussion:* As the digital world can be approximately equivalent to the physical world, it is believed that DTs can play critical roles in Metaverse. Therefore, this study discusses the security and privacy challenges of applying DTs in the Metaverse.

Possible solutions and future works: This study presents possible solutions for some of the discussed challenges and suggests future works in this field.

B. Outline

The rest of the paper is organized as follows: Section II presents the definitions, applications, and general challenges of preliminaries concepts. Section III offers the architecture of combining DTs with Metaverse. Section IV, as the paper's most important section, discusses the security and privacy aspects of applying DTs in Metaverse. Finally, Section V concludes this study and presents some possible solutions and future works.

II. Definitions, Applications, and General Challenges of Preliminaries

In this section, the paper's preliminaries general definitions, applications, and challenges are presented.

A. Blockchain

Blockchain was practically proposed by an anonymous author named S. Nakamoto as Bitcoin infrastructure [5]. Blockchain technology is a distributed computer-based ledger that provides immutability, transparency, and autonomy [6]. The blockchain structure is illustrated in Fig. 1.

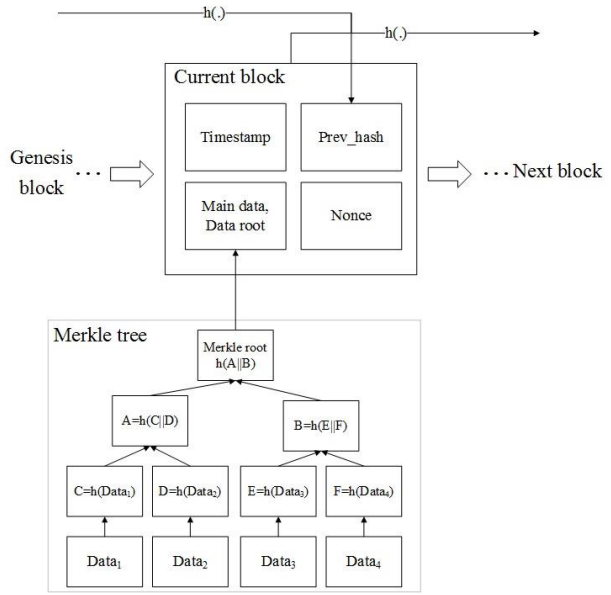

FIG. 1. THE BLOCKCHAIN STRUCTURE [5], [6]

As shown in Fig. 1, blockchain's blocks consist of four main blocks of Timestamp (current block's generating time), Prev hash (previous block's hash), Nonce, Main data as the recorded in the current block, and Data root as the calculated Merkle tree root [11] related to the main data.

1) *Application:* In the first few years, blockchain technology was used as infrastructure for cryptocurrencies (especially Bitcoin). More recently, it has been applied in financial transactions infrastructure and as a tool in money-laundry by criminals (the idea of private cryptocurrencies was not meant to assist criminals. Unfortunately, however, private cryptocurrencies are a popular tool among them). However, blockchain is a well-known technology with numerous applications in industry, science, and state-of-the-art research [12] and has also attracted governments.

   Blockchain applications are not limited to financial transactions, and blockchain technology can be applied as infrastructure for i) storage, ii) users are not trusted, iii) transparency, iv) immutability, v) peer-to-peer connection, and vi) accessibility. Fields that require these properties include digital healthcare records, insurance, smart grids, internet of things (IoT) and industrial IoT, reporting, rewarding, payment, and reputation systems.

2) *General Challenges:* Although blockchain technology is well-known and popular, it comes with significant challenges, including scalability, security, energy and cost, latency and complexity, and regulation and government. Some of these challenges have been solved, and others have various solutions. However, no specific universal scheme exists for all.

B. Non-fungible Token

The concept of the non-fungible token (NFT) first arose from the Ethereum token standard in 2017 [13]. It was proposed to distinguish between submitted tokens by distinguishable signatures. The NFTs are transacted as valuable digital assets on public blockchains (e.g., Ethereum blockchain). The uniqueness of NFTs enables them to link themselves to particular identities or digital assets. Additionally, this feature was considered for decentralized applications (DApp). The process of generating NFT is concisely illustrated in Fig. 2.

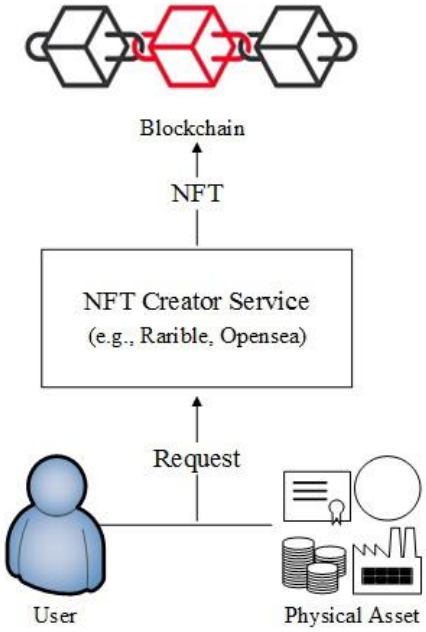

FIG. 2. NON-FUNGIBLE TOKEN DIAGRAM

Using NFTs as distributed ownership documents is the best choice for digital things' proof of ownership (e.g., digital vehicles, lands, markets, movies, houses, etc) in the Metaverse.

1) *Application:* The first application of NFTs was linking them to artworks, and music albums [14]. Recently, NFTs have attracted the attention of investors in digital fields so that they are investing massive values in this field. As a new and hot topic in the investigation, NFTs are used to transfer digital lands in Metaverse (Metaverse will be described in Section II-C), where Decentraland and Sandbox projects are the most famous.

2) *General Challenges*: As digital assets, NFTs have various challenges [15]. Although uncertainty in prices is the most significant, other challenges exist, including proof of uniqueness, buyer and seller security, regulatory issues, cyberattacks, evaluation, and money-laundering.

C. Metaverse

Assume a computer-based or virtual environment where one can find all physical things, services, friends and family, buildings, world map, and the Universe there. Metaverse,

defined in 1992, consists of the two phrases of Meta and Universe, which provides a 3D virtual world that tries to present an approximately equal simulation of the physical world [16]. Several newly-established companies (e.g., Decentraland, Sandbox, Upland, etc) and many famous active companies in information technology (Facebook or Meta, Microsoft, Google, Samsung, etc) focus on Metaverse, and they try to release their Metaverses as new services.

In 2021, Duan et al. proposed a general three-layer architecture for Metaverse [17]. In this proposed general model of Metaverse, the Interaction layer links the Ecosystem and Infrastructure. Based on the proposed architecture by Duan, the mentioned seven layers of Metaverse are summarized in the three phases below:

a) *Infrastructure:* Fundamental and physical requirements, including blockchain, network, and computational powers, are established in this layer.

b) *Interaction:* This layer connects the Ecosystem and Infrastructure layers, and the contents of Metaverse are created in this layer.

c) *Ecosystem:* It is the parallel digital world or Metaverse. This layer involves user-generated content, economics, and AI.

As shown in Fig. 3, Metaverse architecture is defined in seven main layers [16], [18] (these seven layers could be assumed as the equal architecture, with more details, of the three above layers). These layers are described in the following.

1. *Experience:* This is the closest layer to users in the physical world, where it could be assumed equal to the application layer in network architectures.

2. *Discovery:* This layer is driven by creators and service providers for motivating and informing users/communities. This layer consists of the required information, including related content, live streams, advertising emails and messages, and notifications, which are broadcast/informed by the creators' marketing departments.

3. *Creator:* Creators, who power the previous layer, are present in this layer. They design, create and develop their applications for end-users.

4. *Spatial Computing:* This layer supports a hybrid form of computation that reduces the boundaries between the physical and the digital worlds. This layer can be assumed the backbone of the creator layer, consisting of 3D engines (for showing geometry and animation), mapping and Interpreting, spatial mapping, integration of data from sensors, and user interfaces.

5. *Decentralization:* Distributed computing is the essential primary in Metaverse, which provides a flexible ecosystem for developers and reliability for users. Blockchain technology plays a critical role in this layer as the essential component that supports decentralized infrastructure and is responsible for queries.

6. *Human Interface:* Physical-to-digital and digital-to-physical translators are present in this layer to make sense of the digital world and create a natural feel for users based on the digital world. In addition to AR and VR, smart glasses, 3D printers/scanners, biosensors, and perhaps even customer neural could be physical-to-digital and digital-to-physical translators.

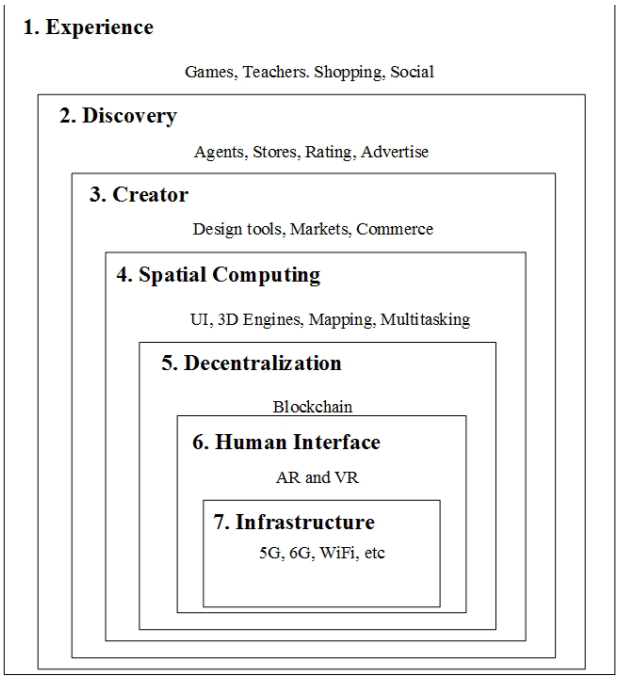

FIG. 3. METAVERSE ARCHITECTURE AND MAIN LAYERS [16], [18]

7. *Infrastructure:* This layer, named the Internet layer, allows users and their devices to connect to the digital world. Even though 6G further improves speeds, 4G, 5G, and WiFi are famous examples of this layer, and Web 3.0 is the best choice for Metaverse.

1) Application: Based on the definition of Metaverse its applications are easy to guess. All daily needs are digitally supported since it is the DT of the same physical world. Additionally, users can also have real senses if they have VR and AR instruments [18]. Therefore, users can resolve their daily needs on Metaverse.

High-level Metaverse applications include military applications (on access to Tactical Augmented Reality (TAR)), real estate applications (on access to VR), manufacturing applications, education applications (on access to VR headset), travel, shopping, virtual meetings, and conferences.

Practical examples of Metaverse applications include film producers showing their film trailers in Metaverse, fashion show companies providing their showplaces in Metaverse, online markets selling their products online supporting real senses, holdings setting commercial meetings, and game producers presenting their creations on Metaverse.

2) General Challenges: As with traditional social networks, Metaverse has several challenges [18]. However, decentralized architecture, where no authority nor regulations prevail, comes with more challenges (more descriptions for the following challenges are not provided, and challenges are only reviewed in this section since they are approximately similar to those

mentioned in Section IV, and you can find them there with detailed descriptions).

Examples of Metaverse challenges are issues with reputations and identities, data security, money-laundering, currency (cryptocurrency) security and payments, regulation, judgment, legality, ownership proof (e.g., of data, NFT, DT, etc), global time, misbehaving detection, and usefulness for criminals.

D. Digital Twin

DT is a virtual model of a process, product, or service proposed by NASA in 1970. Based on the input data, DTs provide process prediction and risk prevention in the physical world [4]. These two main achievements enable managers to have well-organized plans for maintaining their products from possible risks and present better information about them to customers. Therefore, managers and customers have accurate details of the products to get the highest efficiency and adoption. As shown in Figs. 4 and 5, DTs are generated/simulated by computers, 3D scanners, and developers based on the original physical objects.

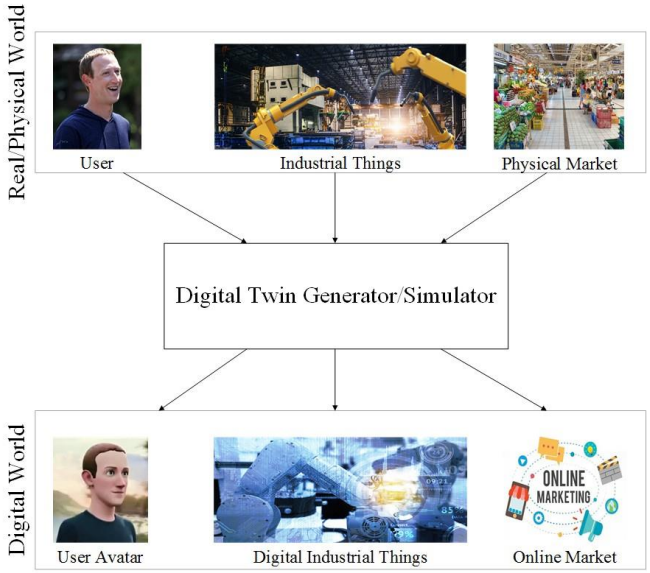

FIG. 4. THE CONNECTION BETWEEN PHYSICAL AND DIGITAL OBJECTS

As an example and for more clarification, for generating the digital twins of the real world, six steps, including i) 2D paper (map), ii) 2D Digital map, iii) 3D Digital map, iv) High definition (HD) live map, v) Indoor city, and vi) Digital twin of the real world, should be passed.

1) *Application:* Developers and researchers try to create more accurate DT as they have numerous applications in the industry, science, and academic research [20]. DTs enable operators to predict the future condition of instruments and prevent possible risks. Additionally, DTs show the effect of real things (products) and simulate their behavior in different environments so that the company owners are at no risk (e.g., physical and financial). DTs empower smart vehicles, electronic healthcare systems, IoT, IIoT, and Industry 4.0 to improve their output and efficiency (it should be noted that DTs' applications are not limited to the mentioned items).7

In practice, DT applications in science and technology reduce production time and help in preparing the final products, retail market modeling for getting more customers, climate prediction, and many fields in business.

2) *General Challenges:* As DT challenges [4], [21], [22] are a critical part of this paper, they will now be itemized in the following:

- Data analytic challenges within the field of machine and deep learning
- IoT and IIoT challenges
- Interoperability (composability, scalability, heterogeneity)
- Security (integrity, confidentiality, availability)
- Dependability (reliability, maintainability, availability, safety)
- Sustainability (adaptability, resilience, reconfigurability, efficiency)
- Reliability (robustness, predictability, maintainability)
- Predictability (accuracy, compositionality)
- Signal processing related challenges
- Latency in real-time communication
- Large computations, data volume, data generation rate, variety of data, veracity of data, and fast archival retrieval
- Data management
- Ethical, legal, and societal issues
- Blockchain adoption

III. THE COMBINATION OF DIGITAL TWINS AND METAVERSE

This section suggests a three-layer architecture indicating the relationship between DTs and Metaverse, empowered by blockchain technology supporting a Metaverse interface. Assumed blockchain-based NFT is equal to DT has various benefits [19] (Fig. 5 clarifies this relation). The benefits of using DTs in Metaverse are listed in the following.

- Immutability and transparency for DTs transactions: Based on the above assumption, immutability and transparency are provided in the DTs transactions, including buying, selling, or ownership transfer. It, therefore, can be said that they are protected against cyber-frauds.
- Automation: Blockchain supports autonomy so that no authority or privileged insider can interfere in DTs results. As a result, Metaverse-based DTs results are reliable.
- DTs identity and legitimacy: Based on decentralized management in Metaverse, all allowed identities, especially of DT, are legal since they all are accepted under a consensus protocol.

- Security and reliability: Blockchain solves some security challenges (not all). Therefore, Metaverse-based DTs are more secure and reliable than their centralized counterparts.
- High accuracy tracking for DTs globally: Blockchain properties, including linking blocks, transparency, and immutability, provide global traceability for DTs and the related correspondences.
- Safeguarding product lifecycle: As with the previous item, each Metaverse-based DT and its linked realworld product lifecycle are easily controllable.
- Peer-to-peer communications: P2P communication in Metaverse guarantees direct machine-to-user or user-to-machine communication using DTs with no intermediary.
- Access privileges and trusted DTs data coordination: Blockchain, as Metaverse infrastructure, provides accessibility to DTs data, which is easy to manage for the company coordinators.
- Enforcing transparency and accountability for DTs data: Transparency is one of the most popular blockchain features and user-friendly properties in Metaverse. Additionally, accountability can alleviate regulatory issues for DT legitimacy and usage.
- Decentralized Infrastructure: Metaverse provides decentralized infrastructure for DTs where all blockchain properties are supported. Therefore, applying DTs in Metaverse is a good and reliable choice.

Fig. 5 outlines the suggested three-layer architecture of generating and applying DTs in Metaverse. In the following, three layers and workflows of the architecture are described.

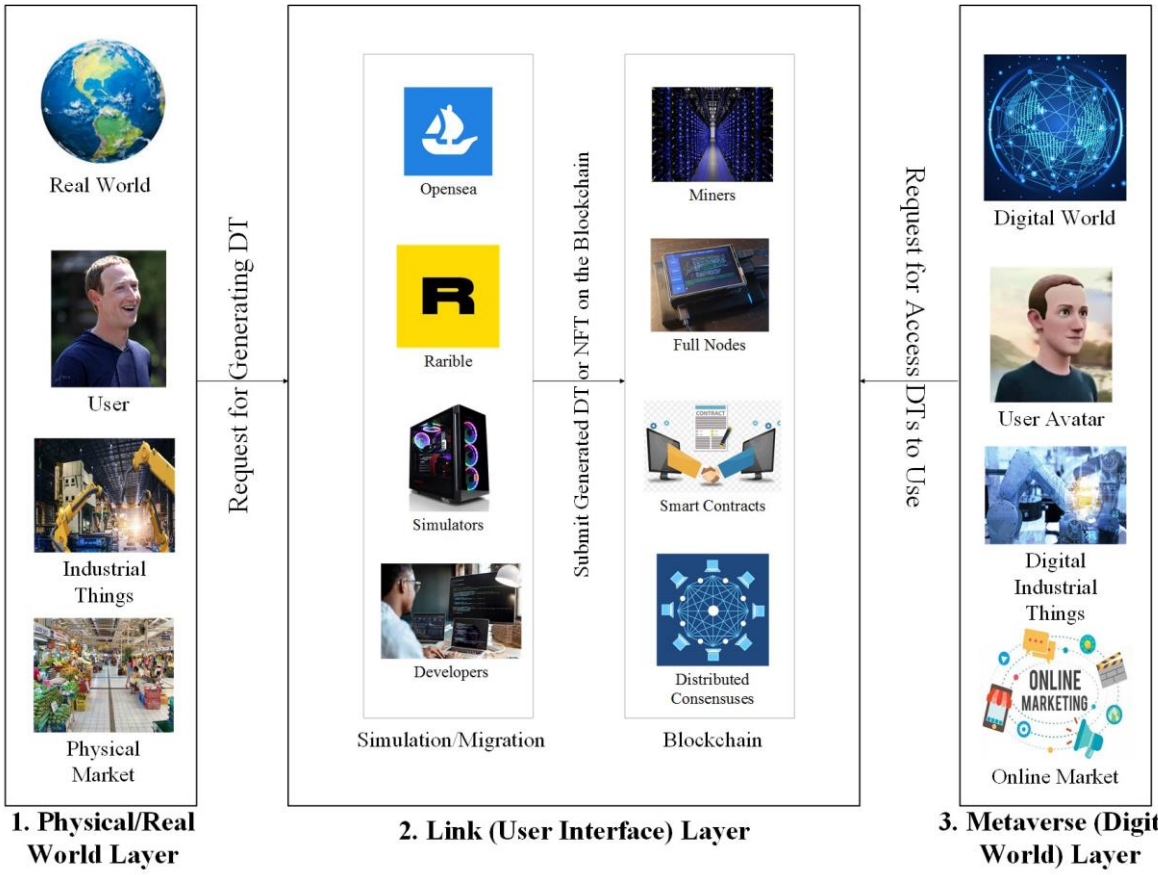

FIG. 5. THE THREE-LAYER ARCHITECTURE OF CONNECTION BETWEEN PHYSICAL WORLD AND METAVERSE WITH THE APPROACH OF APPLYING DTS IN METAVERSE

A. Physical/Real World Layer

Real-world users and components demand highly-accurate DTs of themselves in Metaverse. As mentioned, DTs are the best choice for this demand.

As the name shows, the physical/real world layer contains users, things, and services (market places, healthcare centers, shops, entertainment, etc) in the physical world. For connecting to the digital world (called Metaverse in this paper), users and company owners send their requests to the link layer and pay fees.

DTs can be designed as a wide world, and the biggest DT is the DT of the world. Popular or the most applicable DTs are industrial and business DTs. Additionally, people also like to have highly-accurate avatars in Metaverse. It, therefore, motivates people to use DTs in Metaverse.

B. Link (User Interface) Layer

It is suggested that the most critical layer of the architecture is the one that links the physical world to Metaverse. It consists of the two following sublayers.

1) *Simulation/Migration:* It is the first sublayer of the Link layer, where NFT generator services (e.g., Opensea, Rarible, etc) are present. In addition, computers (e.g., 3D scanners, etc) and developers (e.g., programmers) work there to create digital versions of physical things (digital twins (DTs)).

   Programmers and developers try to create highly-accurate, fully detailed DTs for presenting natural feelings in Metaverse for realworld users. Therefore, expert developers, large companies, and powerful computers are in this layer and compete to attract more clients.

   After generating the DT, the service/user that created it submits the developed DT to the blockchain and pays for it.

2) *Blockchain:* Submitted data, especially DTs, are ready to use after submission on the blockchain, and DApps and other services have access to them (it should be noted that the submission process is out of the scope of this paper for more details on this topic, refer to [5], [6]).

   Blockchain is assumed as the Metaverse infrastructure where miners, smart contracts, blockchain nodes, full nodes, and other components exist. Blockchain, as a distributed ledger, records all Metaverse correspondences and transactions. People (in the physical world) and users (in Metaverse) have access to the blockchain and can submit new transactions or content, and are also able to read and use the submitted content.

C. Metaverse (Digital World) Layer

The most attractive layer of the suggested architecture provides a 3D digital world (Metaverse). DTs are used in this layer by relying on blockchain and smart contracts. As with the physical world, all people, services, and things could be present in the Metaverse layer as DT or NFT, and they can enjoy the digital environment or resolve their problems.

The DT-based digital world provides everything, including people's avatars, businesses, retail markets, and manufactories with all high-accuracy industrial things, satisfying daily requirements of regular people and managers cost-efficiently, remotely, and digitally.

Note: In [17], a three-layer architecture of Metaverse, with a different approach, was presented by Duan et al.. It should be said that the proposed three-layer architecture in [17] focuses on a general model of Metaverse. However, the three-layer architecture proposed in this study involves the Link layer with the aspect of applying DTs in Metaverse, not a general model.

IV. Security and Privacy Challenges

This section first discusses the security aspects of using DTs in Metaverse. It then describes privacy issues (it should be highlighted/repeated that the original definitions of the addressed security and privacy issues are not presented here; they are defined with the aspect of using DTs in Metaverse).

A. Security

Data security is generally defined as Confidentiality, Integrity, and Availability of Data (CIA) [23], [24]. The three main aspects of security and some other security properties will now be discussed below.

1) Confidentiality: As in the physical world, people want to have secure and confidential transactions/correspondence. Confidentiality, as the security feature requested by users, should therefore be supportable as an optional feature based on users' demands. Similarly, confidentiality in Metaverse is better as an optional or mandatory feature for users who requested to use DTs.

2) Integrity: Submitted data, especially DTs, should not be changed along the submission process and after the submission. Used DTs should be the same DTs that have been created/submitted previously with no changes since DT details are critical to them, and many damages may occur after each change.

3) Availability: Users (in the real or digital world) demand that their DTs be available or accessible at all times and places. Moreover, company owners or service providers do not want to be out of service. These facts indicate that availability is a critical feature demanded by all types of users presented in the digital world where DTs play essential roles.

4) Authentication: From the past to the present, people/users have wanted to know their opposite parties completely or authenticate their validity. This is also true in Metaverse where the people/users in the digital world want to ensure the Metaverse-based services and the validity of used DTs. Therefore, mechanisms should be provided for proving the DT validity.

5) Central Management: Decentralization is a popular and essential feature of the Metaverse. However, there is one person or a centralized group of authority on the background of most Metaverse-based services who manage users and components (e.g., DTs) in Metaverse. Therefore, providing Metaverse-based services with no central authority is a critical challenge.

6) Identity Management: As with currently-in-use social networks, Metaverse can be a suitable infrastructure for criminals and users who misbehave. Therefore, identity management, including registration, revoking, and updating is a challenge in Metaverse (it should be noted that the phrase identity is not assigned only to users. However, it is assumed as the digital identity of DTs, NFTs, or other digital entities).

   Submitting high-accuracy DTs, updating the submitted DTs, and revoking invalid DTs (DTs management) are important issues in Metaverse.

7) Duplication Data: Uniqueness is a valuable feature expected from the DTs. Copies or fake versions of DTs can be mistaken as the same valuable DTs. This issue (duplicating DTs to fake versions) is a challenge for DTs owners and can decrease value and validity of their DTs. Therefore, mechanisms should be provided to prevent DT duplication in Metaverses.

8) Cyber Attack: Although blockchain technology provides some security features (e.g., security against DoS and DDoS attacks, immutability, etc) for its applications, cyber-attacks are implementable on DTs in Metaverse. Protecting against common attacks is a primary necessity for DTs and the digital world.

B. Privacy

Data security is generally defined as Confidentiality, Integrity, and Availability of Data (CIA) [23], [24]. The three main aspects of security and some other security properties will now be discussed below.

Privacy is a feature requested by people/users in the physical/digital world(s). However, privacy is not a bounded feature, and its bounds are determined based on users' demands and conditions [25], [26]. In the following, some privacy issues are described regarding using DTs in Metaverse.

1) Users Privacy: Users want to be safe and have privacy in both the physical and digital worlds. As mentioned above, privacy has no certain bounds. This paper, however, assumes anonymity and untraceability as two aspects of privacy. Anonymity refers to having secure pseudonyms, and untraceability is when no one can find links between users' activities. Users who use DTs in Metaverse demand this feature for safety.

2) Trust: Validity, authentication, and mutual authentication are necessary to create trust in users. However, providing them in a decentralized environment where no trusted third party or judgment mechanism is present is challenging. In other words, it is hard or almost to provide trust by untrusted parties. Therefore, users who use DTs in Metaverse need to have a logical trade-off, based on themselves tastes, between faith in untrusted parties and their privacy.

3) Assets Ownership Proof and Security: Based on the value of DT and their applications, hackers and criminals want to steal their ownership. There must, therefore, be a reliable and secure mechanism to prove their ownership publicly provable, and no one can forge that.

4) Ownership Transferring: As with the discussed privacy factors, transferring the ownership of DTs needs the support of security and privacy aspects (e.g., confidentiality, anonymity, untraceability, etc) based on user demands.

5) Money-laundering: Transactions related to buying/selling DTs on Metaverse could be examples of money-laundering if privacy for users and confidentiality for financial transactions are provided.

6) Conditional Privacy and Government Monitoring: Conditional privacy is a prominent feature for governments and authorities who want to control communities. It means they, as authorities or judges, can break users' privacy. It is, however, computationally hard for invalid users (e.g., adversaries, malicious users, or hackers). In this case, privacy refers to DTs ownership, correspondences, and financial transactions related to them.

V. Conclusion and Future Works

This study first presented definitions of concepts, including blockchain, NFT, Metaverse, and DT. It then suggested and described a three-layer architecture that indicated the application of DTs in Metaverse. Finally, it discussed the security and privacy challenges of using DTs in Metaverse as the paper's most important section.

In the following, some possible solutions for solving the discussed challenges and future work of research in this field will be described.

- Using blockchain-based security protocols supporting conditional privacy: As with the real world and internet-based communication, users in the digital world or people in the Metaverse request privacy. However, privacy provides suitable environments for criminals, and users do not want that. Therefore, for controlling malicious users, conditional privacy [27] is a critical feature for Metavese-based services to prevent fraud and insecurity.

- Using blockchain-based payment methods with no central authority: The existence of a central authority is against the distributed implementation of Metaverse-based services. Therefore, for providing reliability in distributed payment systems, it is suggested to specialize payment methods with no central authority [28] for Metaverse.

- Using blockchain-based data auditing protocols: Regarding the value of DTs, protecting DTs' integrity in the digital world is a critical issue. So, using blockchain-based data auditing protocols [29], specialized for Metaverse, for proving DTs integrity and preventing DTs duplication (uniqueness proof) is suggested.

- Applying blockchain-based reporting protocols: Similar to the real world, malicious users exist in the Metaverse. It, therefore, is suggested to use blockchain-based reporting protocols [30] in the Metaverse for detecting malicious users easier.

- Applying zero-knowledge based cryptocurrencies: As aforementioned, privacy is a user-demanded feature in the Metaverse. Therefore, for users who buy/sell DTs and NFTs, applying zero-knowledge-

based cryptocurrencies [31] for providing anonymity and untraceability is suggested.

- Using blockchain-based anonymous authentication protocol: All users want to authenticate the validity of their environments users along with anonymity [32]. Therefore, to provide mutual authentication in related-to-DTs' transactions and users' privacy, it is suggested to use blockchain-based anonymous authentication protocols in the Metaverse.
- Assigning rewards to users who help with the network maintenance: The users who help with network maintenance should be motivated, and using methods assigning rewards to users [33] empower users' motivation for maintaining the network and increase network reliability.

It is clear that the discussed concepts, services, and technologies, including blockchain, NFT, Metaverse, and DT, are beyond the scope of this paper. Therefore, several fields remain for future studies and are not limited to the above items.

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From physical reality to the Metaverse: a Multilayer Network Valuation

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***Abstract*— The physical reality can be partially mapped with network theory, showing the edging links between connected nodes, and their spatial and intertemporal dynamic interaction. The Internet is a network of networks representing a global system of interconnected computer networks. The metaverse is a network of 3D virtual worlds focused on social connection. There is so an evident Ariadne's thread between these ecosystems, interpreted with multilayer network theory that examines the connectivity and interdependency between nodes positioned in the physical world, the web, or the metaverse.**

This pioneering study illustrates a new research avenue, analyzing the application of some of the most evident properties of network theory to the case, showing for instance how replica nodes can link through an avatar the physical world with the metaverse. A valuation methodology of the metaverse ecosystems will be proposed, using a with-and-without approach or multilayer network metrics.

Keywords*— *Avatar, MetaEconomics, connectivity, digital platform, scale-free network, scalability.

I. Introduction

The three-step supply and value chain patterns from the physical world to the metaverse pass through the Internet and follow a technological upgrade whose eventual outcome is still uncertain. In the future, the metaverse [1; 2; 3] is likely to fully incorporate the earlier-stage Internet dimension.

This study starts from the evidence that physical reality can be partially mapped with network theory, showing the edging links between connected nodes, and their spatial and intertemporal dynamic interaction. The Internet is a network of networks representing a global system of interconnected computer networks. The metaverse is a network of 3D virtual worlds focused on social connection. There is so an evident Ariadne's thread between these ecosystems, interpreted with multilayer network theory that examines the connectivity and interdependency between nodes positioned in the physical world, the web, or the metaverse.

The metaverse is an Internet evolution that is oriented towards shared activities (mainly through social networking) with an exponential rise in creativeness, unleashed by a decentralized ecosystem, and integrated technologies.

This innovative study investigates a new research field, analyzing the application of some of the most evident properties of network theory to the case.

Consistently with this framework, *the main research question of this paper is to investigate the potential market value of metaverse ecosystems, using a with-and-without approach or multilayer network metrics.*

II. Scale-Free Networks and the Metaverse Topology

Network theory [4; 5; 6; 7; 8], is the study of graphs as a representation of either symmetric or asymmetric relations between discrete objects.

The World Wide Web is a network whose nodes are documents, and the links are the uniform resource locators (URLs) that allow to "surf" with a click from one web document to the other [4].

A scale-free network is a decentralized network whose degree distribution follows a power law and is characterized by the presence of large hubs (pivoting nodes). Decentralization is consistent with the web, blockchains, and the metaverse.

A scale-free network looks like the air-traffic network, whose nodes are airports and links are the direct flights between them.

Scale-free networks have a very heterogeneous distribution of degrees, and their dynamical behavior is dominated by the hub nodes having a degree order of magnitude larger than the average.

The topology of the metaverse influences its dynamics, workings, and wealth distribution. According to [9], the metaverse, consistently with the Internet, is more like a scale-free network than to a "hub and spoke" architecture, where every network node connects to a central authority that is responsible for controlling access and managing any of the exchanges.

In scale-free networks (e.g., the Internet, open-source software, smart contract blockchains, etc.), the central node acts more like a facilitator than an authority, and where nodes are then free to connect.

III. Scalability and the Network Effect

Scalability indicates the ability of a process, network, or system to handle a growing amount of work. Scalability fosters economic marginality, especially in intangible-driven businesses – such as the Internet or the metaverse – where variable costs are typically negligible. Massive volumes may offset low margins, producing economic gains. Digitalization is defined as the concept of "going paperless", the technical

process of transforming analog information or physical products into digital form. Digital scalability operates in a web context, where networked agents interact to generate co-created value.

Economic and financial margins that represent a primary parameter for valuation are boosted by cost savings and scalable increases of expected revenues. Digitalized intangibles synergistically interact through networked platforms that reshape traditional supply chains. Link (edge) overlaps and replica nodes foster these synergies.

Table I. synthesizes the main properties of the network laws [10].

TABLE I. – NETWORK VALUE

Scalability law	formula	Features / properties
Sarnoff's law	Network Value=n	The value of a network seemed to increase in direct proportion to the size of the network - proportional to *N*, where *N* is the total number of users on the network.
Metcalfe's law	Network Value=n^2	Network value increases exponentially with an increasing number of devices on the network
Reed's law	Network Value=2^n	Network value increases even more than Metcalfe's as subgroups (social networks; messaging apps, etc.) become easier to form. Reed's law is consistent with multilayer network extensions.
Beckström's law		The value of a network equals the net value added to each user's transactions conducted through that network, summed over all users. This model values the network by looking from the edge of the network at all of the transactions conducted and the value added to each. It states that one way to contemplate the value the network adds to each transaction is to imagine the network being shut off and what the additional transactions costs or loss would be.
Radoff's law	[qualitative proposition]	The degree to which a network facilitates interconnections determines the extent of its emergent creativity, innovation, and wealth.
Metaverse extension		3D dimension, increased networking, technological upgrade, etc. improve scalability and so value

Reed's Law is often mentioned when explaining the competitive dynamics of internet platforms. As the law states that a network becomes more valuable when people can easily form subgroups to collaborate, while this value increases exponentially with the number of connections, a business platform that reaches enough members can generate network effects that dominate the overall economics of the system.

Other analysts of network value functions [11] have argued that both Reed's Law and Metcalfe's Law overstate network value because they fail to account for the restrictive impact of human cognitive limits on network formation.

IV. MULTILAYER NETWORKS

Multilayer networks are networks with multiple kinds of relations with multiplex or multidimensional configurations [12]. In a multiplex network, the same set of nodes is connected via more than one type of link, enhancing scalability.

The world is more complex than conventional economic models traditionally assume. Many real-world complex systems are accordingly best modeled by multiplex (multidimensional) networks of interacting layers [13]. These interconnected systems are very sophisticated and may explain better the applications in the field of social network analysis, economics, operations management, finance, etc., being consistent with corporate governance concerns.

Multilayer networks are an extension of the traditional networks and are fully consistent with the framing and research aim of this study. Multilayer networks are intrinsically fit for leveraging the scalability features already examined, since they host bridging (replica) nodes, digital networks, or firms that are simultaneously present in several layers. These properties have deep, albeit non investigated, governance consequences.

Complex multidimensional networks host multiple kinds of relations (multiplex, multilayer, multilevel, multi-relational, interconnected, interdependent, etc.), and may yield valuable insight in many interdisciplinary fields. These networks of networks may affect social networks that involve different types of connections, networks of airports connected by different air carriers, multiple infrastructures of a country that are mutually connected, etc.

Nodes that simultaneously belong to different layers (networks) can be represented mathematically by adjacency tensors with inter-layer edges that connect each network to the other. These links enhance the overall value of the network of networks, boosting Metcalfe's formulation.

Whereas the sophisticated mathematics that explains these relations [12] goes far beyond this preliminary study, some economic implications may be worth considering.

A multilayer network - of which multiplex and interdependent networks are peculiar cases - is a network made up of multiple layers, each of which represents a given operation mode, social circle, or temporal instance.

Multilayer networks show connectivity links between the nodes of each layer that bring interdependency links.

A key feature of any network is represented by its dynamic properties: a network is hardly ever static, and this is never the case on the Internet- metaverse dimension. Many networks expand and grow by increasing their number of nodes and links over time. examples include the Internet and social online networks this evidence is described by non-equilibrium dynamics important information can be gained by studying non-equilibrium models of growing networks that show scale-free properties that can emerge from simple dynamical rules of network growth.

Dynamical processes include:

a. Percolation (the behavior of a network when nodes or links are added);

b. Diffusion/propagation; (the ability to amplify association between nodes that lie in network proximity).

c. Spreading processes on complex networks, showing the transmission probability within and outside a network.

The interplay between the "random versus orderly" structure and the dynamics of multilayer networks contributes to explaining their essential features.

Relevant information from multilayer network data sets cannot be found by considering networks in isolation. Connectedness allows for the possibility of diffusing information and hyper-navigating the network. A further characteristic is represented by communicability - the number of paths that connect the node to the rest of the nodes within the network.

Precious informative sets are represented by big data that are gathered in cloud databases. The digital nature of data softens interoperability concerns, easing information dissemination and exploitation.

This contributes to explaining why interconnected (multilayer) networks are worth more than isolated networks. The implications for metaverse networks that are ontologically connected are evident, albeit hardly investigated.

A further feature is represented by navigability - the possibility of exploring large parts of the network by following its paths through connectedness. This concept can be associated with supply chains and shows which are the iterative patterns from the real world to the metaverse, passing through the internet.

V. Multilayer networks

A metaverse is a network of 3D virtual worlds focused on social connection; a set of virtual spaces where an individual can create and explore with other people who are not in the same physical space.

The term "metaverse" has its origins in the 1992 science fiction novel Snow Crash as a portmanteau of "meta" (in Greek μετα = beyond) + "universe".

The metaverse building features are represented by:

- Social media
- Online gaming
- Digital identity/avatar
- Decentralization/blockchains
- Cryptocurrencies
- Virtual reality
- Augmented reality
- Creator economy (value co-creation patterns)

Complex and interdependent technologies are the core constituents of the metaverse ecosystems:

- Multilayer networks
- Digital platforms
- Interactive technologies
- 5G/6G
- Computer vision
- IoT / robotics
- 3D print
- Distributed computing / Blockchains
- Distributed storage
- Quantum computing
- Cloud/edge computing
- Hardware infrastructure
- Artificial intelligence

VI. Synchronizing the Physical and Virtual: The Avatar Bridging Node

In computing, an avatar is a graphical representation of a user or the user's character or persona. It may take either a two-dimensional form as an icon in Internet forums and other online communities (where it is also known as a profile picture) or a three-dimensional form, as in games or virtual worlds. Another use of the avatar has emerged with the widespread use of social media platforms. There is a practice in social media sites: uploading avatars in place of the real profile image.

Avatars – a sort of virtual second life – can be considered the main bridging node connecting the real world to the metaverse (through the web).

Even if avatars are traditionally linked to "light" applications (e.g., video games or social entertainment), they are increasingly used in more significant practices. For instance, digital twins are used in medicine. A digital twin is a digital representation of real-world entities — an object, system, or process — that is synchronized with the real world.

Even if the original node in the real world (represented by a physical person) is different from Her digital avatar, they may tentatively be considered, as a necessary simplification in this study, substantially coincident.

Thanks to augmented (and virtual) reality, an avatar can be identified, copied, measured, increasing Her value, if compared to the original.

According to [14], "In Multiplex Networks a set of agents might interact in different ways, i.e., through different means. Since a subset of agents is present at the same time in different networks of interactions (layers), these layers become interconnected". These agents are represented, in our case, by bridging avatars and other players (digital platforms, etc.).

VII. A Holistic Ecosystem: From physical reality to the Internet and the Metaverse

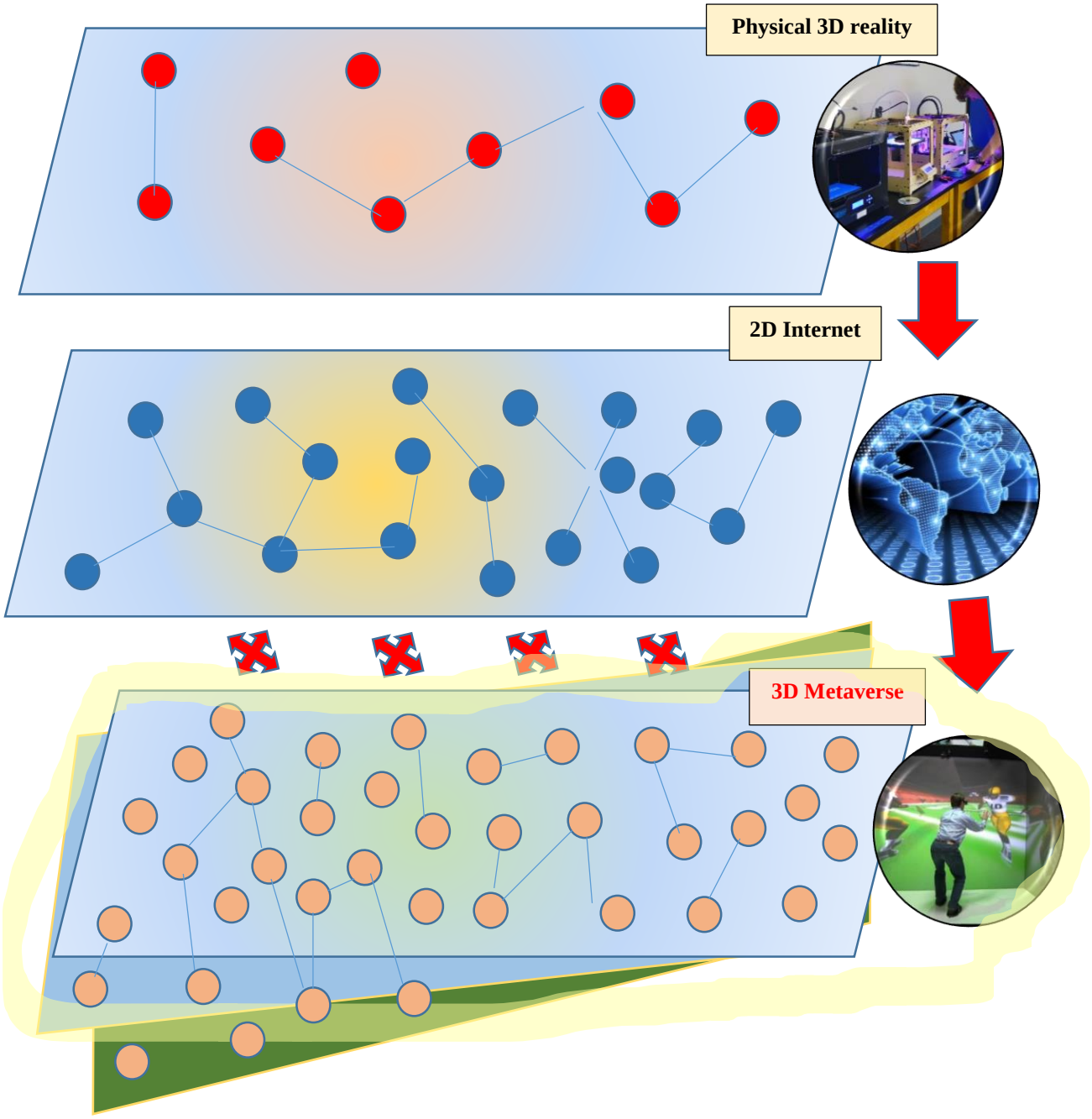
The metaverse and the physical world interact in both directions, generating value-enhancing synergies.

According to [15], "MetaEnterprises and MetaCities can be regarded as the mapping of real enterprises and cities in the virtual cyberspace. They are virtual enterprises and cities running parallel to real enterprises and cities, which can realize the description of real enterprises and cities. Corresponding to the human, material, organizations, scenarios, and other elements in real enterprises and cities, there are various virtual elements such as virtual human, virtual objects, virtual organizations, and virtual scenarios in MetaEnterprises and MetaCities. These virtual elements in MetaEnterprises and MetaCities can be used to analyze and evaluate the decision-making scenarios with computational experiments approach so as to realize the prediction of real enterprises and cities. Through the interaction and feedback

between MetaEnterprises/MetaCities and real enterprises/cities, we can realize the prescription of decision-making in real enterprises and cities, so as to effectively improve the efficiency and effect of various decisions in real enterprises and cities".

The three-step pattern from the physical reality to the metaverse can be illustrated in Figure I.

FIGURE. I. - FROM PHYSICAL REALITY TO THE INTERNET AND THE METAVERSE



Any consideration about the potential market value of the metaverse would be considered as science fiction since the underlying concept is uneasy to define and impossible to measure.

An estimate of the value of the metaverse is, however, important because investors need market traction to drive their efforts, envisaging potential returns out of their expenditures.

The metaverses are spaces where you can not only admire places, monuments, and works of art but also conclude business. The metaverses represent worlds in which commercial exchanges are becoming increasingly important together with the market value of the companies that produce supporting technology. According to a Bloomberg Intelligence report, the market value of companies operating in metaverses is expected to reach $ 800 billion by the middle of this decade and $ 2.5 trillion by 2030.

Inside the metaverse, on the other hand, commercial exchanges take place on two floors. On the one hand, there is the presence of shops that act as a showcase and traditional e-commerce [16], while allowing a more immersive experience in which the customer chooses a product that exists in the real world and pays for it with fiat currency. At the same time, in the metaverse, there are properties, goods, and other values

that are represented by NFTs or, more precisely, they are NFTs whose exchanges take place through digital currencies.

The metaverse, through the interactions between avatars, makes possible strategies of value co-creation in which the single virtual nodes actively participate in this creation, receiving remuneration in tokens/cryptocurrencies that are usually lacking in many traditional business models. Even the feedback on the Internet (such as, for example, the reviews on Tripadvisor) does not involve any direct remuneration for the user, who for her part provides valuable big data that feeds increasingly advanced profiled marketing strategies. With the metaverse, there is a customer-centric qualitative leap, which places the user at the center of value co-creation and sharing of new value.

The currency of the metaverse is currently represented by controversial cryptocurrencies, linked to blockchain technologies potentially harbingers of tax evasion and money laundering. The boundaries and exchanges between fiat money and cryptocurrencies are still confused, although full convertibility could, in perspective, represent an important milestone in the convergence of segregated ecosystems.

The value of the metaverse can be direct, if it concerns this integrated ecosystem (declined, as it has been shown, in many interrelated dimensions), or transferred to the real world and the Internet, which expand the range of goods and services exchanged, also in terms of usability, generating a differential / incremental surplus value.

The new paradigms of value co-creation rely, in many cases, on social networks and behavioral models inspired by the sharing economy, facilitated by the plasticity and resilience of the digital and virtual world.

The growing sensitivity towards development paths inspired by sustainability and ESG metrics must be confronted, first, with the energy-intensive trends of blockchains.

In the logic of the metaverse, the experiential experience and the contents shared between the virtual players will assume preponderant contents in the co-creation of shared value. In perspective, the content will be able to count more than the technological infrastructure, destined to become a commodity (this trend is already visible in the world of digital media).

Metaverse business models fuel value creation and monetization strategies. A summary is shown in Table II.

TABLE II. - THE METAVERSE: BUSINESS MODELS AND VALUE CREATION

Business model	Value leverage and monetization strategies
3D clothing e-commerce	Presentation of the product in the metaverse with offline delivery to the customer. Sale of virtual products (see the "Gucci Garden Experience" event on the Roblox platform for all).
Metaverse platforms	Sale of cryptocurrency that can be spent on the platform, advertising agreements, license agreements, and royalties on the sales of products on the platform.
Real Estate	Sale of "finished" properties and both virtual plots of land. The user, in turn, can monetize the investment through renting and other forms of management. Sale of professional services (architecture, design, etc.) necessary or useful for the construction of the virtual property. Sale of waste materials following the demolition of virtual properties.
NFT	Direct or auction-based sale of unique "computer codes" linked to digital-only works or digital representations of physical works with or without transfer of the relative copyright.
Digital / profiled advertising	Sale of experiential marketing services in which the customer can experiment with a product and submit indications for its further development.
Gaming	Sale of the cryptocurrency needed to purchase the characters and accessories to participate in the game. Play-to-earn model that awards rewards to users based on their participation in the game. These rewards are in cryptocurrency that users reinvest in the game itself, guaranteeing liquidity to the system. Sale of game characters in the form of NFT.
Immersive experiences	Sale of the devices necessary to take advantage of the gaming experience or participation in virtual events (3D viewers, headphones, gloves, etc.).

The pioneering investments in the metaverse are based on prospects of economic returns in the medium-long term, which in turn depend on the revenue model incorporated in the business models and disruptive strategies, with a highly innovative and discontinuous scope. These investments are made above all by Big Tech (starting with FAANG - Facebook, Amazon, Apple, Netflix, and Google), intent on creating new lifestyles and entertainment, in the hope that they will become market standards, guaranteeing promoters the role of first movers and standard settlers, from which oligopolistic rents can derive (where barriers to entry are created for new competitors).

Consistently with the methodology of this study, the potential value of each metaverse ecosystem may be tentatively appraised with complementary approaches that are based on the mentioned monetization strategies:

1. With-and-without approach (comparing a hypothetical value with or without the metaverse, so showing its incremental/differential contribution in value creation);
2. Mathematical modeling consistent with multilayer networks;
3. Network effect laws.

The with-and-without methodology is traditionally used in the evaluation of intangibles and is so consistent with the intrinsic features of the metaverse. For instance, the International Valuation Standard (IVS) 210 considers this method within the income approach methods (§ 60.5).

The incremental (marginal) value of an added network, represented in this case by a metaverse ecosystem, can be economically appraised by the with-and-without approach,

and mathematically evaluated using (multilayer) network theory. The Network Effect Laws illustrated in section III. are complementary to these approaches.

To the author's best knowledge, this joint approach has never been used in network valuation.

Every network can be expressed mathematically in the form of an adjacency matrix. In these matrices, the rows and columns are assigned to the nodes in the network and the presence of an edge is symbolized by a numerical value.

The matrix representation is fully consistent with:

a) The with-and-without approach (each "with" is represented by the introduction of a new node and edging link; "without" represents node absence, deletion, or isolation);

b) Network effect laws that are enhanced by new nodes and edges;

c) Multilayer networks, where interconnections are mapped with adjacency matrices.

The with-and-without approach is also consistent with the differential analysis (confrontation) between networks without and then with interlinks (that depend on avatars or other linking nodes or edges). Digital links are intrinsically flexible and favor immediate linkings through the web or the metaverse.

VIII. Metaverse Evaluation with Multilayer Network Analysis

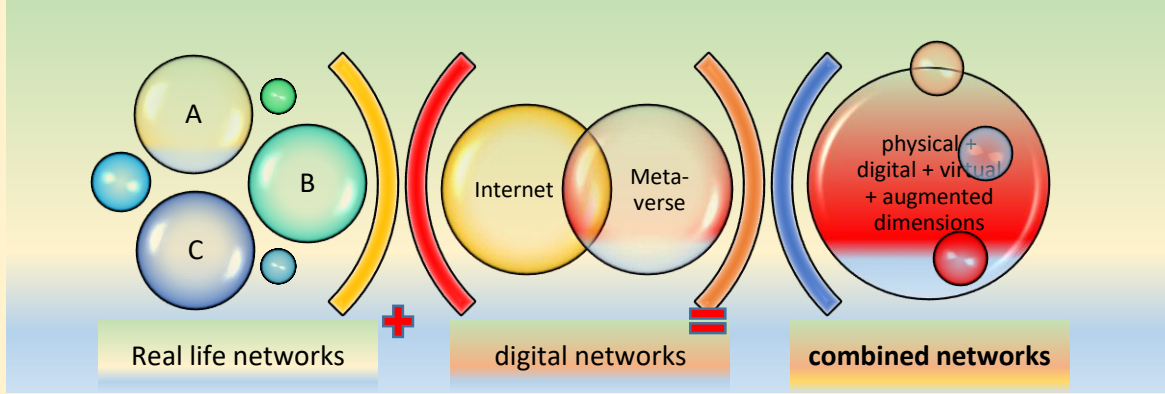
Metaverse evaluation is still a frontier research issue. Each single metaverse ecosystem, ideally corresponding to a closed network (with well-defined boundaries) may be evaluated, even in economic terms, considering it as a static single entity. This is just the first step for appraisal that needs to be complemented (and complicated) introducing dynamic interactions, and interrelations with other networks (both within and outside the metaverse).

Interrelations (exemplified in figure II) incorporate economic synergies, for instance, if a node (individual) in the physical world is complemented by her avatar in the metaverse – their joint value, albeit difficult to assess, is certainly higher than their straightforward sum.

Porous borders make networks intrinsically unstable and more difficult to appraise, but also increasingly valuable.

Scalability is a further feature that encompasses the physical world – internet – metaverse value chain, as shown in Figure II.

Figure II. – Network Interrelations, From The Real-Life To The Metaverse



Multilayer network analysis is a powerful tool for the evaluation of a metaverse (considering every single layer-finite ecosystem, wherever possible).

The mathematical properties of the network and its multilayer extensions preside over the evaluation patterns that should conveniently consider:

a) The architecture of the metaverse network (scale-free, etc.);

b) The number of its nodes and edges;

c) The intensity of the edging relationships;

d) The hyperlink with other (multilayer) networks (real life, internet, other metaverses);

e) The dynamic evolution of both the networks and their interactions.

The monetization of the edging relationships within and outside the metaverse stands out as the final valuation target.

IX. Discussion

The paper's research question is to investigate the potential market value of metaverse ecosystems, using a with-and-without approach or multilayer network metrics. The metaverse can be roughly interpreted as a digital (virtual/augmented) social network, confirming its consistency with network theory – by now a well-established discipline, albeit still underexploited in its economic applications.

Network theory, with its multilayer extensions, is well suited to represent a cornerstone in the interpretation of the evolutionary path from real-life to the metaverse. This explanation is also consistent with the attempt to give a rough estimate of the potential economic value of metaverse layers.

The metaverse can be roughly interpreted as a digital (virtual/augmented) social network, confirming its consistency with network theory – by now a well-established discipline, albeit still underexplored in its economic applications.

The segregation of the metaverse from the real-life and the bridging internet is far from representing a real threat in this still pioneering phase, even if it may represent a critical issue in the future. Node or edging deletion is the primary cause of isolation, a state of the world that typically destroys value (erasing the synergies between the real-life and the metaverse). This occurrence is well known in network theory [17] and should be carefully examined, to anticipate and possibly fix unwanted consequences (e.g., digital identity theft, when the avatar is detached from the originating individual). In most networks, some nodes are likely to disappear. As long as the network continues to grow, its scale-free nature can persist [4].

X. Conclusion

This preliminary study considers the value chain relationship that starts from real-life networks and arrives at metaverse networks, passing through the internet (that, sooner or later, is expected to "merge" with the metaverse).

These findings are consistent with the following definition: "The Metaverse is the post-reality universe, a perpetual and persistent multiuser environment merging physical reality with digital virtuality. It is based on the convergence of technologies that enable multisensory interactions with virtual environments, digital objects, and people such as virtual reality (VR) and augmented reality (AR). Hence, the Metaverse is an interconnected web of social, networked immersive environments in persistent multiuser platforms" [18].

As most complex ecosystems are composed of interacting elements, networks are ubiquitous and are linked among themselves through replica nodes. Multi-slice networks describe time-dependent interactions that represent an intrinsic feature of naturally evolving temporal social networks. Metaverse interactions are continuously updated in real-time, being consistent with this dynamic framework that instantaneously incorporates socio-pattern data.

Networks are a powerful common denominator of all these states of the real or digital world, so representing a clue for joint interpretation. Since these networks operate on different layers, multilayer networking applications need to be considered. While the investigation area is fascinating, the evaluation issues are complicated by several factors, starting from the novelty of still unstable metaverses, up to the mathematical intricacies of multilayer networks.

Adjacency matrices represent a powerful tool to estimate the potential value of each metaverse subset, being consistent with the with-and-without approach, the network effect laws, and the multilayer network interpretation.

Further scrutiny is needed for a more comprehensive dynamic evaluation that inspires and justifies the huge investments that Big Techs are pouring into the metaverse.

A better comprehension of the mathematical and appraisal properties of these extended networks, from the real-life to the metaverse, can ease the understanding of value co-creation patterns, systemic failures, and shock resilience (even to targeted cyber-attacks), improving the overall efficiency, to the benefit of all the real and virtual stakeholders.

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Human-Centric Functional Modeling and the Metaverse

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***Abstract*— Human-Centric Functional Modeling represents systems in terms of functional state spaces defined through analogy with the functional state space hypothesized to be occupied by human cognition. These functional state spaces are hypothesized to define a complete representation of the human meaning of the system being modeled, and therefore are hypothesized to define the first complete semantic model of any given system, or of information itself. One potential use of functional state spaces is to represent the physical world or any virtual world. This paper explores the barriers to and implications of using Human-Centric Functional Modeling to define a functional state space as a semantic model of any real or imaginary world, and explores how those barriers and implications impact upcoming applications such as the metaverse proposed by the company formerly known as Facebook, as well as others.**

Keywords*— *Human-Centric Functional Modeling, functional state space, General Collective Intelligence, metaverse.

I. Introduction

In the study of logic, a discipline within philosophy, there is an established tradition of using semantic models for representing information such as scientific theories [1]. The philosopher Bas C. van Fraassen has been attributed credit [2] for the concept of the "state space" as a semantic modelling approach, and a number of researchers citing his work have taken the concept of "state spaces" and applied them to all of science in general, including to physics and to modeling the physical world [3]. A state space is the set of all possible configurations of a system [5] and state spaces are useful abstractions for reasoning about the behavior of a given system that are now widely used. The difference between this paper and those previous works appears to be that this paper has made the additional refinement of using the human system, particularly the cognitive system, as a basis for this state space modeling approach, so that these models could be understood intuitively by first person introspective observation (by looking "inwards" to understand the human system, and by understanding the external world in comparison to this system), which removes the need to understand any logical frameworks at all. Hence the name "Human-Centric Functional Modeling" or HCFM.

Human-Centric Functional Modeling or HCFM [4], [8] describes systems as having a set of potentially human-observable functions fi through which the system might transition from one state "a" to another state "b", or in other words fi(a) = b [6]. Each state is then defined in terms of which functions are available to transition to other states. These states described in terms of functions are referred to as "functional states", each of which might be composed of other functional states. All of the functions of a system within a given domain of behavior map between functional states belonging to the same category, or in other words, for all "a" and "b" in the functional state space, both a and b belong to the same category. Any given category of functional states then forms a "space" of functional states or a functional state space.

As an example, in the cognitive system each concept is a functional state. Concepts as functional states might consist of larger concepts and therefore larger functional states. Reasoning processes function to transition the cognitive system from one concept (one functional state) to another. The cognitive system can then be represented as navigating a space of concepts connected by reasoning processes which act as functions that enable the cognitive system to transition from one concept to another. This representation of cognition as moving through a "conceptual space" has been used to define a model of artificial cognition (Artificial General Intelligence or AGI [7]).

In the theory of dynamical systems, the state space of a discrete system defined by a function f can be modeled as a directed graph where each possible state of the dynamical system is represented by a vertex with a directed edge from a to b if and only if f(a) = b [6]. In network terminology the functional state space of cognition is represented by a directed graph containing a network of nodes each representing a functional state (concept), where those functional states are connected by edges representing the reasoning processes through which the cognitive system might transition from one functional state (one concept) to another. HCFM utilizes this open network to make it possible to represent every possible concept and every possible reasoning process connecting each concept. If the graph of the functional state space of the cognitive system (the conceptual space) represents the complete human meaning of each concept and each reasoning process, it is therefore a complete semantic model.

II. Modeling the Physical World or Virtual Representations

The physical world or even the entire physical universe can also potentially be represented as a functional state space [9], as can other systems such as blockchain platforms or other computer software [10], as well as biological organisms [11]. In Human-Centric Functional Modeling the universe is represented in part as a "distributed cognition" that computes the evolution of matter according to the forces represented in one functional state space. Since forces are not transmitted instantaneously, the universe is also represented in part as a "distributed consciousness" that computes the evolution of the

awareness of the state of matter according to awareness processes represented in another functional state space.

Seeing the universe as a distributed cognition and a distributed consciousness doesn't change the laws of physics or result in new physics. But this perspective allows it to be seen that consciousness and cognition are fractal patterns that repeat [17] in that metaphorically the universe can be seen as a zeroth order cognition and consciousness, individual humans can be seen as instances of first order cognition and consciousness, a General Collective Intelligence can be seen as a second order cognition and consciousness, right up to an Nth order cognition and consciousness.

In HCFM, the well-being of a system is represented by its fitness to execute all of its functions, and is described in terms of a position in a generalized "fitness space". Life is a self-regulating process by which an organism tends to maintain stability. In terms of HCFM, any living system is hypothesized to move through its functional state space in a way that reliably keeps its fitness within the bounded range of not going to zero (dead) and not increasing to the point of magical abilities. The same pattern of dynamics that solves the problem of adapting to stay within a bounded region in one fitness space for one system, then potentially solves that problem for all fitness spaces for all systems. If this adaptation is intelligence, then all of these intelligences are potentially instances of the same pattern of dynamical stability in a generalized "fitness space". The importance of modeling the physical world this way is that it potentially facilitates:

- The same model that solves the problem of simulating the evolution of the universe from the perspective of Human-Centric Functional Modeling can also potentially be reused to simulate an Artificial General Intelligence, a General Collective Intelligence, or a higher order intelligence, as well as a wide variety of other biological processes, and vice versa.

- Modeling the physical world as a distributed consciousness and cognition then facilitates defining the needed infrastructure for simulating the evolution of semantically represented matter and awareness at any scale from quantum scales to cosmological scales.

- Modeling the physical world as a distributed consciousness and cognition facilitates the use of Human-Centric Functional Modeling to define a semantic representation of physical matter, and for matter in one region it facilitates the use of Human-Centric Functional Modeling to define a semantic representation of the awareness of the state of matter in another region [4], [7].

- Creating a semantic representation of the physical world means modeling the physical world as a functional state space that is a human-centric representation (a fully self-contained representation of human meaning). This semantic model of physical matter must then be capable of storing all the properties of that matter at any scale without the need for any external reference or translation table, so that any physical effects at any scale can be explored using the same "semantic simulation" infrastructure. With a semantic model any representation of the physical world in every simulation, every computer game, every Computer Aided Design (CAD) tool, every Computer Generated Image (CGI), or every other computer interaction becomes part of a single data format. This data format is a directed graph. Modeling the real or virtual world in terms of the directed graph of a functional state space creates the opportunity to decouple every component of every model since it is completely represented by the corresponding piece of that graph, enabling it to potentially be reused in every other simulation, production, game, or other interaction.

- General Collective Intelligence is predicted to exponentially increase the general problemsolving ability of groups, and therefore is predicted to exponentially increase ability to solve any problem in general, including the problem of finding opportunities for reusing components of models of real or virtual worlds. This suggests that GCI might exponentially increase opportunities to reuse such components. One way is that every simulation involves a model of the entity being simulated, and also involves simulation infrastructure to calculate the evolution of that model. Modeling the physical world or virtual world as a functional state space that defines a universal data model for such representations might then contribute both models and simulation infrastructure that might be used in all other simulations or other physics research and vice versa, thereby effectively multiplying research funding.

- Taking the approach of modeling the metaverse as a functional state space then effectively represents the physical or any virtual world as a functional state space navigated by the distributed consciousness and cognition of the universe. Spreading the use of Human-Centric Functional Modeling has deep implications for all sciences studying all systems, since an exponential increase in general ability to solve problems in understanding any system is hypothesized to be achievable through the same pattern of solution in all functional state spaces, and therefore in the functional state space of every system [18]. For example, in physics, modeling the metaverse as a functional state space and therefor representing the physical or virtual world as a functional state space is implicitly a path towards exploring how Human-Centric Functional Modeling might be used to represent simpler universes as functional state spaces that interact to create the known universe, and why this approach might methodically step through all possible options to more reliably achieve a Unified Field Theory, as well as how General Collective Intelligence might orchestrate collaboration to make this massive effort feasible.

III. Human-Centric Functional Modeling, Quantum Computing, and the Metaverse

If the metaverse is a model of the physical world or imaginary virtual worlds, then computing power determines the level of detail of that world that is manageable, as well as the speed and scale at which it might be possible to interact with that world. Quantum computing is therefore intimately related to the future of the metaverse, since the promise of quantum computing is to revolutionize high-performance computing enabling computations that were not previously considered possible. Quantum logic gates provide a minimum set of operations that quantum computation can be expressed in terms of. However, the speed at which it is possible to access stored data is a fundamental limitation that means conventional quantum computers which express computation in this way are poorly suited for certain types of problems,

namely those requiring a great volume of input data as compared to the possible calculations that potentially need to be made. Interactions with a very realistic and therefore a very detailed and data intensive representation of the metaverse is one of those problems that conventional quantum computers might be poorly equipped to solve.

Human-Centric Functional Modeling on the other hand defines functional state spaces that are essentially distributed databases of information about the systems they describe. Furthermore, simulations based on Human-Centric Functional Modeling essentially distribute the problem of computing the evolution of any interaction involving such systems. In addition, Human-Centric Functional Modeling hypothesizes the complete set of functions required to represent human cognition [7]. Most importantly, in addition to the six internal (not consciously observable) functions hypothesized as being required to navigate fitness space in a way that results in general problemsolving ability (intelligence) in conceptual space, only four external (consciously observable) functions are hypothesized as being required to navigate all of conceptual space. In other words, four functions are believed to span all of conceptual space so that any concept can be reached through reasoning consisting of some composition of those four functions, and another six functions are believed to be required to execute these four functions in an intelligent way that creates the capacity to solve any general problem. If this Human-Centric Functional Modeling theory is correct, then implementing those four functions as quantum logic gates implies the ability to represent all reasoning in terms of some composition of quantum logic gates. Human-Centric Functional Modeling theory also posits that any open functional state space is spanned by some set of four operations in that any process can be represented in terms of some composition of those four operations. In the physical world these four operations presumably correspond to the four physical forces. It remains to be explored whether and how applying these basic functions to quantum computing, and applying quantum computing to a distributed graph of data might greatly increase the problems to which quantum computing might be applied to.

In systems and software engineering, functional modeling approaches are commonly used to permit massive collaboration in developing complex systems. By defining functional components with welldefined interfaces, functional modeling removes the need for experts in one discipline to understand another involved in the solution, and also permits them to work independently. Reducing all quantum computing algorithms to be expressible in terms of a set of basic functions could have the advantage of making all implementations of those functions in every quantum computer compatible, so comparing those implementations could potentially improve all quantum computers. Furthermore, this compatibility between implementations of those operations could also significantly simplify implementation of any quantum computing algorithm expressed in terms of such functions. The implication of representing the metaverse as a functional state space, and in doing so building mind share about the power of HCFM, is that doing so might have the potential to radically accelerate research in quantum computing. These implications of quantum computing on the metaverse remain to be explored.

IV. Elaborating the Missing Elements of Conceptual Space Required to Implement the Metaverse

If all open functional state spaces can be represented as directed graphs, and if the conceptual space is the only functional state space that is by definition reliably conceptualizable, then solving the problem of defining an implementation for conceptual space will solve the problem of representing an implementation for any other functional state space. There are a number of assumptions in the statement that conceptual space is a "complete" semantic representation and therefore a complete representation of human meaning. One assumption is that descriptions (meanings) are self-contained within every region of conceptual space in that there is no "Rosetta Stone" to store translations that give meaning. Meaning must be conveyed through patterns in the nodes and their connections as in Figure 1.

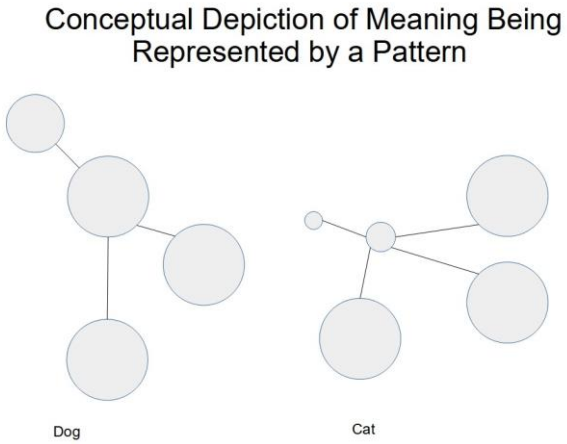

Fig 1: Conceptual depiction of meaning in conceptual space being represented by a pattern.

Although the combination of this conceptual space and cognitive system are together suggested to define a complete model of semantic meaning, the model of conceptual space has not yet been completely implemented. A number of challenges remain, for example how to define absolute and relative position in this space? How to quantify distances? How to define the extent (size) of concepts? How to specify the reasoning interactions between concepts? How to specify directedness in the graph? Furthermore, how far does the analogy of a conceptual "space" extend with regards to the relationships governing the many other types of spaces used in modern mathematics, such as Euclidean spaces, linear spaces, topological spaces, Hilbert spaces, or probability spaces?

Other literature confirms the opinion that current semantic modeling approaches fall short in a number of areas including at minimum: inability to express intended meaning and as a result leaving their intent to interpretation, classification of concepts that is ambiguous and can be done many different ways, lack of a comprehensive methodology for translating semantic models into computing methods and software, and semantic technology and knowledge repositories that remain in silos [12].

The incompleteness of current semantic modeling approaches is also reflected in the need for human's in adapting semantic models for new data sources, and in the difficulty humans have to even understand these formal

semantic models once defined [13]. Some approaches other than HCFM define semantic "spaces" differently [14], in the attempt to address the incompleteness of current semantic modeling approaches. However one problem such definitions of a semantic "space" might suffer from is that they are not part of a coherent model of cognition that represents individual words in a complete way. Depending on the representation, any distance measured between words might be the same, so that such representations cannot be used "to indicate semantic distance for individual words" [14].

A number of assumptions made in Human-Centric Functional Modeling remain to be validated and a number of properties defined in functional state spaces remain to be quantified. The extent of any concept (its resolution) in conceptual space has been hypothesized to depend on the number of reasoning relationships linking it to other concepts (i.e. the number of edges connecting the node in the graph representing the concept). But the dependency of size on number of edges has not been quantified. Similar concepts have been proposed to be those with many of the same relationships (many of the same edges that connect them to the same nodes) and similar concepts have been proposed to be closer to each other in conceptual space than concepts that are dissimilar. But this distance has not been quantified. It has been proposed that two concepts might move closer in the conceptual space over time if they come to share many of the same relationships (e.g. if the cognition learns over time that those concepts are similar). Therefore concepts might move in the conceptual space. If concepts move then they have the equivalent of "forces" moving them. But these forces have not been quantified. Assuming that concepts have some location, then the conceptual space might be mapped to a three dimensional space. Or it might also be mapped into some shape matching the structure of the brain. In addition to quantifying sizes and distances in conceptual space so that a representation of conceptual space in 3D can be defined, any mapping of conceptual space to the physical layout of the brain as the only known cognitive system currently in existence must be determined.

If any node (concept) in conceptual space is described by its relationships, then its relationships must be described within the concept in order to ensure the description of the concept is fully self-contained so that reasoning can be executed on it. Fully self-contained descriptions in conceptual space are complete self-contained descriptions of meaning, and are therefore semantic descriptions. Any implementation of this conceptual space is a semantic description of concepts and potentially a language-free representation of meaning if each meaning is represented by a particular pattern of nodes and edges in conceptual space regardless of language. The usefulness of a semantic representation as a "semantic storage" format is that it provides a way to store data that can never become unreadable because of new hardware or software. This is true whether the semantic representation is of concepts and reasoning as otherwise described by human language, or whether the semantic representation is of the physical or virtual world as otherwise described by some specific data format.

Any generalization of a concept is a concept that covers a larger region in conceptual space and therefore might contain other concepts. Being a concept as well, the description of this region must also be self-contained. In summary, for any implementation of the conceptual space, all regions must have descriptions that are self-contained in that region. The importance of validating the assumptions and quantifying the properties that remain open questions regarding conceptual space is that any functional state space, whether the functional state space representing cognition or the functional state space representing the physical universe or any virtual universe like the metaverse, are expected to have the same representation. Therefore solving these representation problems for one system like cognition will also solve them for the metaverse.

V. Simulation of a Network of Nodes Representing Concepts in a Conceptual Space

An implementation of conceptual space might potentially be validated by simulating the behavior of the cognitive system in that proposed implementation of conceptual space. Some requirements which might be addressed by an implementation of a graph that is able to satisfy the requirements of conceptual space and is therefore able to satisfy the requirements of any functional state space, such as that representing the metaverse, are that this conceptual space might respond to a simulation as below:

- A simulation of conceptual space might demonstrate that "level of interest" or other potential attractive forces cause concepts to move in conceptual space, such as towards a concept of interest. Forces are associated with acceleration. If interest is such an attractive force then level of interest might be detected in conceptual space by the resulting acceleration of motion of concepts over time. Similarly, in a simulation of the metaverse, objects in a functional state space representing the physical world should accelerate and otherwise behave according to the observed laws of physics.

- A problem in conceptual space is defined by the lack of a path from some concept A to some concept B. A solution is reasoning that provides a path from concept A to concept B. Any reasoning that creates a link between concept A and concept B moves both closer together. A simulation of conceptual space might demonstrate that "attention" behaves in experimentally observed ways, such as perhaps causing concept A to move in conceptual space in the direction of the problem being solved (concept B). If so then attention can be represented in conceptual space by the resulting motion of concepts over time. Similarly, in a simulation of the metaverse physical objects can undergo transitions. Solutions to these physical transitions provide a path through functional state space that solves the problem of transitioning from one physical state to another. To validate this one might show that physical transitions continue in the direction dictated by the laws of physics. Of course, one might define a metaverse with a different physics, or one might describe the metaverse in functional state space using a low resolution that leaves out most physics, but for simplicity the same physics might be assumed.

- An abstraction is a larger concept that encompasses other concepts. A simulation of conceptual space might demonstrate how a cluster of concepts can act as a single concept. Similarly, in the case of the metaverse a simulation might show how a graph representing macroscopic objects might be constructed from graphs representing microscopic components.

- In any simulation of any functional state space it remains to be demonstrated that all nodes can be described in a way that contains all their edges (descriptions are self-contained within the node).

VI. General Collective Intelligence

The same Human-Centric Functional Modeling can be used to define a collective conceptual space navigated by a hypothetical collective cognition, where the general problem-solving ability of that collective cognition is measured by a general collective intelligence factor (c) [15]. Implementations of Collective Intelligence (CI) are solutions which might increase ability to collectively solve problems in a narrow area. A General Collective Intelligence or GCI platform is a CI that provides general problemsolving ability (intelligence), and that also creates the possibility of exponentially increasing that collective intelligence [16]. Creating social media platforms is one such problem that GCI might be turned towards. This has profound implications regarding social media platforms that might interact with the metaverse, since it predicts that with GCI such platforms might self-assemble to eliminate any possibility of censorship or surveillance, and do so at unprecedented speed and scale in ways that current centrally controlled social media platforms would not have the ability to compete with until the advent of Artificial General Intelligence or AGI [22].

VII. Conclusion

A functional state space representing any region in the physical universe would not only be important to physics in enabling all theories to be tested against all data. It would also provide a common format for representing the world in games, simulations, experiments, or any other computer interaction. This would enable a "metaverse" that could be managed through a common platform such as a General Collective Intelligence, rather than a proprietary platform owned by Facebook, Apple, or some other company. A number of companies are investing heavily in the metaverse becoming very prominent, and some believe the metaverse to be important to the future of work because the greatest opportunities to create jobs are in areas such as virtual reality that are not constrained by finite natural resources. Since all functional state spaces are likely to have the same representation, solving the remaining problems in implementing a working representation of any functional state space is likely to solve the remaining representation problems for all functional state spaces. Human-Centric Functional Modeling attempts to define an objective model of human perception that allows it to be seen that all problems and solutions that can be perceived by humans are represented by patterns in human perception that can be reused in defining other problems and in discovering other solutions. As an example, it is hypothesized that properties such as sustainability in the environment or in sustainable development are patterns in some functional state space, and that by understanding those patterns we might exponentially increase our capacity to solve wicked problems like poverty and climate change to the point that those challenges are reliably solvable for the first time [19], [20], [21]. It has also been hypothsized that the use of functional state spaces to define semantic models of information that a General Collective Intelligence might use to exponentially increase the general problem-solving ability of groups, might also radically accelerate progress in every field from physics to quantum computing. Perhaps given the massive resources being invested in the metaverse, this potential use of functional state space to define the metaverse might inspire participation in the challenge of defining a functional state space to benefit all of these other areas.

Human-Centric Functional Modeling is in its early stages and remains to be explored both experimentally and theoretically. Implementations of the functional components suggested by HCFM as being required for semantic computing have not been defined using classical computing hardware and software, much less quantum computers. However, the great theoretical benefits of the functional modeling approach make this line of inquiry worthwhile. Namely, defining cognition in terms of a minimally reducible set of cognitive functions has the potential to radically scale cooperation in defining problems, as well as cooperation in modeling data to be provided as input to solutions, and cooperation in modeling the solutions themselves. And from this point of view the biggest limitation that currently exists on both classical and quantum computers is not their computing power, but the constraints to cooperation that force researchers in domains such as quantum computing to develop solutions that are not easily reusable to solve all other problems researchers in the same or other domains might face.

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Accounting and Auditing in the Metaverse World from a Virtual Reality Perspective: A Future Research

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***Abstract*—The research aims to illuminate and raise questions about the future of accounting and auditing from the perspective of the most prominent technology, virtual reality technology, the Metaverse. A normative approach is considered an appropriate approach for future research. The research's contribution is that it is the first scientific study to identify a link between accounting, auditing, and the Metaverse, which no other research has done. As prominent results' of the research, the Metaverse represents a vertical rather than a horizontal development in accounting and auditing, where their objectives remain unchanged. Metaverse technologies will serve as auxiliary tools for them. Furthermore, Metaverse creates new digital assets that require accounting measurements to provide tools and disclosure methods that are accurate. In addition, the Metaverse has potential effects on planning the audit process and collecting evidence. Moreover, because it provides an interactive environment with enormous potential, the Metaverse can be used in education and accounting training.**

Keywords— Accounting, Auditing, Augmented Reality, Metaverse, Virtual Reality.

I. INTRODUCTION

As a result of the innovations in information and communication technology, Today's business and financial world is developing at such a rapid pace that sometimes can be hard to keep up with and absorb. While, the world is still attempting to adapt the products produced by the third industrial revolution, at its peak and to absorb social media and the cultural, political, economic, and social changes that have resulted. The World Economic Forum announced several integrated technologies with enormous potential in Davos, Switzerland, in 2016, under the banner of the Fourth Industrial Revolution (4IR) (WEF). The World Economic Forum announced several integrated technologies with enormous potential in Davos, Switzerland, in 2016, under the banner of the Fourth Industrial Revolution (4IR) (WEF). These technologies have infiltrated almost every field, arousing the curiosity and enthusiasm of many organizations and individuals. Research and exploration continued at a moderate pace until 2020, when COVID-19 spread across the globe, quarantining everyone in their homes. These technologies got the attention to serve as medicine, to keep the world in general, and the business and finance world in particular, active and continuous, and reliance on technologies increased the performance of remote businesses. In the technology and communications fields, the pace of research and exploration accelerated.

As the world prepares to recover from the consequences of COVID-19, Mark Zuckerberg, founder, and CEO of Facebook announced the change of the company's name to Meta on October 28, 2021. The company will work under this new name to help build an Internet that consolidates social relationships and embodies experiences and makes the user an element within them, not just a viewer of them, and this is called the Metaverse, where anyone can meet another person they want within. This world may be a virtual embodiment of our physical world, the real world with all its features and characteristics, or a completely virtual world with new features and characteristics. Whatever the geography of the Metaverse is, everyone can do anything that they can imagine, such as meeting with friends and family, working, learning, playing, shopping, creating, and experiencing different new experiences that do not harmonize with the current way in which we interact with machines. The ultimate goal of the Metaverse world is for the user to feel his presence with another person. To move virtually instantaneously as an anthropomorphic to anywhere he wants without moving from his place in the physical world. These would create more opportunities for everyone, regardless of where they live. It will reduce congestion and the total harmful effects of emissions resulting from individuals, companies, or events, called the carbon footprint. The most prominent role of companies in the coming period will be to accelerate the development process to renew life and weave this world with the means of current social media to have a better social experience [1].

The Metaverse is a digital reality that combines aspects of social media, online games, Augmented Reality (AR), Virtual Reality (VR), Blockchain, and cryptocurrencies to allow users to interact virtually [2-3]. It is an umbrella term for a group of technologies. The Metaverse has begun to spread, and the news sites have filled with articles about it, its meaning, and its future possibilities. The focus has been on virtual reality (VR), while scientific research still lacks research in this aspect, whether dealing with the Metaverse or virtual reality, especially in accounting and auditing. The reason is likely to be the nature of the field, as the application of accounting precedes theorizing.

Earlier, Sunder's research indicated that humans have a significant talent that other living beings do not possess, namely: the imagination of a large percentage of human beings. They are aware that much of human civilization and its achievements, from the Seven Wonders of the World, and multiple inventions, are the results of the imagination of

human beings, none of which would have been possible if no one had dared to imagine them into existence. Sunder saw it as logical to imagine the alternative (virtual) that literature deals with, just as science explores alternative perceptions of the material world. Sunder saw that accounting is, in the limit itself, the result of human imagination, and is contemporary with mathematics, writing, and civilization itself, and added that if imagination is the source of the discipline of accounting and all human progress, it may be essential to explore the state of imagination in our profession today, and in the future [4]. Sunder poses a question: why not imagine alternative scenarios rather than just waiting for changes to happen or imposing them on us? [4] Referring to the importance of imagination in business and finance changeable environment, as well as innovation in practices and organizations, in addition to the above, this research comes to visualize what the future of accounting and auditing may be in the world of the Metaverse after introducing and adopting virtual reality technologies more broadly. That is limited to addressing the most prominent technologies that make up the Metaverse world. The rest of the techniques are left to be dealt with by other accounting research. Although this research may touch on some tangentially in some places, it is not the primary aim of this research.

As for the accounting literature that dealt with the subject of the Metaverse, the researcher failed to obtain any of them, and therefore it can be said that there is no previous literature in the field of accounting and auditing that dealt with the topic in the question, and what reinforces this is research entitled "Metaverse Shape of Your Life for a Future: a bibliometric snapshot" which attempted to provide a bibliometric assessment of the literature that dealt with the Metaverse for the period from 1990–2021 and concluded that there was little literature dealing with the Metaverse worldwide, and previous research focused in the technical field, the fields of education and digital marketing [5]. Another research entitled "A Content Analysis of the Metaverse Articles" aims at analyzing the content of articles containing the keyword "Metaverse" in all fields. They concluded that the Metaverse had been a subject of academic research in many areas over the past years, from literature to art, and from music to education, where they examined 40 scientific articles published in refereed journals, and none of these articles dealt with the field of accounting and auditing [6]. Accordingly, the research gap covered by this research is clear. Previous literature used to build a theoretical framework that clarifies the idea of the Metaverse and some related aspects and uses this general framework in anticipating the reality of accounting and auditing in the world of the Metaverse, proceeding from the point of view of Shotton, who stated that the ability to explore, integrate, and reuse scientific outputs from the previous literature is critical to innovative research [7].

II. METHODOLOGY

The research uses the normative approach because it is trying to determine what the future of accounting and auditing might be in the world of Metaverse after the introduction and adoption of virtual reality technology on a large scale, and not what it is today. It is research seeks to embody the traditions of utopian thinking as an attempt to draw a picture of a practical and desirable future. It also aims to create reliable maps to determine alternative future paths. If these maps cannot show the final destination, we need to find pathways that lead to the desired direction, which is often hard to see but worth building. The normative approach is considered one of the approaches to building accounting theory. According to Matar and Al-Suwaiti, it depends mainly on deduction in deriving accounting rules and procedures, elicits standards of behavior, and provides model solutions for accounting procedures, and reducing it depends on assumed assumptions that may be difficult to measure objectively and to reach conclusive results that represent acceptable practical facts. Therefore, normative research remains just a set of ideal rules whose goal is to devise better practices, but it may contradict the current practical reality [8]. In this regard, Sunder argues that thinking about possible alternatives for the current accounting and auditing firms is essential if our world is changing, and thinking about the potential consequences of these alternatives is essential if such change is for the better [4]. Pietro & Cresci added that if we do not anticipate the complexity of the Metaverse, or if we fail to predict its potential effects, the losses incurred and the risks might be enormous and high [9].

III. WHAT IS METAVERSE?

The introduction of the research mentioned that the term "Metaverse" includes a group of technologies, and it clarified that this research deals with only one of these technologies, which is Virtual Reality (VR). Because of the importance of the chronology of events in the context of talking about historical roots, it is better to highlight virtual reality then move on to the term "Metaverse" in addition to the fact that the latter is recent compared to Virtual Reality.

A. Virtual Reality (VR) as a core technology in Metaverse

To avoid any confusion occurring because of the similarity of terminology. It is necessary to clarify the difference between virtual reality (VR) and augmented reality (AR). The idea of the Metaverse embodies virtual reality in the first place. Augmented reality represents a technology based on projecting virtual objects and data in the user's environment to provide additional information or serve as a guide for him, a technology that superimposes digital data and information over the current user's environment. Reality can enhance by adopting specific devices that allow users to control their presence in the real world [2]. It is a technology in which real-world data interacts with digital appearances to give an in-depth perspective to enable individuals to face real scenarios better [10]. Perhaps the most prominent example of augmented reality is Pokémon Go was launched in 2016 by Niantic Inc., an American company that publishes and develops video games. This game enables users to search for Pokemon in their environment, such as rooms of their houses, stores, and streets. This level of explanation of augmented reality technology will suffice.

In contrast to Augmented Reality technology, indicated by Ramadan, Virtual Reality (VR) is a technology-based on dropping realistic objects into a virtual environment to make them appear as if they were in the real world. It is an interactive three-dimensional environment designed by computer programs. The interactions between the virtual environment and the user's senses and responses will reflect on the fictitious world [11]. According to Folger, this technology enhances fictional facts in a completely virtual world, users access this world via special devices, and the system controls the users [2]. Besides, The Financial Reporting Council (FRC) stated that it is a technology that creates a complete simulation experience. The realistic

situation or landscape but completely artificially is mirrored, and the user will be fully immersed in this reality to contribute to its formation and development [12]. Ray defined the virtual environment as a mathematical representation of things in three dimensions through simulation, creating an almost replica of realistic physical objects and their properties (e.g., size, weight, color, width, height, etc.) [13].

Virtual Reality technology is not new technology as it is an old technology that spanned several decades to develop, and there is no room to review the Virtual Reality journey that began at the beginning of the twentieth century but will stop at some stations for clarification only. In 1929, Edwin Link, an American inventor, and pilot built the first flight simulator under the name Pilot maker, and this device captured the interest of the US Army Air Force, which acquired six simulators in 1934 AD, and also used them to train pilots for World War II. In 1962, Morton Heilig introduced the Sensorama, a Virtual Reality machine that can view movies in three-dimensional (3D). It was a project for the future cinema at that time, it was not just about watching, but the viewer felt the wind, vibration, and smells. This machine was similar to the three-dimensional devices currently found in entertainment and game centers, and this device may have obtained a patent at the time. In 1968, a head-mounted display (HMD) Ivan Sutherland developed an American computer scientist. The devices related to Virtual Reality that improved at that time were used in military applications. From 1970 to 1990, the Virtual Reality industry flourished in various sectors, such as medicine and the automobile industry. The beginning of the twenty-first century represented a new era for the Virtual Reality industry [14-17].

In 2010, American engineer Palmer Luckey created the prototype of Virtual Reality glasses under the name Oculus Rift. He was seeking to provide a technically mature system at an affordable price. In 2014, Facebook bought Oculus VR, the developer, and manufacturer of glasses, for $2 billion. The final version was on the market in 2016. These are not the only modern product, as many companies are working on innovating and launching their own Virtual Reality devices, for example, Sony, which released Playstation VR (PSVR), and HTC, which launched the HTC Vive by the end of 2010. Many other companies are developing software for these systems, which means that devices are under constant improvement and development due to the presence of many competitors [14]. It is worth noting that all previous VR devices rely on 360-degree video technology, as this technology uses a series of cameras to obtain simultaneous feed from multiple angles. The feed from each camera is combined to create a video clip that allows 360 movement degrees. This technique can be said to replicate a location or event in the real physical world [12].

Not all VR technologies have attracted attention, in both professional and consumer environments, until recent years [18]. The video game industry was the first driving force in the development process of VR devices. It can be considered, the driving force behind the increase in investments in this field since the beginning of the first decade of the twenty-first century [14].

By wearing these devices, the user enters Virtual Reality or a virtual environment. Earlier, this virtual environment could be accessed via a specific website via the Internet and navigating this environment or this Virtual Reality by computer. The user sees this environment on the computer screen, and at the same time, the environment of the physical reality. Today, the matter is different, as these devices have worn to obscure the view of the environment of the physical reality, transport the user to a virtual environment, where he can use the complementary devices that he wears in his hands to move, immerse all his senses, body and mind in this Virtual Reality.

To further clarify the form of the virtual environment, it is necessary to briefly refer to one of the previous experiences that used a form of Virtual Reality, taking into account the level of technical development in that period, the Second Life. One of the Virtual Reality platforms was introduced in 2003 by a private company, Linden Research Inc (also known as Linden Lab), in San Francisco. Johnson & Middleton define it as a virtual three-dimensional educational, public relations, and economic impact on the Internet. They suggested that this platform merge online video game technology and social networking tools, such as Facebook and e-commerce capabilities. Notably, it's not a game, not even intended for kids. Johnson & Middleton found that BusinessWeek Magazine, The Wall Street Journal, CNN's blog featuring stories about Second Life (SL), and the Reuters news agency, which has an Office on this platform, are already on this platform to cover VR events. In addition, on the professional level, IBM, Toyota, Pontiac, H&R Block, and many groups of companies. Either on the academic level, many universities have set up a virtual campus on this platform, for example, Ohio University and Princeton University [19].

The number of people who flocked to this platform in 2007 reached nearly one million people. This period can be called the boom period of this platform. During this period, the founder of the platform, Philip Rosedale, met with Jeffrey Jorgensen, one of the financiers of this platform and the founder and CBD of Amazon. They thought deeply about the ability of the Internet to change the way of life. The meeting was about thinking about the future of the Second Life (SL) platform. After this boom period, the number of users of the platform stabilized then receded. Due to the lack of rapid development, slow Internet connections, and a new popular place for online gatherings. The social network Facebook has reached 2.9 billion users today, while the number of users of the Second Life (SL) platform today is about 600,000 users. As a result of these situations, Rosedale stepped down in 2008, and Jorgensen's focus quickly shifted to dominating the 2D mainstream internet. Amazon did not establish a formal presence in the Second Life (SL) platform [20].

The Second Life platform (SL) was not the only virtual world, as there are many other experiences, such as Active Worlds. A virtual world launched on the Internet in 1995. There is a platform launched in 2003 that represents a three-dimensional virtual world. In addition to CitySpace, which was active from 1993-to 1996 AD [6].

B. The concept and historical roots of the Metaverse

Despite the long development process spanned about a century for Virtual Reality technology. It faces limited usage and a shortage of spent on it. This technology was making its way quietly and cautiously towards an unknown future with modest technical and economic curiosity until 2021. Until the announcement of Mark Zuckerberg, the founder of Facebook, about the Metaverse, on October 28, 2021. Though, he has changed Facebook's name to Meta. Which created a sensation

as if he was returning to eliminate the remaining of the Second Life (SL) platform after sabotaging its career when he launched the Facebook application.

The main reason for the hype surrounding the announcement of Metaverse in Virtual Reality, According to Brown, is that Meta (formerly Facebook) has some things that help achieve the concept of Virtual Reality better than others have done in the past. Meta can invest huge money in a short period (two or three years), which exceeds the total dollars spent on the concept of Metaverse and Virtual Reality during the previous thirty years. In addition, the situations are now more favorable than before. Dealing with virtual communications and remote work has become more comfortable. Nevertheless, Zuckerberg aspires to access Virtual Reality through advanced modern devices previously referred not through computer screens or a TV connected to game consoles, such as Xbox or PlayStation [20].

The term "Metaverse" dates back to the 1992 science fiction novel "Snow Crash" by Neal Town Stephenson, where he coined the term "Metaverse" [21]. The researcher could not locate a definition of this term in the dictionaries. Whereas the online encyclopedia Wikipedia divided the term into two parts, the first one being "Meta" which means the sense beyond, and the second one being "Verse" which drafts from the universe, this means that the term is "beyond the universe" about the world of metaphysics. Wikipedia indicated that it is a term usually used to describe the concept of future versions of the Internet consisting of a static three-dimensional (3D) space linked to a perceived virtual universe. According to META's official website, the Metaverse represents the following development in social communication. Factually, the Metaverse represents a significant convergence between physical and digital life, achieved through developments in Internet connectivity, Augmented Reality (AR), Virtual Reality (VR), and Blockchain technology. It is just the culmination of all the attempts at science fiction contained in science fiction films. The movie Ready Player One, released in 2018, takes place in 2045, where most of humanity uses a Virtual Reality program to escape from the gloom of the real world. The idea of virtual simulation where people can interact was present in Already, appeared in the 1982 movie Tron. Likewise, the Metaverse creates a world that simulates the physical world with domains related to man and society [6]. Moreover, it is considered a virtual universe in which people are in a daydream-like state [22]. Some regard it as the third version of the Internet (WEB 3.0), the Spatial Web, or the three-dimensional Internet (3D Web), which is divided into [23]:

1. Physical layer: The world as we currently know and experience it through the five senses.
2. Digital information layer: Through sensorization and digital mapping of the physical world, we will eventually create a digital twin of every object in every place. Today, this type of digital information is primarily accessed via screens and dashboards. In the future, it will be retrieved primarily via the spatial interaction layer.
3. Spatial interaction layer: Through next-generation interfaces (e.g., smart glasses or voice), we will be able to interact with contextual, real-time information that has been called up by intuitive and sensory triggers such as geolocation, computer vision, and voice, gesture, or biometric commands. In effect, this merges the digital and physical layers for the user.

Some have considered that the Metaverse is a collection of interconnected virtual worlds with some common characteristics that can change how they interact with the Internet [24]. Others added that a Metaverse is a location where people meet to socialize, attend work meetings remotely, and participate in concerts, conferences, or games where there are digital copies of everything that exists in the physical world. This location is not a separate entity, nor just an online community; it is an inclusive world in which all aspects of the community can be found, including game worlds; it is neither an online game nor simply a platform like Second Life (SL). It is not pure Virtual Reality, despite being accessed through virtual and augmented reality devices. It is more than just a collection of a series of innovations; it is an augmented interactive layer of our physical and online lives, containing applications, platforms, games, experiences, societies, and spaces in a seamless and woven way between the real and the digital [25]. It is best to think that the Metaverse is a convergence of technologies that faded for years (and even decades) and emerging technologies, shown in Fig. 1.

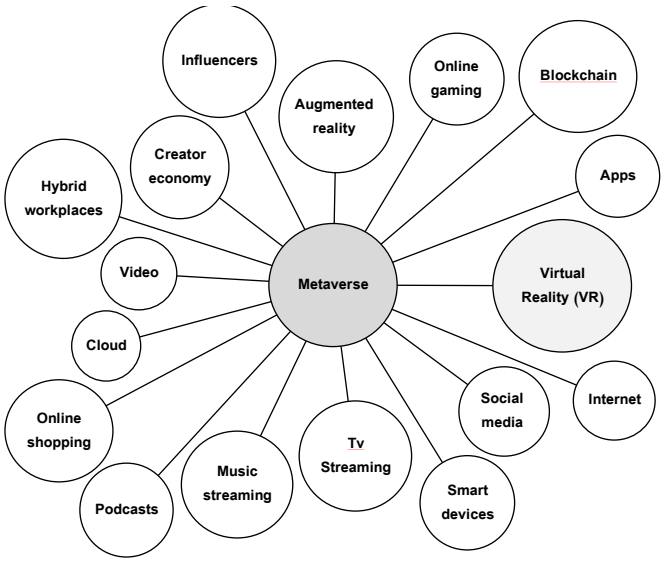

Fig. 1. Techniques covered by the term Metaverse
Source: Prepared by the researcher based on [25].

While discussing the Metaverse and Virtual Reality, another term confronted by readers in the relevant literature, Neuro Reality (NR), is a subset of Virtual Reality. This term, which has recently emerged, refers to technologies that directly interact with the human brain to create a more immersive sensory experience. Elon Musk, Canadian entrepreneur and founder of both Tesla and SpaceX, is a pioneer in research into the power of Neural Reality through his neurotech company Neuralink; Which he founded along with eight other businessmen in 2016, since Nervous Reality within Virtual Reality, Metaverse includes it as well.

Metaverse uses non-fungible tokens (NFTs), which are unique and non-fungible units of data stored in a digital ledger. They are unexchangeable new virtual assets type that fueled much of the growth in the Metaverse. NFTs may be images, videos, or items within a particular game. In accounting parlance, all NFTs consider assets regardless of their

classification (which will be discussed later). The ownership of these NFTs recorded by Blockchain technology authorized to trade NFTs as an alternative to the digital assets they represent, which means that the Metaverse allows creating, owning, and monetizing a new type of decentralized digital asset. Notably, these assets will be bought and sold in the Metaverse by Cryptocurrencies [3; 26], which requires referring to Cryptocurrencies and Blockchain technology:

> Cryptocurrencies: They are virtual currencies that can compare to current official currencies such as the dollar and the euro, but with several key differences, the most notable is that they are only traded online without a physical presence. Since there is no central bank issuing these currencies, it is an electronic cash system based on the principle of peer-to-peer (P2P) in financial transactions, a technical term that means direct dealing between one user and another without the presence of an intermediary [27].
>
> Blockchain: It is one of the types of distributed ledgers based on connecting a group of blocks in a series. Each block is linked to its previous block by encryption mechanisms representing a record of financial transactions is only records transactions in this registry after approval by a network of Nodes. Nodes are computers registered in the chain, where each network node solves complex mathematical equations to accept their validation of the transactions in exchange for some rewards, such as Cryptocurrencies. This technology had characterized by decentralization, encryption, security, the possibility of moving the origin of ownership (and not copying), continuous updating, and immutability [28].

This clarification will suffice because Cryptocurrency and Blockchain are beyond the scope of this research.

Despite Facebook's announcement in September 2021 that it had invested $50 million in global research and program partners to ensure the development of Metaverse technology, Metaverse has no single creator or identifier, implying that Facebook does not own or is responsible for developing it. Mark Zuckerberg believes that, like smartphones, Virtual Reality glasses will become more widely available in the future [2]. Contrast the Metaverse with the World Wide Web, which had built by many smaller entities anyone can access the Metaverse through their devices. Either no one (person, corporation, government, etc.) will be able to access the entire Metaverse. Furthermore, the Metaverse can not control by a single entity. It is accurate that each corporation will have it's own [24].

As giant technology corporations (Apple, Google, Facebook, and Microsoft) are determined to embrace the Metaverse, some believe that the rise of the Metaverse star is inevitable [29]. By 2030, As giant technology corporations (Apple, Google, Facebook, and Microsoft) are determined to embrace the Metaverse, some believe that the rise of the Metaverse star is inevitable [29]. Microsoft Mesh is a platform for collaboration and communication created by Microsoft to unify 3D virtual cooperation across multiple devices, such as Virtual Reality glasses, laptops, or smartphones [30]. In the same context, BMW, a German multinational car manufacturer, partnered with Nvidia, one of the largest producers of graphics processors and video game systems, which is called a company without a factory and factoring equipment, to build a virtual factory that will be the digital twin of the factory in the real world. So physical assets, systems, or processes can virtualize by a platform called Omniverse, powered by the Metaverse idea owned by Nvidia Corporation [29]. By 2030, Virtual and Augmented Reality has expected to be worth 1.5 trillion US dollars [31].

On November 3, 2021, Seoul, becoming the first government to enter the Metaverse universe, revealed its plan to provide governmental services and cultural events in the Metaverse in collaboration with a large body of about 500 firms, including Samsung, Hyundai Motors, and SK Telecom. This project will receive approximately 26 million dollars in funding in 2022 [32; 33].

On December 23, 2021, PricewaterhouseCoopers (PwC) acquired a virtual land in Sandbox, a 3D Metaverse game based on Blockchain technology owned by Animoca Brands. Thus, PwC became the first global company and the first member of the professional services network to enter the Metaverse universe. In this regard, PwC Hong Kong Partner William Gee commented that we utilize our experience to counsel clients who wish to adopt the Metaverse [34].

C. Possible capabilities and limitations of the Metaverse

Due to the term embrace potential, corporations are investing in the Metaverse. While the Metaverse reshapes society, restructures policies, and changes cultures, it can also open up new markets, providing innovative social networks, advanced tools, different consumer behavior patterns, and new patents. Either the Metaverse can impose its limitations to replace those of the realistic, moreover, help people interact, collaborate, and reduce duplication of assets and skills [29]. The most powerful and attractive feature of the Metaverse may be the feedback loop, where all content is freely available to individuals and corporations to be remixed and reused [24]. Moreover, major international accounting and auditing firms have agreed that VR helps improve processes, activities, and products and may transform entire industries [23; 31].

In the same vein, the Institute of Chartered Accountants in England and Wales (ICAEW) stated that in the Metaverse, the entire world becomes a user interface. It is not about re-creating the two-dimensional Internet (2D internet) or converting a 2D communication platform into a 3D platform, but rather about reimagining how we do business and think about things. Many corporations will benefit from the digital Metaverse's Next Generation, digital twinning, avatars, and user interfaces (UI) [35]. According to the Metaverse, rates of productivity and profit in the business world will determine by artificial intelligence and data science measures [29].

Despite all the above capabilities, some researchers have highlighted the potential limitations of using the Metaverse (specifically VR) on a large scale. The most prominent determinants are the length of time it takes to learn to operate these technologies and the increasing technological requirements necessary for these systems and platforms [36]. On the other hand, one of the most prominent determinants is the speed and energy of the currently available devices, like VR, such as the Metaverse, which requires very high computing power and a powerful component for the operation, which are not present in the devices available today. VR devices consume high power. Therefore, they require high-power batteries for long-term operations. Additionally, these devices, which are supposed to be collaboratively connected, require a high-speed frequency band and the fifth-

generation network (5G) unavailable in some countries. The security concerns related to data connection and devices using the Internet as a vein for data and information transmission, collection, and use raise a set of privacy, protection, and identity issues [37; 6].

The Digital Catapult report included education as a determination. Because few people understand VR (including the Metaverse), the user experience is the main factor. Many users, particularly the elderly, find it difficult to set up, operate, and experiment with advanced VR devices [38]. In addition to corporations' perceptions of these technologies, many are still hesitant to incorporate VR into their businesses because they see it as merely a gaming and entertainment medium [15]. One of the determinants of use is the relatively high cost of creating full content in the virtual form [37-38] [15]. Other limitations identified by the Financial Reporting Council (FRC) include a lack of a user base, with a small number of users compared to social networks or the Internet in general [12].

Jeremy Bailenson, director and founder of Stanford's Virtual Human Interaction Lab, stated the "30-minute rule," which indicates that the maximum amount of time someone should spend in VR per day is 30 minutes. After 30 minutes, they must remove the devices, drink water, touch the wall, and converse with a person. They must do whatever it takes to reconnect with reality. That begs the question: is half an hour sufficient for the Metaverse universe? [20].

However, the FRC has argued that such barriers, which have been real issues for decades, can be demolished in the Metaverse today. Rapid changes in technology access are shifting dynamics in favor of VR. Statista.com, Statista.com, for example, estimated that 5.5 million VR devices are sold in 2020 alone, implying that there is a large audience of potential users. Reports presented as traditional videos attract users more than texts that provide an opportunity for VR versus videos due to a lack of interest. Finally, with the new generation of cloud-based Reality as a Service (RaS) platforms, costs and complexity will reduce [12]. All of these determinants, according to the researcher, will vanish with the increase in technological developments and the innovation of new technologies, particularly in the scope of increased investment in the Metaverse; this is consistent with the perception that increased engagement and investment in the Metaverse would accelerate the development and invention of related technologies [39].

Finally, some recommended the need to pay attention to stakeholders in the VR industry and not focus on VR corporations only. It has also recommended communicating with government agencies to keep abreast of the latest legislation, with customers to receive comments and feedback from them, and with academic researchers to provide input and access to the latest research in this aspect in preparation for adopting VR technology and living in the Metaverse universe [38].

IV. Accounting and Auditing in the Metaverse

Metaverse is almost the latest in technology. The term may still be in the stage of formation, exploration, and controversy. But expectations indicate that it will replace social networks and reshape how people interact and perform work. Therefore, the Metaverse will garner more attention than social networks or the Internet. Since the Metaverse includes many integrated modern technologies, it is better to refer to the coming era as the Metaverse world. This section of the research aims to elicit some professional and academic ramifications or echoes for the Metaverse in accounting and auditing, but only from the perspective of one technology, Virtual Reality technology.

A. Accounting in Metaverse

Firstly, a question may arise, "Why do we need accounting in the Metaverse, which is a virtual world?". To answer this question, historically, the need for accounting was born out of the existence of economic exchange and barter between people, which still exists in the Metaverse as well, where a user can buy or sell digital assets to another user. Since there is an economic exchange, the accounting will need to protect scarce and limited resources and ensure optimal use. In this regard, some see that the Metaverse has its virtual economy, based on the same scarcity idea as the economy in the real world, which means the Metaverse needs the accounting profession. Others convey that the structure of the virtual world makes them unsuitable for economies based on scarcity and that the repetition of the economy in the real world is not the best way forward in the Metaverse [24]. Notably, accounting information systems (and accounting in general) will not change their goals in the Metaverse world but will change how they achieve them, which will reflect in the functions of these systems: measurement and accounting disclosure. There will be two accounting units, one in the Metaverse universe and one in the real world.

The Metaverse has its own economy, known as the Token economy. It is primarily based on the previously mentioned non-fungible tokens (NFTs). In this economy, new forms of trust are available in proving and recording the ownership of assets through tokens. Every digital asset is given a unique digital code (as are smart contracts), and every physical asset is given a digital code that represents it, and this is known as a token. NFTs are a type of digital asset in their own right, that has value and can be managed, traded, and owned.

The world today seeks to exploit cyberspace, known as the Fifth Domain. Digital or virtual space has become the fifth field (after the land, sea, air, and outer space) that humanity seeks to exploit to emerge into a new society, considering the Internet as its backbone [40]. Corporations will expect to establish branches in the Metaverse's virtual world. Offering various digital products to Internet users via branches through activities, operations, and programs had been designed to work with the Metaverse. If corporations succeed in opening virtual branches, they should consider accounting issues as challenges. Digital products and non-fungible tokens (NFTs), for example, are considered digital assets [29; 3; 26].

This raises a question, namely, how can these assets be measured in accounting? What is the appropriate accounting classification for it? And how will it be disclosed?, meaning there will be considerations related to measurement and accounting disclosure that were not raised previously, but what was written about digital currencies as digital assets that will be dealt with in the Metaverse can be guided, although the controversy has not yet been resolved in this direction as well, as companies Currently analyzing some of the international accounting standards and guidelines to determine the most appropriate classification; Due to the lack of clear accounting guidance for digital assets in general, and Cryptocurrencies in particular, some see their inclusion within cash and quasi-cash, others see them as financial tools, and others see them as

intangible assets, while some went to consider them as stock items [41; 42].

For issuers or developers of non-fungible tokens (NFTs), the accounting at their companies may be similar to that of a traditional game company (sales of certain virtual consumables or durables), or to hardware manufacturers (sales of virtual reality glasses). However, some have argued that NFTs pose unique accounting challenges, particularly in terms of realizing revenue from the sale of NFTs, as well as challenges in determining the appropriate accounting treatment for NFTs development costs (which may be capitalized, deferred, or considered an expense when paid). Companies will need to understand the underlying intellectual property being developed, the rights that will be transferred to the buyer, and the nature of the costs being paid; Because NFTs usually transfer digital rights in the Metaverse rather than transferring tangible property in the physical world. For the investor or buyer of these tokens, he is also required to determine the nature of the rights transferred by the NFTs to determine the appropriate accounting treatment [43].

This accounting controversy must be resolved and viewed by the international bodies that have taken upon themselves the responsibility of regulating the accounting profession and framing its practices. For the virtual branches of physical companies to be able to process digital assets by international accounting guidelines and standards, and based on the argument that the application in accounting preceded the theorizing, it is expected that in the short and medium-term these assets will be measured in multiple ways, which may not suit their nature and may sometimes violate some accounting principles Until the most appropriate method is known, then attention will be paid to these methods and work on framing them theoretically and perhaps revising them if necessary.

The opening of virtual branches of the company raises the question: Will these branches be independent (with an independent legal personality) from the real physical branches or non-independent branches? in other words, will these virtual branches enjoy a large degree of financial independence? and will you maintain a complete hypothetical accounting ledger suite? Will it have its accounting system, with its inputs, processing, and outputs?. Looking at the most important reasons why the company grants its branches independence, it is noted that they are either due to market conditions (such as competition), or because of the geographical location, as in the case of branches that operate outside the borders of the country in which the head office operates, or because of the distance between the head office and its branches within one country. Thus, the researcher can say that the virtual branches are closer to the independent branches; For their work outside the borders of the state first (and even outside the borders of the material world), and secondly, for the nature of their activities and privacy.

The existence of a fully virtual company or a virtual branch of a real physical company, necessarily means that there are information systems within these virtual entities, and among these systems are accounting information systems, as there will certainly be virtual information users who need virtual financial reports to make rational decisions in the world of Metaverse.

Metaverse includes a set of technologies as previously mentioned, foremost of which is virtual reality, and these technologies are highly integrated and harmonious, which means the possibility of designing accounting information systems that fit the virtual environment and the world of Metaverse, and these systems will be able to provide confidence in financial data and reduce the chances of falling into Errors and preventing opportunities for fraud and fraudulent practices, thanks to the Blockchain technology, which has been confirmed by many types of research on its ability to reduce fraudulent practices, for example [44-46].

It is noted from the above, that the Metaverse is in itself a virtual environment in which accounting can be practiced, with its encrypted and highly reliable virtual inputs, and a processing method in which the capabilities of virtual reality, augmented reality, Blockchain, and artificial intelligence are combined; To produce high quality hypothetical financial reports compared to the real physical environment.

It is not required that companies open virtual branches for them in the world of the Metaverse, it can only use the Metaverse or a kind of virtual reality as a means of communication that allows it to display its data, information, and reports that were produced in the real physical reality in a better and more attractive way, this perception was based on what was mentioned by one of the researchers that virtual reality and its capabilities can serve as a promising ground for accountants to improve financial reporting [47], and on what was stated in a report issued by the Financial Reporting Council (FRC) which indicated that The possibility for companies to display their reports that contain a set of scheduled events, and express their annual events and results using virtual reality capabilities (such as 3D video), instead of texts. The report indicated that some companies around the world have recently experimented with innovatively presenting their annual reports. And conducted its annual meetings with shareholders using virtual reality technology, however, the FRC saw that the current use of virtual reality in corporate reports is still limited and in the experimental stage, but it is expected that these technologies will have a place in corporate reports (albeit in the long term), and it should be noted. Here, what is meant by video in the world of the Metaverse is not simply displaying data in the form of a visual recording that lists events and is presented on social networks or the official website of the company, such Two-dimensional formats limit the level of interaction that they can provide, but the point is that virtual reality goes beyond mere viewing to experience, and puts the viewer within the narration, not the viewer of this narration. The French group specializing in luxury clothing [12], LVMH Moët Hennessy Louis Vuitton, is one of the parties that used a completely virtual report.

In the same context, it can be noted some of the considerations that must be taken into account when companies adopt virtual reality technology to produce financial reports in the Metaverse world, which may pose challenges to the accounting profession shortly, as follows [15; 12]:

1. The nature of the content of financial reports: The nature of the annual financial report includes different types of detailed financial statements and descriptive paragraphs about the business model and company strategy, and this combination of the content may be difficult to translate into an effective virtual reality experience.
2. The risk of ignoring: the focus of a range of groups benefiting from the data contained in the financial

reports, specifically analysts and investors, is on detailed analysis across a large number of companies, and therefore companies that use different technologies such as virtual reality may be at risk of being ignored in comparison; Due to the different nature of its reports, the lack of significant content due to the adoption of VR technology by relatively few companies remains the main challenge and obstacle to the widespread use of this technology.

3. Delayed issuance of financial reports: Virtual reality isn't a quick build-and-test process (yet). Experimental annual reports issued in virtual reality are often released publicly weeks or months after the official annual report issued in paper or PDF format, and this Limits its usefulness and value to its users.

It follows from the above, that the adoption of virtual reality technology and seeking to benefit from the capabilities of the Metaverse world by companies located in the real physical reality, may reduce - in the early stages of adoption - some of the reinforcing characteristics of the accounting information contained in financial reports, while it may improve some the other, as follows:

1. The company's adoption of virtual reality technology before the rest of the companies adopt these technologies, making its accounting information disclosed in the financial reports of a different nature that is difficult to compare with companies that did not adopt the mentioned technology, and this, may reduce the feature of comparability between the company and similar companies in the field, Users will therefore not be able to identify and understand similarities and differences between the items in these reports.
2. The potential delay in the issuance of financial reports due to the low speed of virtual reality technology in creation and testing may reduce the appropriate timing feature that requires the availability of information to decision-makers at the time making it useful for their decisions, and this is considered a challenge for companies seeking to adopt the technology, especially in light of A world of business and finance in which information loses its value whenever it comes late.
3. Virtual reality technology can increase the feature of comprehension, as it is a technique that helps in visualizing data by displaying it differently with the visual and auditory immersion of the user in the world of the Metaverse, and these elements are required for accounting information to be understandable.

But in general, accounting information is likely to be better understood, interpreted, and visualized by users and stakeholders in the Metaverse world, and the previous analysis was only from the perspective of virtual reality as the most prominent technology in the Metaverse, but what if the analysis was to take all the potentially integrated technologies In the future?, and even if the analysis is limited to virtual reality, it is noted that it allows providing consistent experiences to a wide audience, and these experiences can be cost-competitive compared to providing a real physical experience, and it also allows users to interact with an object that does not yet exist in reality In addition, it highlights data individually or in a sequence in a way that enhances understanding beyond what can be achieved through a simple text, and virtual reality can be used to reach different stakeholders and more international audiences [12].

Through virtual reality technology - and other techniques - the accountant can simulate the situation that occurs in the Metaverse world, with many possible outcomes, and it is also possible to move between these results, study and visualize them better as if the Metaverse world is implementing a form of time travel. , where the user can move backward through past events [24], this means that using the Metaverse, it is possible to help greatly in the comparison between alternatives and the selection of the most appropriate and optimal alternative, and thus help the administration in performing its functions, which comes in the forefront of the decision-making function, and this is similar - to some extent - with what some referred, where they saw that virtual reality allows the generation of experience-driven decisions and the acquisition of experience from an artificial world close to reality [48]. For example, in the context of financial markets, when immersed in a virtual environment, the user acquires the feeling that he is interacting with a real financial trading market, interacting with virtual agents, improving his actions there using trial and error procedures, defining strategies, taking action and realizing the consequences of his decisions with a high degree of visualization, which enhances his awareness of the complexity and unexpected events that can occur in the real financial market.

In the same regard, Some praised the capabilities of virtual reality in displaying financial figures in 3D graphs instead of 2D, and this would provide a different perspective for the accountant [15], as it enables him to perform financial simulations in real-time while increasing the perception of accountants of the numbers and the consequences of changes in them, meaning how can changing one variable change the company's expectations? Imagine harnessing the capabilities of the Metaverse to perform a Monte Carlo simulation or what-if analysis.

It follows from the above, that the function of Accounting disclosure of companies based in the physical World may perform better through the possibility of the Metaverse, and therefore it can be said that the level of accounting disclosure may improve significantly, which increases the value of accounting information for decision-makers, and improves the media aspect of accounting As a whole, virtual reality can provide a new package of accounting disclosure methods and tools, and this package should cover all the needs and expectations of users of accounting information that will increase shortly, as the level of demand for disclosure is expected to rise and may include other things more than just numbers, and the annual financial reports in Metaverse may be reports that tell stories about the entire history of the company and not just one year, through the union of the capabilities of virtual reality and augmented reality. That is, the beneficiary denominations of financial reports will be at the end of the year with a three-dimensional accounting journey. This, in turn, raises the question: What is the appropriate amount of skills and experience that a user of financial reports must possess to understand the disclosed data? What skills and experience should a Financial report preparer have to present it well? It makes sense to rethink the skills required of accountants shortly to provide users of accounting information with a closer view of the economic

reality of the company; To live in the Metaverse, these skills are expected to be fundamentally different from current skills.

Accountants are guided in performing the accounting measurement and disclosure functions by a set of guidelines, including but not limited to: Generally accepted accounting principles (GAAP) and International Financial Reporting Standards (IFRS), depending on the accountants' geographic location, these principles and standards are supposed to be in harmony with the shape and state of the financial and business environment, and therefore it is logical to ask a question here about the extent to which the nature of these standards is consistent with the expected technological developments in the Metaverse world. By searching in the previous accounting literature, a proposition was found that might be worth reconsidering with today's developments, which was reported by Sunder, who saw that international accounting standards are not in harmony with the digital or virtual world in which companies aspire to do their business, and thought that it is better to think about A wise mixture consisting of the social standards of the business and accounting community that derives its strength from social networks on the one hand, and the accounting rules and standards imposed by international professional accounting bodies that regulate the profession on the other hand, while not abandoning the penalty, in order to achieve a better balance in this new world, meaning a world is imagined in which written accounting rules, regulations and standards, no matter how elaborate, studied and judged they are, are only applied with the help of social rules and norms and within the framework of vaguely defined social sanctions that are understood by almost everyone, that is, Sunder prefers the existence of accounting norms applied by accountants according to their professional judgments and within the framework of social norms, rather than written rules applied by accountants for legal purposes and regardless of social norms. This means that the smaller the role of professional judgment, the lower the fees [4].

It is this proposition that Sunder considers necessary to preserve the profession and its prestige. It seems logical to think of this argument in light of the global trend toward the Metaverse, in which the lines between physical and digital are blurring to a large extent, as policies, cultures and even social norms will differ. Projecting what Sunder puts into the material world in which we live today, a lot of logic can be found. Humans adhere to customs and traditions (social norms), while they do not adhere to legislation and rules and are always looking for maps that show them the appropriate ways to escape. This is in the physical (real) world, so what about the Metaverse world?

B. Accounting education and training in Metaverse

Fortunately for accounting and auditing in the Metaverse, the virtual reality technology that constitutes the idea of this world may contribute to accountants and auditors acquiring the necessary skills that are in harmony with the needs of the Metaverse world, where virtual reality can be used in training, education and Continuing Professional Development (CPD), This has been pointed out by many reports, articles and literature, some have concluded that the use of virtual reality technologies can help in refining the skills of accountants and auditors, especially critical thinking skills, professional judgment, teamwork, project management skills, effective documentation and interviewing [49], and others added that virtual reality can be used to test different patterns of behavior, and to represent the roles that accountants will play in real life; Because virtual reality simulates real-life situations and thus helps develop communication, leadership, and teamwork skills of accountants and auditors, in virtual reality making bad decisions has the consequences of little to no embarrassment behind the screen [18]. This was also confirmed by research and articles that linked virtual reality and education in various sciences, where they all agreed that virtual reality has positive repercussions on education and training, and through it, students can understand the many scenarios related to ethical dilemmas that occur in business practices, observing potential consequences and making decisions to solve concrete situations, i.e. virtual reality allows students to simulate situations virtually and develop their long-term experiences [50-51], which is critical in light of the increased likelihood that society will live shortly in a mixed or mixed world Both virtual and physical space.

Looking at the previous experiences of virtual education in the fields of accounting and auditing, it is noted that there are some promising indicators in the process of adopting the Metaverse world. In 2009, a group of professors at North Carolina State University (NC State) created a virtual repository for students in the Second Life (SL) platform. , which was referred to earlier, and this was part of the audit course teaching program, which seeks to teach how to conduct inventory audits. Students had to go to the virtual store, pull data and documents from a virtual administrative office, and set appointments to meet the store supervisor (who was one of the professors), the students were assessed on whether they could follow instructions, and whether they showed a degree of professional skepticism, and this initiative came because most students do not know what it is like to enter a large warehouse with huge amounts of stock, but When this digital store was created they could immerse themselves in it, and the training program became more realistic. It should be noted here, that the North Carolina State University Department of Accountancy's exploration of the benefits of using the Second Life (SL) platform as a tool to enhance the educational experiences of accounting students was supported by Ernst & Young (EY) in 2008 [36]. In evaluating such educational initiatives, one research concluded that teaching in a Second Life (SL) platform increased student performance, however, there may be negative psychological reactions when students wear virtual reality glasses, such as dizziness and nausea, and their research showed that about 15% of students experienced one or more of these symptoms, and this percentage is expected to increase with the development of techniques that are used for movement and navigation in virtual reality [52].

In an article published on the ICAEW website, it was noted that VR learners are 40% more confident than learners in traditional classrooms, and 35% more confident than learners using electronic tools, in their ability to act on What they have learned [18], a recent report by PricewaterhouseCoopers (PWC) showed that VR training was up to 40% more effective for trainee confidence, and up to 50% less expensive than classroom training, for large audiences [12], others concluded that the Second Life (SL) platform is a low-cost entry into the field of accounting education [53], as well as a creative mean of communication capable of attracting the new generation of young people to the accounting profession, this generation that has grown up with high internet connectivity Speed, instant messaging, and online multiplayer [19].

All the previous compliments on virtual reality technology in the field of accounting and auditing education were based on the experience of the Second Life (SL) platform and similar platforms, and even though this platform continued until the date of preparing this research, which means that previous educational experiences can be repeated through it. However, it is expected that the possibilities of the Metaverse world will be more comprehensive and useful than all previous experiences; because it is not only virtual reality, but also includes a range of technologies such as augmented reality, Blockchain technology, artificial intelligence, and others.

Speaking about the Second Life (SL) platform, it is necessary to shed light on an important part, which is that there is a private island for Certified Public Accountants (CPA) Island, and this island is considered a center for the accounting profession in this platform, and on this island there is a virtual association under the name The Second Life Association of CPAs (SLACPA), which includes accountants, educators and students in the field of accounting from all over the world, explores the potential of virtual worlds, as a prelude to carrying out accounting applications used in the real world there, and this island is still in a state of development in terms of Infrastructure and depends on modern architecture in construction, and it may be found empty of avatars if it is visited sometimes, and many avatars may be found in the event of an accounting event there, such as: a conference, seminar or accounting workshop [19], and it should be noted here that the joining of the accounting profession to the Second Life (SL) platform was thanks to the pioneering efforts of the Maryland Association of Certified Public Accountants The Maryland Association of Certified Public Accountants (MACPA), a statewide professional association in the USA, and Katz, Abosch, Windesheim, Gershman & Freedman (KAWG&F), a leading public accounting, tax, and advisory firm founded in 1969.

By searching the Internet for a tested virtual environment designed specifically for accounting and auditing, whether professional or educational, it became clear to the researcher that there is no virtual environment specialized in these two areas, and therefore there is a need to design these environments for accounting and auditing to harmonize with the world of Metaverse, and given the Previous modest accounting initiatives, and with the increase in technological development and the widespread interest in technologies, it is envisaged that major international accounting and auditing firms and regulators of the accounting profession will take serious steps to support an accounting environment in harmony with the world of the Metaverse, in partnership with specialists in the field of information and communication technology. As you did previously with the Second Life (SL) platform.

C. Auditing in Metaverse

Any changes and updates in accounting must extend to the audit since the second depends on the outputs of the first and its operations begin from where the first ended. At the outset, it must be noted the necessity of the audit profession in the Metaverse; Because there may be stand-alone companies in Metaverse, and their financial reports will be issued to virtual users, and it is not excluded that there will be a virtual money market and an integrated business and financial environment there, and therefore there is still a need for the impartial technical opinion of the auditor. But fundamental changes are expected in the audit process thanks to the integration of virtual reality technology and Blockchain technology in Metaverse. With that, technical development is not expected to eliminate the need for external audit.

The first stage of the audit is planning the audit process itself, by developing a comprehensive plan for the scope of the examination and translating it into a program that includes a set of steps and procedures. In preparation for the development of the audit strategy, which is later translated into a more detailed plan, leading to the design of the audit program within the framework of the strategy and plan. Looking at the previous series of steps from the angle of the Metaverse, it can be said that planning the audit process for companies that operate in this world or that operate in the physical world but use virtual reality technology in performing some tasks and activities, will require the auditors to have sufficient knowledge of the nature of the Metaverse, from a technical point of view And to identify the nature of the financial and business environment and the types of risks there, so that they can develop a comprehensive audit strategy, plan, and program.

In this regard, some have indicated that health and safety risks are reduced in the world of Metaverse [15]. While others have pointed out that despite the low health and safety risks when conducting the audit process in the world of the Metaverse, cyber security risks The risks of data privacy and identity will be high and may reach deeper levels [29]. This requires auditors to carry out additional tasks in the planning phase of the audit process and the implementation phase of the audit process by ensuring that the risk management assesses these risks, and checks the controls that will be established Information technology management about the use of this technology.

Also, in the planning of the audit process, it is important that the auditors understand the accounting information system and the internal control system of the contracted company. If the company is based primarily in the Metaverse, this requires the auditors to identify the characteristics of all the technologies that make up this world and relate them to their concepts and requirements of auditing, To judge those systems that form the cornerstone of developing an audit strategy and plan.

After completing the planning stage of the audit process, implementation and gathering of Evidence of proof begin, to be relied upon in expressing an impartial technical opinion on the fairness of financial reports (Financial Statements), and this is what the third standard stipulates. Also from the fieldwork criteria, the external auditor is required to obtain sufficient and convincing evidence to form an adequate basis for expressing an opinion. A clear, audited, and visible record that cannot be altered or falsified. Also, the registration process in this registry is only after the approval of all the parties and members of the network [54], so there will be less need for authentication in the Metaverse. That is, the combination of the characteristics and capabilities of the technologies that make up the Metaverse will have a positive effect on the supporting evidence that the auditor needs.

In addition to the above, the Metaverse can be used as an audit tool, as it enables the auditors to make tours of the company’s locations located in remote geographic areas in the physical world, rather than moving to those areas physically and incurring travel and accommodation costs, where they just

go to the virtual location that simulates the physical location and its characteristics, and a 360-degree view of the Metaverse, thus achieving savings in costs and time, which can be used to carry out new activities that add value to the company. That is, the Metaverse can make the audit process safer and less wasteful of economic resources in some situations. In this regard, some have indicated that people can interact with virtual reality in a way that appears to them as real or physical, using the previously mentioned virtual reality devices. These devices make them immerse themselves in virtual reality [44]. Here, the expected that this technology will facilitate Auditors' work largely in the Metaverse. They can perform a document audit and discuss management through these technologies, so that the auditor and members of the management wear them and move to a virtual reality in which they meet and discuss what they have, regardless of space barriers. In the Metaverse, data may be available and additional information compared to the real physical environment, due to the harmonious integration of a range of technologies within this world.

It should be noted here, that some of the previous advantages or opportunities are also referred to when talking about remote auditing, and here we must alert a very important point, which is that the term remote audit refers to the traditional audit processes implemented by electronic devices and social networks traditional, and not by virtual reality devices or in the Metaverse world, meaning that the auditor under the term remote audit roams in the real physical environment by cameras and software, and not in a fully virtual environment as in the Metaverse world.

In the same context, the Financial Reporting Council (FRC) has reviewed a legislative issue that will need to be resolved shortly, as, by current legal requirements, no audit work will be conducted on the default version of financial reports or any enhanced layer of data (financial and non-financial) that is not visible in the paper document, there is no obligation for the auditor to do so; Because the financial report is considered - so far - in terms of concept and from the point of view of the law, a paper document only that is signed from within the company, and the references give it confidence by sealing it and signing it from outside the company [12]. However, the auditor should not wait for legislation, and can optionally provide confirmation, and provide new services to its clients, thus constituting a competitive value for it, until the legislator has his say and forces the audit to expand its services. Companies may look at this issue from another angle, where their point of view may be that the user of financial reports trusts the contents of the audited reports, and since the audit has not yet been obligated to audit the financial reports issued in virtual reality, this is likely to affect The value and level of trust given to this type of financial reporting by its users, and therefore there is no need to use these technologies, and therefore they may view the matter as a limiting factor for the use of full virtual reality [12], and therefore the company does not step into the world of the Metaverse.

D. Accountants and Auditors at Metaverse

Although the world of the Metaverse provides accountants and auditors with an immersion in virtual scenes with their minds and bodies, which positively reflects on their perception of the real and virtual financial and business environment together, and although this development releases the curiosity, enthusiasm, and intelligence of accountants and auditors to explore the state of the scene before them. The researcher does not hide his fear that both accounting and auditing will become more miserable in the world of the Metaverse, through the disappearance of direct interaction between accountants, auditors, stakeholders, and other relevant parties, and that accountants and auditors move from one virtual work environment to another in a way similar to their transition from page to page on the Internet today, Thus, the feeling of the other decreases, and feelings become dulled. The researcher finds that no matter how technology reaches its advanced levels, it will not match the real physical reality that is full of emotions.

The discussion takes another turn when talking about what one of the researchers touched on, which is the issue of the informational corpse. Personal information in the Metaverse world can live virtually long after the death of a person in the physical world. To clarify the idea, a reference was made to the Musical Hologram Tour for Whitney Houston after her death [35], she passed away in 2012, and she revived concerts in the material world in 2020. Although the previous example refers to augmented reality technology and not virtual reality technology, meaning that the Houston concert was held in the physical world by augmented reality technology, that is, a virtual thing was called into the physical world, but what if the opposite happened? That is, what if the media corpse is seen as the one that will remain in the Metaverse world after the death of its owner in the physical world? And if this issue is linked to accountants and auditors in the Metaverse world, this means that the accountant or auditor is expected to die in the physical world and remain alive in the Metaverse. Here, some questions need to be answered, for example, how the virtual version will be dealt with Who are the accountants and auditors? and will this copy stop working as soon as its owner dies in the physical world by linking it to certain databases that are continuously updated (such as the Blockchain)?

Some may see that what this corpse will do is a mere repetition of previous actions and that it will not bring anything new. For example, in the case of the Houston concert, no new moves were introduced, and all the moves were previous moves that were replayed. But what about the possibilities that artificial intelligence (AI) that takes advantage of the accumulation of knowledge and attitudes in this aspect might offer? Where he may be able to make the virtual character of the accountant and auditor complete the journey for a certain period alone as a hypothetical corpse, although the researcher believes that it is difficult (and almost impossible) to repeat all actions in accounting and auditing in order not to repeat the same economic events.

V. CONCLUSION

Metaverse is the latest technology that seeks to fundamentally change the way we do business and interact with those around us, including the business and financial environment, and therefore accounting and auditing will likely have some impact, This research has tried to raise some future questions about accounting and auditing in Metaverse, leaving some of these questions open unanswered, and in some details, it tried to imagine some scenarios, but all of them remain just a forecast for an unknown future, but it is important to visualize the extent and size of the potential impact.

The research tried to start by identifying the extent of the need for accounting in the world of Metaverse and concluded that there is a need for the accounting profession as long as there is an economic exchange in that world, and the nature and functions of accounting information systems in Metaverse may be affected, but the goals of accounting will remain the same, the changes It will be in applications and not in theories, in addition to the fact that Metaverse provides new assets that need an accounting measurement, and it also provides new disclosure tools, all of which are in the interest of the characteristics of accounting information in the long run. On an academic level, Metaverse can provide a different interactive learning and training environment for accountants and auditors, which may improve their abilities and skills to fit in with the digital world. In addition to the above, accounting cannot be isolated from auditing, so we can expect to hear Metaverse echoes in auditing as well, especially in terms of audit planning, evidence gathering, and risk assessment.

Finally, whatever the level of capabilities of Metaverse, this research sees that Metaverse represents a vertical development and not a horizontal development in the fields of accounting and auditing, where the objectives of accounting and auditing are still the same and have not changed, and Metaverse technologies will be auxiliary tools for accounting and auditing.

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