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Review

Influential Factors in the Design and Development of a Sustainable Web3/Metaverse and Its Applications

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Abstract: This paper summarizes the work of many different authors, industries, and countries by introducing important and influential factors that will help in the development, successful adoption, and sustainable use of the Web3/metaverse and its applications. We introduce a few important factors derived from the current state-of-the-art literature, including four essential elements including (1) appropriate decentralization, (2) good user experience, (3) appropriate translation and synchronization to the real world, and (4) a viable economy, which are required for appropriate implementation of a metaverse and its applications. The future of Web3 is all about decentralization, and blockchain can play a significant part in the development of the Metaverse. This paper also sheds light on some of the most relevant open issues and challenges currently facing the Web3/metaverse and its applications, with the hope that this discourse will help to encourage the development of appropriate solutions.

Keywords: web3; metaverse; blockchain; virtual reality; augmented reality

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1. Introduction

Recently, the Metaverse has become a familiar name among tech enthusiasts all around the world. The term "metaverse" was first coined by Neal Stephenson almost 30 years ago in his science fiction novel "Snow Crash" [1]. The word is a combination of "meta" (meaning beyond) and the stem "verse" from "universe". It entails a three-dimensional virtual space in which users can interact and communicate with each other as Avatars [1]. The world we live in today may not be so different from the Metaverse described by Stephenson. The Internet and the web have become such essential parts of the way we work, live, and communicate that life without them seems almost impossible to imagine [2]. For instance, online shopping (as one of the foundations of the Metaverse) is an integral part of the lives of young people born after the year 2000 (Generation Z) [3]. In 2020, partly due to a response to COVID-19, many online retail companies grew exponentially due to the increasing demand for online shopping. This trend is not likely to decline or change, even after the end of the pan-demic [4] based on current expectations that the online retail industry will grow to over USD $6.5 Trillion by 2023 [4].

Indeed, it is anticipated that in the not-so-distant future, we will see a transition from the current Internet of information to an Internet of value which will build the foundation of any metaverse. Such a metaverse will include a variety of digital assets, digital identities, digital contracts, digital intermediaries, and other digital resources [2]. There are many signs that the next generation of the Internet, which will include the Metaverse, will become the center of our lives even more than it is now, thus transforming humanity as we know it [5]. The Metaverse or perhaps multiple decentralized interoperable metaverses will change our economy, finance and money, science and technology, and in general the way we live, socialize, and work in the future [4].

On the other hand, there are several metaverses readily available today [6] and many technology giants have their own metaverses in the making [7]. However, there is no guarantee that users will accept one of these, or even in the case of initial acceptance, they will continue using it [7]. There are a variety of different reasons why users might show an interest in a metaverse [8]. Those reasons could be far from what the creators of such metaverses initially had in mind [8].

In this paper, we will introduce a few important factors derived from the state-of-the-art literature. In the following sections, we will review the existing novel metaverse research in the field, including a description of each one of those factors. Our conclusions will discuss our findings and how they may guide the eventual outcomes of the Metaverse developments we anticipate will happen as a result.

2. Methodology

Using prismatic analysis [9], this study aims to explore the multifaceted nature of the Metaverse by examining its various technological, social, and economic dimensions and how they interact with each other to shape this emerging virtual space. We have chosen Google Scholar, which provides a wide range of scholarly articles, conference papers, and other research publications related to the topic. In addition, the World Wide Web is also searched for some of the industry examples and non-scientific instances. This approach has been used in similar prior studies [10].

The main research questions proposed to be answered based on the objectives of this study were:

(1) What is the correct definition of Web3 and Metaverse?
(2) What are the most influential technological, psychological, economic, and social aspects of a sustainable Web3/metaverse and its application(s)?
(3) What are the open issues in this field?

Some keywords that are used to create proper search queries from Google Scholar are shown in Table 1 below. These keywords were combined in various ways to create search queries that would help identify relevant studies for the systematic review.

Table 1. Keywords Used in Search Queries.

Metaverse	Sustainability	User interface	Community building	Energy consumption	Decentralization
Web3	Virtual Reality	User-centered design	Content creation	Carbon footprint	Smart contracts
Sustainable design	Virtual environment	Blockchain	Governance	Environmental impact	Gamification
Sustainable development	Augmented Reality	Cryptocurrency	Regulation	Economic impact	Social interaction

To begin the systematic review process, initial search results were collected, and duplicate papers were removed. The remaining papers were then assessed against inclusion and exclusion criteria based on their titles and abstracts. Full-text screening was conducted on the remaining papers to ensure they met the eligibility criteria. During this process, references from each paper were manually examined to ensure they also met the criteria. The remaining papers were then examined again in relation to the research questions, with information extracted and recorded.

The inclusion/exclusion criteria ensured that search results were both accessible and relevant to Web3/Metaverse, meaning that the topics studied had to contribute to either application, design, development, or consumer behavior. Only the most extended version of a search result was included, and the eligibility criteria ensured that all included results could contribute to at least one of the three research questions. Additionally, papers that did not provide a comprehensive explanation of the research process were not considered.

Figure 1 provides a summary of the search process, including the number of remaining papers at each step. The initial database search returned 989 papers, with 316 papers remaining after duplicate removal, retrieval, and assessment against inclusion and exclusion criteria. An additional 35 online articles were identified through the WWW search, and 29 of them were examined again using the relatedness criteria. Finally, 71 papers as well as 16 online articles that were the most up-to-date and relevant to the study, were included. Figure 1 demonstrates a summary of the whole process.

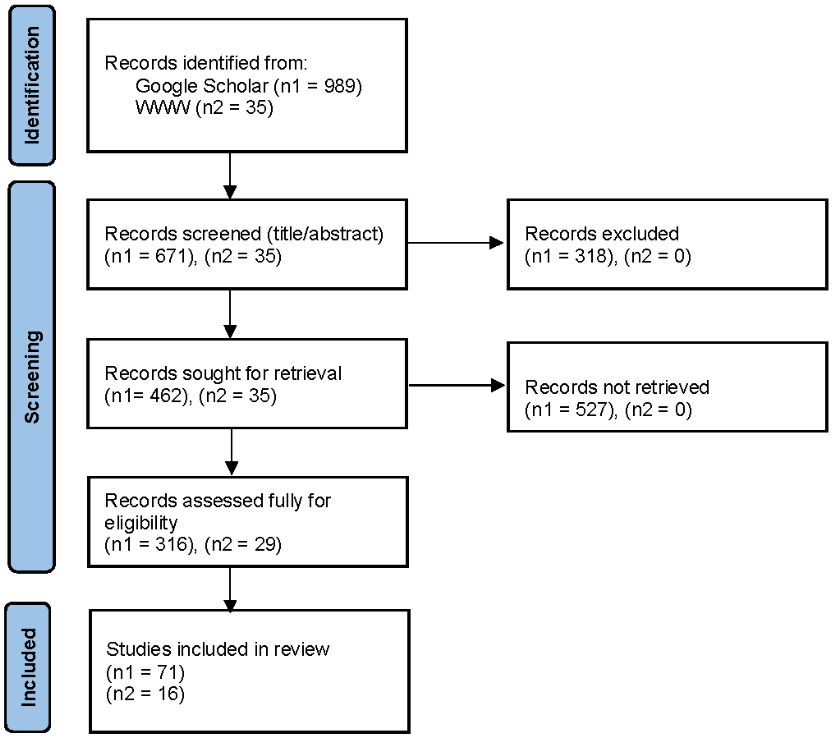

Figure 1. Summary of the Search Process.

The following are the inclusion, exclusion, and eligibility criteria for each paper extracted from Google Scholar.

- Inclusion criteria:
  - ➢ A full-text version of the paper is available.
  - ➢ The paper is related to Web3/metaverse.
  - ➢ The paper is written in English.
  - ➢ The paper is written any time after 2019.
- Exclusion criteria:
  - ➢ A full-text version of the paper is not available.
  - ➢ The paper is not related to Web3/metaverse.
  - ➢ The paper is not written in English.
  - ➢ The paper is written before 2019.
- Eligibility criteria:
  - ➢ Be an original research paper published in an academic journal or conference.
  - ➢ Be a complete research paper, presenting the research issue, process, and results.
  - ➢ Address a research topic related to virtual commerce.
- Relatedness criteria:
  - ➢ Answer either question Q1, Q2, or Q3 or help to form an answer for them.

3. Web3 and Metaverse

Today, the Internet is facing many challenges, including data authenticity and integrity, privacy, transparency, trust, and security, partly due to its centralized nature that tends to exacerbate unresolved problems as the Internet gets bigger over time [11]. The concept of a server/computer controlled by a central authority serving millions of users essentially comes from the nature of the static web, the so-called "Web1" in the early 90s. At that time, the static content of a website was supplied by a server to its (many) users through a unidirectional channel from a static file rather than a database [12]. A bank was a good example of that, and the content they showed at the time was only information. Later, with the introduction of "Web2" or the "social web", interactions with online databases became common with bidirectional communications between servers and users, which led to users creating content for the websites they used [12]. Good examples of that are the blogosphere or *Facebook*, where content created by users became an integral part of the platform. Recently, the concept of "Web3" was born with the emergence of Blockchain technology. Web3 has already begun to affect many industries by making the communication channel multidirectional (peer-to-peer). It has brought change to all the industries it affects, including the Internet itself [11].

Web3 integrates several technologies which together provide an immersive user experience by creating a digital world that mirrors the real world. It also creates a new type of modern social form that comprises cultural, economic, and legal systems of its own, which tend to mimic the real world. In addition, it has the characteristics of hyper spatio-temporality, which refers to a parallel virtual world that breaks the boundaries of space and time by offering free, open, and immersive experiences to the users [13]. In the following, we discuss a few influential factors that play important roles in the adoption and sustainability of the resulting Web3 applications, regardless of the purposes for creating such applications.

3.1. Appropriate Decentralization

Web3 is based on decentralization. To sustain a decentralized web, metaverse projects need to be built as decentralized platforms. These digital decentralized platforms must store transaction information, which is accessible and verifiable and nearly impenetrable to manipulation. There are four essential elements required for the appropriate decentralization of Web3 applications: (a) decentralized computation, (b) storage, (c) database, and (d) blockchain [14]. We now describe the first three elements and dedicate our next section to the fourth factor (Blockchain) due to its importance and connection to the Metaverse.

3.1.1. Decentralized Computation

Everything in Web3 is data, and all that happens to data is computing. Thus, a large number of separate computing machines is needed to provide all the calculations required to build any desired environment (i.e., the digital world). Decentralization makes the computations efficient and accurate [14]. Moreover, in case of any system failure of any of the computation nodes, the whole application must not fail.

3.1.2. Decentralized Storage

There are a variety of objects that may exist as data within a Web3/metaverse application, such as avatars, energy, buildings, land, space, power, medical, and healthcare materials, etc. Storing everything in a fully decentralized way ensures that [14]:

- Everything will be accessible to everyone, and nothing will be modified without following a specific protocol. In addition, everyone will know about such modifications as they occur.
- Everything will be safe in case of a system failure since the storage is decentralized, and everyone owns a copy.

3.1.3. Decentralized Database

This concept is a bit different from decentralized storage. A decentralized database provides a solid base for users to organize and use their data to build things in Web3, enriching them as time goes by. A decentralized database will ensure that the data are always available for user access [14].

3.1.4. Distributed Ledger Technology (DLT)

DLT allows multiple parties to share a single version of the truth in a decentralized and secure way [15]. For instance, DLT plays an important role in the realization of the Internet of Things (e.g., smart homes, etc.) by contributing towards (1) security and privacy, (2) identity management, (3) machine-to-machine transactions, and 4) traceability and provenance [16].

3.1.5. Inter-Planetary File System (IPFS)

IPFS is a peer-to-peer protocol that enables users to access and share files and data directly without the need for a centralized server [17]. For example, in the context of healthcare, IPFS can be used for fast retrieval and easy sharing of patients' personal health records among a variety of players, such as physicians, nurses, insurance companies, or researchers, without any concerns for security and privacy [18].

3.1.6. Decentralized Identity (DID) and Identity Management System (IdMS)

DID allows users to have control over their personal data and identity on the Web3 [19]. In addition, the process of uniquely recognizing and representing an entity as a digital identity in a virtual environment is performed under the hood of an Identity Management System (IdMS) [20]. For instance, any domain name is a decentralized identity in the context of the World Wide Web, defined and managed by the W3 consortium [21].

3.1.7. Smart Contracts

Smart contracts are self-executing contracts that can be programmed to automatically enforce the rules and penalties of an agreement [22]. Smart contracts are based on and empowered by blockchains [23]. For instance, Solana (SOL) is one of today's fastest blockchain networks that has implemented and is using smart contracts [24].

3.1.8. Blockchain

Blockchain is a technology that was described by a group of researchers in 1991 with the intention of time-stamping digital documents to make them tamper-proof. This idea went mostly unused until the surfacing of Bitcoin [25]. Essentially, the concept is to store records of transactions in digital blocks that are created by solving cryptographic puzzles. Newly created blocks validate their predecessors, and the resulting ledger of blocks is distributed and updated by every node or user participating in the network [26]. This process creates an accurate and decentralized ledger of transactions that every network participant can trust and use, hence eliminating the need for a centralized record-keeping entity. However, despite its groundbreaking role, the traditional blockchain structure has inherent limitations and deficiencies [27] that have created a need for more advanced alternatives [28].

3.1.9. Appropriate Protocol

Since blockchain by design is a distributed peer-to-peer system, a consensus protocol is required to come to a consensus on how a decision is made about writing a block to the chain or what is considered to be a valid/invalid block, etc. [29]. The better a consensus protocol becomes, the better blockchain performs. For instance, comparing the two famous consensus protocols, Proof of Stake or PoS [30] (used by TRON, Nano, and Steem, where the participants vote on the current state of the ledger based on the number of tokens they own), and Proof of Work or PoW [31] (used by Bitcoin, Ethereum, and Litecoin, where the participants expend machine time and electricity solving an arbitrary mathematical puzzle (i.e., hash) to decide the state of the ledger), clearly shows the superiority of the former in terms of scalability, transaction cost, and energy consumption [32].

As a matter of fact, there are many alternatives to these two protocols suggested, including [33]: permissioned, permissionless, consortium or federated, DAG-based [34], and many others. A DAG (directed acyclic graph) is a form of a directed graph that consists of vertices and edges, with each edge directed from one vertex to another in a way that following those directions would never result in a closed loop [34]. There are a variety of different implementations of DAG-based Blockchain [35]. The Block-lattice is another variation that allows each user to have their own blockchain that only they can write to instead of writing all user transactions to a single blockchain shared by everyone [36]. DAG-based Block-lattice systems could theoretically achieve near-instant transaction times along with unlimited scalability, near-zero transaction fees, and superior cost-efficiency because of their low energy consumption protocol, as well as great reliability and security [36]. Therefore, it seems that this type of blockchain (and its derived coin/token) is potentially a suitable choice for the purpose of decentralization at this time.

3.1.10. Blockchain Interoperability (Technical Perspective)

According to both industry and academia, the interest in the development of real-world decentralized applications, such as those in public administration and access control, has been on the rise, thus the need for blockchain interoperability [37]. Blockchain interoperability is defined as "*a composition of distinguishable blockchain systems, each representing a unique distributed data ledger, where atomic transaction execution may span multiple heterogeneous blockchain systems, and where data recorded in one blockchain are reachable, verifiable, and referable by another possibly foreign transaction in a semantically compatible manner*" [37]. Endorsed by the European Commission, the National Interoperability Framework Observatory (NIFO) has suggested several interoperability layers for those applications, including technical, semantic, organizational, legal, integrated service governance, and interoperability governance layers [37,38]. The full interoperability of any metaverse or Web3 application is directly dependent on the blockchain interoperability of these mentioned layers. Interoperability not only provides flexibility and portability but also promotes scalability and privacy (the two major challenges of blockchain) while creating new business opportunities that would not be there without interoperability [39,40].

Currently, in the realm of Web3/Metaverse, many players in different industries are working on creating/improving their own applications and targeting their own users/customers [41], which simply means no single entity will be controlling the future, at least not completely. The possible big picture could be that "The Metaverse" would be formed, comprising many existing and upcoming Web3/metaverse applications that would become interoperable and join each other. Thus, interoperability plays a huge role in the sustainable use of any new Web3 application.

3.2. Good User Experience (UX) Design

Although UX (User Experience) is tightly related to user satisfaction, there is no widely accepted consensus on the theoretical model or definition of UX, which in turn, affects both the design and evaluation of the system. Thus, the means for evaluating UX should be more holistic [42]. While working with different and often conflicting requirements of today's modern software (e.g., metaverse) is a significant challenge, designing a good user experience is essential. Hence, in conflicting situations, priority must always be given to the betterment of UX over other requirements [43]. In the case of a metaverse, UX is a multi-dimensional concept, including a wide variety of aspects that may conflict with each other. Below, we try to cover different aspects of UX in the context of the Metaverse.

3.2.1. Proper Visualization and User Interface Design

Even though the Metaverse is still considered to be in its infancy stage, it is supposed to be an extended visual world/universe blended with the real world that users can see and interact with as players or avatars [44]. The extended visual world in a Web3/metaverse would usually include three specific technologies: Virtual Reality (VR), which replaces the user's full vision with a digitally created world; Augmented Reality (AR), which blends the real world with digitally created objects; and Mixed Reality, which is a hybrid of both VR and AR [14].

The proper design and visualization of such a universe require technologies that enable user exploration and bi-directional interaction. The virtual world environment can be built by either using 3D laser scanning and photogrammetry to create the necessary digital 3D models or by using specialized 3D modeling software. In either case, the user must be considered at the core of the design since the Metaverse is user-centric by design [44]. For the sake of object visualization, creating an environment for users to be useful and easy to use should be the core of any design effort [45]. Figure 2 demonstrates a visual depiction of the construction pipeline, including the two specified methods that would help us achieve the process of integrating initialization, modeling and rendering, and animation.

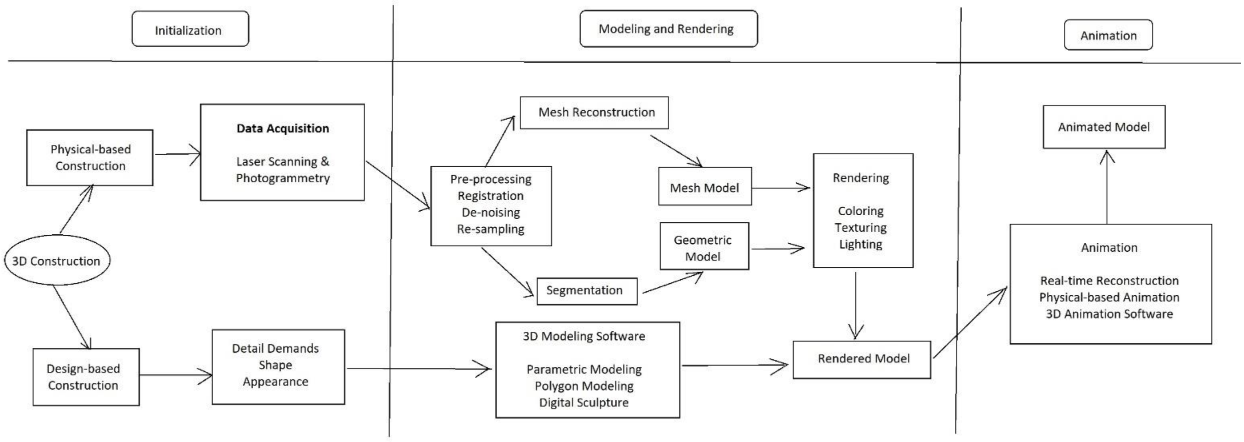

Figure 2. Visualization Construction Pipeline (courtesy of [45]).

3.2.2. Using Advanced Tools to Customize User Experience

By leveraging advanced tools and techniques such as business intelligence tools, machine learning, natural language processing, data-driven decision-making tools, sentiment analytics, and real-time IoT (Internet of Things), the user experience can be personally tailored to serve each user the best way possible. This includes enhancing business performance and configuring customer purchasing habits to improve customer expectation, confidence, loyalty, and engagement, which should eventually result in user/customer satisfaction [46].

3.2.3. Gamification and Hedonic Motivations

Plenty of studies [47–49] offer evidence from different contexts and industries that gamification works. Hedonic motivations such as perceived user enjoyment have a significant effect on users and how they use any application [47]. One study [50] showed that in the presence of hedonic motivations, a user would be encouraged to go the extra mile to keep using the application. In addition, studies in the Metaverse are also showing that gamification in the context of the Metaverse is also very effective and beneficial [51]. Thus, we can safely infer that to achieve success in the adoption and continuous use of any newly designed metaverse, gamification and hedonic motivations should be incorporated into the design plans.

3.2.4. Proper Content Accessibility

The Metaverse represents a novel paradigm that extends beyond the scope of VR or Augmented Reality (AR). It is characterized by its persistence, synchronous and live nature, and unrestricted access to concurrent users. It also incorporates a fully functional economy with direct ownership of assets, offers an experience that bridges the digital and physical worlds, and is interoperable. Furthermore, it is designed to encompass a multitude of diverse experiences contributed by different types of contributors [52]. Naturally, the question would be whether we (the industry) are ready to provide experiences in Metaverse that suit persons with disabilities [53], including:

- **Vision**: vision accessibility refers to the design and implementation of digital products, services, and environments that are accessible to people with visual impairments or other visual disabilities [54]. It is an important aspect of digital accessibility and ensures that people with visual disabilities can access and benefit from digital content on an equal basis with others.
- **Audition**: audition accessibility refers to the design and implementation of digital products, services, and environments that are accessible to people with hearing impairments or other auditory disabilities [55]. It is an important aspect of digital accessibility and ensures that people with auditory disabilities can access and benefit from digital content on an equal basis with others.
- **Tactition**: refers to accessibility to VR and Metaverse for people with physical disabilities, such as those who use wheelchairs [53]. For example, WalkinVR is one of the innovators in the field which tries to provide accessibility for people with physical disabilities to access VR environments [56].
- **Olfaction and Gustation**: despite the fact that the senses of taste and smell (or in other words, gustation and olfaction stimuli) have a significant impact on our daily lives, affecting our behavior, choices, and ability to focus, they are often overlooked and given less attention [57]. While olfaction and gustation can significantly enhance the user experience in the Metaverse, they are primarily output stimuli and, therefore, not likely to serve as alternative means of communication with computer systems for individuals with disabilities [53].

3.3. Appropriate Translation and Continuous Synchronization to the Real World

Web3 is all about combining and syncing the real world and its digital twin in the virtual world. Having a live copy of physical entities in the form of digital twins in a Web3 environment (i.e., a metaverse) has a variety of applications, including manufacturing, healthcare, smart cities, education, next-generation networks, and many more. It provides several advantages, such as enhanced productivity, more efficient and effective business processes, fewer delays, and faster innovation, with significantly fewer costs [58]. Such operations would also require continuous synchronization between the two worlds.

One of the most important aspects of creating a digital twin of the real world (i.e., in a metaverse) is continuous and consistent data synchronization by continuous acquisition and comparison of data from both worlds to keep the digital twin world up to date [59]. As an example, virtual driver training software—which uses real-world data to simulate other drivers, weather, and roads—should continuously update itself and make sure that the simulation is the closest possible to the real world to ensure its service reliability, along with a realistic examination of driving skills of the trainees [60]. Having said that, the correct and proper translation of value as well as consistent and continuous synchronization between the two worlds, are the top goals to ensure the success of Web3 applications of any kind. The technologies described in the following sections are essential for achieving those goals.

3.3.1. Spatial Computing

The ability to map and understand physical space and objects in the real world is called spatial computing [61]. In the context of Web3, spatial computing can be used to create decentralized and immersive virtual experiences that can be accessed through the

Web3 ecosystem. AR (Augmented Reality) and MR (Mixed Reality) are technologies that could be used for a variety of purposes, such as an object or facial recognition, plane detection, and movement tracking. An example is doctors using such technologies in environments such as digital operation theatres, where everyone can watch live patient medical operations [14]. According to many sources [62–64], the following are the key technology elements in spatial computing in Web3:

- Augmented Reality (AR): AR technology allows users to overlay digital information and objects onto the real world, creating a more immersive and interactive experience.
- 3D modeling and mapping: 3D modeling and mapping technologies are used to create detailed and realistic virtual environments that can be accessed through Web3.
- Location-based services: Location-based services can be used to provide contextually relevant information and experiences to users based on their physical location.
- Edge computing: Edge computing allows for the processing and storage of data closer to the point of user interaction, reducing latency and increasing the responsiveness of spatial computing applications.
- 6G wireless communications: 6G wireless communications technology enables faster and more reliable data transfer, which is necessary for the real-time interactions that are required for spatial computing applications.

3.3.2. Internet of Things (IoT)

One of the most effective tools to enable such frequent updates and continuous synchronization of both worlds is to employ IoT (Internet of Things) devices, such as smartphones, drones, and self-driving cars, to collect and submit the needed data from the real world to a Virtual Service Provider (VSP) which would serve the Metaverse [59].

3.4. Viable Economy

Since the early ages of human civilization, physical properties and belongings have been indicators of human wealth. However, the problem was that exchanging value was an issue. In those days, "bartering", or exchanging goods or services for other goods or services, was the main tool for exchanging value among humans, which led to the invention of commodity money (a commodity such as wheat), coins, gold and eventually paper money [65]. Later, real estate and, more importantly, land became important indicators of wealth due to their value-holding properties. Real estate provides the owner with the power to generate wealth by growing crops, raising livestock, and borrowing "money" based on such ownership, which is still relevant today [66]. With the emergence of new technologies such as AR/VR, Blockchain, fast mobile Internet, AI, etc., metaverses have become a reality, and digital assets have also become the primary pillars for such virtual worlds [67]. Like the real-world, digital assets can play the same role in creating wealth in a metaverse [67]. For instance, users may acquire digital real estate and rent/lease/develop/use them, not only to create wealth but also to profit from their growth in value over time [68].

Digital assets include but are not limited to:

- Cryptocurrency (coins/tokens)
- Non-Fungible Tokens or NFT (these are unique tokens which hold some sort of data that belongs to specific users)
- Digital real estate
- Digital identities
- Other digital assets such as games or real-world objects, relics, etc.
- Consumable digital assets (such as life bars in games or simply how many times the user gets to play the game. The users may have to buy more life bars to be able to continue playing the game).

Having said that, cryptocurrency would play the biggest role in the whole economy of any metaverse since it would be the base for transferring or holding any type of value in such a space. Designing any type of metaverse without a sound and viable token economy to exchange value in a meaningful way among the users is likely to lead to failure. Here in the next section, we explain the types of token economics that we have seen in the industry [69].

3.4.1. First Generation (gen 1)

This is the most primitive type of economic framework based on supply and demand and driven by speculation and transaction volume. The higher demand and lower supply give more value to tokens and vice versa [69]. This generation usually uses the Proof of Work (PoW) protocol [31]. This economy would eventually result in a zero-sum game: the inflow of value (e.g., mining equipment, operating costs, etc.) would be equal to the output value of the system in the form of mined tokens. Transaction fees are small for the overall design. Furthermore, the value can be derived from speculation [69]. Bitcoin [25] and Litecoin [70] are good examples of this primitive economy.

3.4.2. Second Generation (gen 2)

It involves the implementation of basic incentives for users to keep the tokens and get rewarded for keeping them [69]. This would reduce the token velocity, which is defined as "*the average number of times a token or coin changes hands within a defined period*" [71]. This generation usually uses the Proof of Stake (PoS) protocol [31], although there are some exceptions as well. EOS [72] is one example of the second generation that uses the PoS protocol. In addition, Ethereum [73] has also started as a second generation. However, it has been evolving into the third generation.

3.4.3. Third Generation (gen 3)

This is the state-of-the-art token economics that is currently seen in the industry. This generation (gen 3) has at least the first two and some of the other following attributes:

- **Modern Token Supply and Control Model:**

  Almost all the gen one and most of the gen two projects are using fixed token supplies. The introduction of the PoS protocol allows for a more modern token supply model. Such models may use an Inflationary model (increasing the supply of tokens based on the assumption that it is needed to keep the costs low and support the users) or a Deflationary model (using a burn mechanism to get rid of tokens to make the remaining tokens more valuable), or a combination of both. It also includes a monetary flow control mechanism to increase or decrease the amount of capital in and out of the system [69]. For example, the decentralized finance (DeFi) platform provided by Ethereum incentivizes capital inflow to the ecosystems while disincentivizing capital outflow [74].

- **Smart Contracts:**

  Smart contracts are defined by IBM as "*Smart contracts are simply programs stored on a blockchain that run when predetermined conditions are met. They typically are used to automate the execution of an agreement so that all participants can be immediately certain of the outcome, without any intermediary's involvement or time loss. They can also automate a workflow, triggering the next action when conditions are met*" [23]. Cardano is an example that has implemented Smart Contracts into its economy [75].

- **Perks and Incentive Pools:**

  There would be rewards and credits given out on a distribution curve to incentives anyone that in any way can help the project. For instance, developers who use the project and its tokens to build decentralized apps are given these incentives. Instead of having developers focus on apps to generate profit, these rewards incentivize them to build apps that benefit the well-being of the whole ecosystem [69]. For instance, XRP offers such incentives for its developers [76].

- **Token Burning and Decay Mechanism:**

  Both are essential mechanisms for making the remaining tokens more valuable. Thus, they are a sort of deflationary mechanism to control unintended inflation. In the first one (burning), the network will burn specific tokens (either a portion of all tokens or some pre-defined tokens) to control inflation. Decay could also be in the form of fewer block rewards after a pre-defined amount of time, mined tokens, or mined blocks. For instance, in Bitcoin, the reward per block will reduce after a predetermined number of blocks [69].

- **Liquidity Pool—Lending and Market Making:**

In the real-world market, traders make money by providing or offering liquidity/capital. These pools are designed to create incentives for users to create permanent or temporary required liquidity/capital for products/services or tokens. Rules in these pools are clear, and there will be no fine print [69]. An Example is Kyber, a liquidity hub for Crypto trading and DeFi [77].

- **Insurance Pools:**

These pools are designed to protect the system against risks such as catastrophic exploits, hacking, 51% attacks, etc. The pools can be managed by the network (consensus), a council, a foundation, or even a company with the main purpose of moving tokens in a scalable and continuous manner [69]. A great example is Nexus Mutual which is focused on protecting against failures of smart contracts [78].

- **Inter-chain Operability and Inter-Chain Messaging:**

These capabilities enable apps on a chain to interact and exchange value and messages with other apps on different chains that may even be using completely different technologies [69]. The Cross-Chain Interoperability Protocol (CCIP) aims to establish a universal connection between hundreds of private and public blockchain networks by providing a generalized infrastructure for unlocking messages and token transfers and empowering cross-chain applications for all on-chain ecosystems [79].

- **Foundation Economics:**

Foundations are responsible for managing value inflow and outflow in an ecosystem in a sustainable manner. It is also to decide the size of token allocations. For instance, if the allocation is too large, the supply may become over-incentivized and thus constricted. On the other hand, if the allocation is too small, it may not incentivize the users to keep value in the system, thus unsustainable [69].

- **Governance:**

Governance is essentially a mechanism to decide matters such as inflation, burn, block rewards, validators, etc., and adaptability is the key for this mechanism to succeed [80]. In order to be adaptable, the governance must properly consider, anticipate, and react to changes in the market, economy (both crypto and real world), ideologies, and the underlying technology [69].

3.4.4. Fourth Generation (gen 4)

There is no 4th generation around just yet. However, the consensus is that this generation will optimize all the above-mentioned attributes or gen 3 and connect them directly to traditional equity and assets of the real world. Essentially, there would be no border between virtual and real-world value in the fourth generation. There would be two primary goals for gen 4, and that would be to (1) create leverage similar to the real world (i.e., Real Estate: 30 to 1 leverage in buying a home using an FHA loan at 3.5% down payment), and (2) bridge the virtual and real world by allowing leverage, collateralization, and claims on the physical assets (e.g., legally enforceable smart contracts on your home equity and getting leverage to lend out the money) [69].

The key to this transition is going to be smart contracts. As per a recent publication in Forbes [81]: "Smart contracts will likely become more widely used, and that may require a change of mindset. Those who are party to these agreements will need to adopt a more results-based outlook rather than maintaining an ideology that revolves around the malleability of paper contracts. It will ultimately change the way we create contractual agreements, which can have positive results in spite of the challenges it currently poses". Further, it is almost certain that all of these, including gen 4 will be revealed in the form and the environment of a decentralized, blockchain-based metaverse [82].

4. Open Issues for Consideration

The Web3/metaverse concept is global, borderless, and in its infancy. Therefore, many issues remain to be solved over time. We live in the real world, divided into different geographical/political jurisdictions that dictate different rules. There are many important open issues to be considered [83]. Those include technical and non-technical issues that are explained briefly below.

4.1. Computation and Storage Issues

The Web3/metaverse must have the capability to serve a larger number of users, demanding richer computing and network resources. It would require computing, storage, rendering, and several other technologies that not only require server reliability and resilience but also place high demands on client device performance. This could also be another bottleneck of the whole system [13].

4.2. Standards and Compatibility

The Web3/metaverse is multi-dimensional, technology-rich, and closely connected to the reality of our world. Not having standards and compatibility among its variety of elements is a significant issue to be resolved sooner rather than later. These issues could be divided into two aspects [13]:

- Compatibility issues among technologies created by different companies.
- Compatibility issues between the real world and the Metaverse.

4.3. National, Political, and Global Geopolitical Status and Issues

Not all countries have the same approach and policies towards Web3 and the Metaverse. For example, Japan has welcomed cryptocurrency and NFTs and has formed an NFT task force that recommended (in April 2022) having a Web3 ministry handle related Web3 issues and regulate all tax-related matters [84]. On the other hand, we have countries such as China [85] that have completely banned or restricted the use or mining of cryptocurrency and NFTs, which will hinder the usability of Web3.

4.4. Ethical, Social, and Environmental Issues

There is a broad range of such issues in the Web3 realm. Issues include, but are not limited to [83]:

- The exploitation of game developers
- The exploitation of game players
- No straight accountability in Web3
- Energy consumption and environmental effects.

4.4.1. Exploitation of Game Developers

The exploitation of young game developers by offering low salaries or earnings from the games they develop is an issue to consider. As an example, a big player (Roblox) reported paying less than 30% of the earnings associated with its game [86].

4.4.2. Exploitation of Game Players

The exploitation of game players by overcharging them to use game objects such as NFTs. Since many game players do not have the means to buy those game objects, they end up renting them from more token-wealthy individuals and such rents may accumulate and become very high [83]. For instance, the Axie Infinity game has a concept called "Scholarship", in which players that own the game tokens but do not have time to play the game can lend them out to others who want to put in the time and play but do not have the resources to buy the tokens [87]. According to analytics, players in this scheme will earn only a portion of the earnings, and the rest goes to the token owners [88].

4.4.3. No Straight Accountability in Web3

Web3 is built and based on the concept of decentralization. Thus, there is no straight accountability in Web3 due to the lack of a central authority. Web3 can be harmful because there is no accountability for wrongdoing toward the victim when things go wrong [83].

4.4.4. Resource/Energy Consumption and Environmental Effects

Blockchain is the key building block of Web3. Hence, energy consumption and its eventual environmental effects are massive issues for any responsible government. Even though Blockchain provides a lot of great benefits such as machine trust, traceability, and security, putting up with the amount of wasted energy (especially in the case of the Proof-of-Work protocol) makes it quite challenging to proliferate such technologies [89]. The two very popular protocols of Blockchain (Proof-of-Work and Proof-of-Stake) differences have already been discussed in this paper; however, considering that Bitcoin still remains the largest—and the most valuable crypto-asset in the market [90] which uses PoW protocol—that affects any type of Web3 application, either directly, or indirectly.

Based on a very recent systematic review, the environmental impacts of using cryptocurrencies, and more specifically, the PoW protocol, are as follows [91]:

- **Resource Consumption**: the mining aspect of such technology is using large amounts of resources in the form of hardware (Electronics, CPUs, GPUs, FPGAs, etc.) to increase computation power and stay competitive. This drains the market from those valuable assets that could have been used more productively elsewhere [92].
- **Electronic Waste**: using a huge amount of electronics means producing a huge amount of waste over time. Electronic waste contains a lot of harmful chemicals and toxic heavy metals. It is a severe threat to the environment that can result in soil, air, and water irreversible pollution [93].
- **Energy Consumption/Waste**: most of the energy consumed by mining activities is wasted just to complete a certain hash and receive a reward [94].
- **Carbon Footprint**: The high energy consumption of blockchain and its related mining activities are tightly correlated with high emissions from non-renewable energy sources [95], which will significantly account for global warming effects on the planet. The emissions related to Bitcoin alone are posing a threat to meeting the goals of the Paris Agreement [95].
- **Environmental-related social aspects**: these aspects can affect and be affected by the security of energy, the global supply chain, human health, and access to products and services [91]. For instance, needing a significant amount of semiconductor manufacturing capacities and producing mining equipment has put a toll on the already weak semiconductor supply chain. It is worsening the global electronic chip shortage. It also can delay or limit access to clean mobility with reasonable pricing for customers who seek to purchase Electronic Vehicles [92].
- **Environmental-related economic aspects**: these aspects can describe how related economic factors such as trading and the price of cryptocurrencies can affect the environment. The cryptocurrencies' rise in price will make mining activities more profitable, thus attracting more people into mining activities [96]. In turn, this will result in more resource and energy consumption, more electronic waste and finally, more carbon footprint [92].

4.5. Privacy and Security Issues

In today's world, you either pay for the product or service you are using on the Internet or you (and your data) literally become the product, which brings up the following issue in terms of privacy [97]: current data collection techniques enable applications to collect and track many critical pieces of information such as tracking the user's physical movements, physiological or psychological responses, virtual and real interactions with their environments and more. It is a trade-off with the tailored, unique user experience that the users will receive for their privacy. There should be a balance between those goals, requiring critical attention to privacy issues these would cause for unaware users.

Further, the achievement of such innovative technology (i.e., metaverse) has its own security threats as well, including the following [97].

4.5.1. Humans in and out of the Loop

In achieving scalability, the need to delegate tasks to AI is crucial. However, such delegation may have dire consequences, such as unfair or unfit outcomes, vulnerability to manipulations and attacks, and lack of transparency, to name a few [97].

4.5.2. Integrity and Authentication

There are a variety of different technologies unified under an umbrella called "metaverse". The integrity of those technologies, consistent and secure communication of such technologies, as well as universal user authentication across those technologies is of utmost importance for seamless transition among spaces and activities [97].

4.5.3. Polarization and Radicalization

The unfitness of the Metaverse, and the possibilities and potentials it provides as a massive aggregator of different products, services, and people, may intensify polarization or radicalization of users on an unprecedented scale. The results may be undesirable behaviors such as trolling, harassment, or taking advantage of some users in new, unforeseen, and unanticipated ways [97].

5. Conclusions

This paper summarizes the work of different authors, industries, and countries by introducing four important and influential factors that will help in the development, successful adoption, and sustainable use of Web3/metaverse and its applications, including:

1. Appropriate Decentralization
2. Good User Experience
3. Appropriate Translation and Synchronization to the Real World
4. Viable Economy

In addition, we have attempted to explore and shed light on some of the most relevant open issues and challenges currently facing the industry. We hope that solutions for them will be developed soon to suit the major body of potential users. Blockchain plays a vital role in metaverse development because the future of Web3 is all about decentralization. Finally, as part of sustaining a decentralized web, metaverse projects need to be built as decentralized platforms.

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