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RESEARCH ARTICLE

Defining the Metaverse: A Systematic Literature Review

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ABSTRACT The term Metaverse is emerging as a result of the late push by multinational technology conglomerates and a recent surge of interest in Web 3.0, Blockchain, NFT, and Cryptocurrencies. From a scientific point of view, there is no definite consensus on what the Metaverse will be like. This paper collects, analyzes, and synthesizes scientific definitions and the accompanying major characteristics of the Metaverse using the methodology of a Systematic Literature Review (SLR). Two revised definitions for the Metaverse are presented, both condensing the key attributes, where the first one is rather simplistic holistic describing ''a three-dimensional online environment in which users represented by avatars interact with each other in virtual spaces decoupled from the real physical world''. In contrast, the second definition is specified in a more detailed manner in the paper and further discussed. These comprehensive definitions offer specialized and general scholars an application within and beyond the scientific context of the system science, information system science, computer science, and business informatics, by also introducing open research challenges. Furthermore, an outlook on the social, economic, and technical implications is given, and the preconditions that are necessary for a successful implementation are discussed.

INDEX TERMS Metaverse, virtual reality, augmented reality, immersion, virtual economy, blockchain, systematic literature review.

I. INTRODUCTION

We can hardly predict what our digital future will look like. What will be the next digital revolution and how will it affect our everyday lives? These are central questions that not only scientists, but also the industry, politics and part of the population are constantly pondering. A *Metaverse* as an answer might shape this digital future, in which economic and political barriers of the current Internet could be overcome [1]. To begin with, Metaverse is a collective term for digital three-dimensional worlds [2], wherein companies have made large investments in their own Metaverse projects in the recent past [3]. According to certain investors, the Metaverse could become the next generation of the Internet and thus establish Web 3.0 or at least become a part of it [4], [5]. Moreover, another target vision of the Metaverse is a kind of walkable version of the Internet, which might also open up entirely new business areas [6]. As one of the largest corporations worldwide, Facebook, announced in 2021 to usher the next digital revolution through their Metaverse and subsequently renamed their company to Meta [7]. With this event, the term Metaverse experienced a renewed momentum that went strongly beyond the circles of the scientific community. It can be observed (see Fig. 1) that the search queries on google.com of the term Metaverse skyrocketed after this event and have not dropped to the former level since. Fig. 1 is based on the open-access Google Trends analysis for the year-five period from May 2017 to May 2022 [8] and plots the search interest using weekly values from 0 to 100. The value 100 reflects the relative maximum of the measured search interest for the term Metaverse. Based on this analysis, it is presumable that the term Metaverse has been established among a broad

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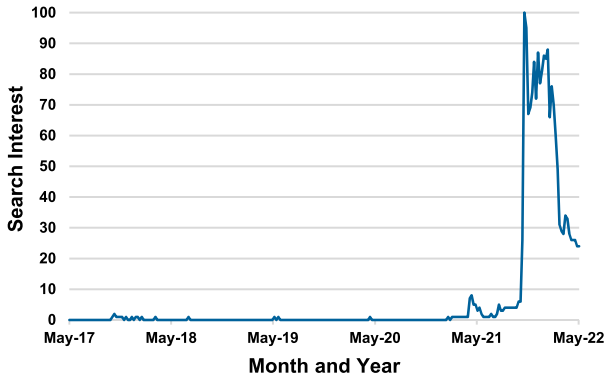

FIGURE 1. Search interest in the google search engine of the term metaverse from may 2017 to may 2022 worldwide.

audience inside and outside the scientific community, thus creating a certain level of awareness about the Metaverse. Furthermore, Ghose et al. [9] projected that by 2030, the Metaverse economy could grow to a market size of between USD 8 trillion and USD 13 trillion if an open and accessible implementation succeeds.

In science and in practice, there is a multitude of different understandings about the meanings of the term Metaverse. Consequently, a uniform scientific definition has not yet been found. Definitions differ to date, have continuously evolved historically, and are perceived differently by different stakeholders. For instance, Kumar et al. [10] define that Metaverses (here referred to in plural) are initially fully immersive persistent virtual spaces where user-generated content can be experienced. This differs from a more recent definition by Duan et al. [11]: The Metaverse (here referred to in singular) marks the next generation of the Internet, where users can interact with each other and with software applications in a virtual space using avatars. From this, it can be concluded that the notion of the Metaverse has changed over time and that the concrete design is moving towards inclusivity, i.e., the creation of perhaps a single large Metaverse with a powerful interaction dimension.

This paper first introduces and classifies the topic of Metaverse using relevant background information to familiarize the reader with the underlying research questions (chapter 2). After that, the methodological procedure is explained, in which the scope of the paper is defined, the database search is explained, the literature is selected, and the literature selection is analyzed (chapter 3). Following this, the findings of the literature selection are presented (chapter 4), and the results of the analysis are elaborated in the form of creation of new definitions (chapter 5). Finally, the results are discussed while outlining a research agenda (chapter 6), and possible research limitations are pointed out and concluded (chapter 7).

II. BACKGROUND

The term Metaverse was first introduced by Stephenson [12] within his science fiction novel *Snow Crash* and marks the origin of the art term Metaverse and its underlying idea. However, the fundamental technical understanding of the term was entirely different compared to today. This dystopian novel describes the story of the main protagonist Hiro in a collapsing postmodern civilization, where people move into a virtual successor of the Internet, the Metaverse. Science fiction became a vision, and this vision became an attempt at the realization. In 2003, for example, the Second Life platform was considered one of the first attempts at a technical conversion of a Metaverse [13]. However, Second Life failed to achieve a breakthrough by given technical limitations and the size of the audience it could reach. Both IT infrastructural problems and the at that time immature virtual reality (VR) glasses technology prevented the platform from commercial success. The platform still exists today, but currently serves only a niche in the interconnected age of social media [14]. During this entire period, the understanding and the use of the Internet and media has changed entirely and expanded drastically. Repeatedly, the term Metaverse was in discussion and always tried to be redefined [1], [15], [16], [17], [18], [19]. The definitions essentially summarize the characteristics of the Metaverse repeatedly: it is often described by similar characteristics, and yet differing characteristics are also listed throughout. These similar and also differing characteristics can be used for an evaluation in which the frequency of the addressed characteristics in all definitions is measured in order to obtain an overall weighting of those characteristics.

With the announcement of Meta's (formerly Facebook) development of its own Metaverse in 2021, the term Metaverse made its next big comeback. Meta is thus trying to combine its market position in VR and augmented reality (AR), and its market leadership in social media [20]. A Metaverse could therefore be used with conventional 2D display devices, but one of the core ideas behind the use of the Metaverse is also often the concept of immersion, understandable as the virtual diving into the Metaverse [21]. This refers primarily to system immersion [22], which is characterized by a simulated reproduction of human perception via multisensory display and tracking technologies in the form of feedback and feedforward [23]. This system immersion is brought about in particular with VR technologies, but also with mixed reality (MR) and AR technologies. In recent years, these technologies have developed rapidly and are therefore receiving increasing attention in the consumer and the enterprise market. It is estimated that the VR, MR and AR market alone will reach a market size of approximately USD 250 billion by 2028 [24].

Taken together, different understandings and definitions of the Metaverse exist within the scientific community, revealing a research gap where a general overview of the scientific definitions of the Metaverse is missing so far. To fill this research gap, the following research question (RQ1) is formulated, which will be answered in this study:

Which scientific and science related definitions of the term "Metaverse" do exist?

Another research gap derives from a missing evaluation of these definitions, in which the definitions are compared with each other, and a weighting of the characteristics

Characteristic	Categories			
Focus	Research Outcomes	Research Methods	Theories	Applications
Goal	Integration	Criticism	Identification of Central Issues	
Perspective	Neutral Representation		Espousal of Position	
Coverage	Exhaustive	Exhaustive/ Selective	Representative	Central/Pivot
Organization	Historical	Conceptual	Methodological	
Audience	Specialized Scholars	General Scholars	Practitioners	General Public

FIGURE 2. Taxonomy of the SLR.

takes place. Such an evaluation could further justify establishing a holistic definition of the Metaverse that supersedes the previous descriptions of the Metaverse while linking all the main characteristics of the earlier definitions. Therefore, to close this research gap, this study addresses the following research question (RQ2):

How can the term "Metaverse" be uniformly defined?

III. METHODOLOGY

We performed a Systematic Literature Review (SLR) following the method of vom Brocke et al. [25] to answer the outlined research questions. In parallel, the work is contextualized within the taxonomy framework of Cooper [26] to further define the scope of this work (see Fig. 2). The focus of this SLR hereby lies in the identification of theories (the definitions to be found). The goal of this SLR is to integrate the various definitions into a single more accurate definition. This involves organizing this SLR conceptually and from a neutral perspective. We address a specific as well as a broad professional audience that is interested in the Metaverse.

In this SLR, definitions and descriptions of the term Metaverse are systematically retrieved from the literature and presented to answer RQ1. To answer RQ2, the definitions and descriptions are then systematically analyzed for the occurrence of specific terms as shown in the definition analysis of Girard and Girard [27], in order to establish new holistic definitions of the Metaverse.

A. KEYWORD AND DATABASE DEFINITION

Since the scientific definitions are searched by the term Metaverse, the term "metaverse" is the only component of the search term (see Fig. 3). Terms like "virtual world" or "cyberspace" were also considered in a preliminary analysis. For example, the term "virtual world" was not used, because it describes only one characteristic of many of the Metaverse. As Dionisio et al. [1] pointed out, several "virtual worlds" can form a Metaverse, although for this purpose many more characteristics of a Metaverse must be fulfilled. The current conception of the term "cyberspace" differs from that of a Metaverse and rather refers to the IT infrastructure in which different systems are interconnected [28]. As a result, both keywords cannot be used as synonyms and rather represent a different scope of observation.

To capture a broad spectrum of the literature, the scientific databases WebofScience, JSTOR, Wiley, and Association for

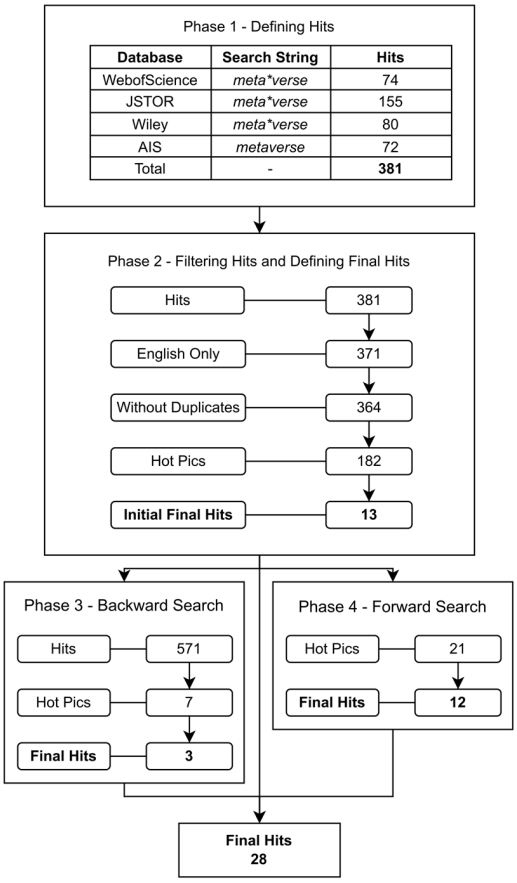

FIGURE 3. Definition of final hits.

Information Systems eLibrary (AIS) were queried with the search term in April 2022. For the databases where it was possible, WebofScience, JSTOR and Wiley, the search term was preceded by a "*" to include possible deviations such as hyphens. The search yielded 381 hits. A hit describes a paper found in the search process. A final hit describes a hit that is considered to be part of the final selection.

B. CONDUCTING THE SEARCH PROCESS

The search was carried out between April and June 2022. First, the hits were filtered from the database search. A hit was defined as any publication found within the search process in every database. Following this, all hits that were not written in English and duplicates were excluded. The resulting basket of literature then comprised 364 hits. We have read every hit's title, abstract, and keyword to check for an initial possible matching to the defined research scope. After this pre-selection was made consisting of 182 hot pics to be analyzed. In the concluding phase, the hits were then read in their entirety. Thus, 13 final hits could be identified that contain definitions and descriptions of the term Metaverse. The inclusion criterion for a final hit is an existing definition or description of the term Metaverse or the concepts or key characteristics of what the authors would consider a Metaverse. Addressing the novel character of the Metaverse,

TABLE 1. Definitions of the term metaverse.

Discipline	Author	Definition	Cit.
Arts and Humanities	Tasa & Görgülü [29]	What makes the metaversal worlds different from the other online environments and graphically similar —even better— online games is the idea of the user-created content. The inhabitants are not presented with a ready-made world, but they can design and possess the real world copyrights of their designs; they can construct their identities from scratch, study or work to earn real money, and socialize by participating in any kind of group activities. Thus, they create collaboratively not only the graphical and interactive content but also the economical and social structures in these 3-D worlds.	5
Business, Management and Accounting	Boulos & Burden [30]	There were four emerging technologies that make up the so-called Metaverse–a digital domain equivalent to the atom based domain of our physical lives. These technologies are Mirror worlds (digital representations of our own atom based world), Virtual worlds (digital representations of any space, imagined or real), Lifelogging (the digital capture of information about people and objects in the real or digital worlds) and Augmented reality (sensory overlays of digital information on the real or even virtual world).	64
	Papagiannidis et al. [31]	In this positioning paper we will focus on the business activities and commercial applications that virtual worlds can host, and examine the wider implications of these virtual environments, often referred to as "metaverses".	165
Computer Science	Jaynes et al. [16]	The objective of our Metaverse is to provide users with an open, untethered, immersive environment that fools their visual senses into believing that the traditional barriers of time and space have been removed. Users access this meta-world through an interface called a Metaverse Display Portal that is (1) visually immersive, (2) self-configuring and monitoring, (3) interactive, and (4) collaborative.	58
	Wasko et al. [32]	Second Life is a three dimensional metaverse that is visualized graphically, where individuals are represented by avatars, and interact with other avatars and their environment.	1
	Hendaoui et al. [15]	Beyond the entertainment and game-play features, virtual worlds are evolving toward Stephenson's concept of a metaverse in which social and economic interactions are the main drivers. Currently, one of the best examples of this evolution is Second Life, an social virtual world in which people (called residents) can communicate, collaborate, and buy and sell not only virtual goods and services (such as clothes and real estate) but also real products through their customized virtual spaces and avatars.	233
	Kumar et al. [10]	Three-dimensional virtual worlds can be broadly classified into online games and metaverses. Meta-universes, or metaverses, are fully immersive virtual spaces that significantly differ from online games in several ways. [Key characteristics are] Seamless persistent world, User-generated content and Massive and dynamic content.	212
	Arroyo et al. [33]	These virtual worlds or metaverses are in fact true social networks and they are useful for interaction between people in different locations.	13
	Bourlakis et al. [34]	Until now such theories had to primarily deal with two spaces, the physical 'offline' one and the online one. This has been true even in the information age as the world's institutional and legal structures are largely still geographically based. However, new technologies made it possible to add new virtual spaces and environments, often referred to as metaverses, within which economic and social activities can take place.	76
	Davis et al. [21]	Metaverses are immersive three-dimensional virtual worlds (VWs) in which people interact as avatars with each other and with software agents, using the metaphor of the real world but without its physical limitations. This broad concept of a metaverse builds on and generalizes from existing definitions of VWs Metaverses provide virtual team members with new ways of managing and overcoming geographic and other barriers to collaboration. These environments have potential for rich and engaging collaboration, but their capabilities have yet to be examined in depth.	361
	Owens et al. [35]	A virtual world (VW) is an instantiation of a metaverse—a fully immersive 3D virtual space in which people interact with one another through avatars and software agents.	35
	Arroyo et al. [36]	These virtual worlds, or metaverses, are in fact true social networks, and they are useful for interaction between people in different locations.	5
	Owens et al. [37]	Metaverses are immersive three-dimensional virtual worlds (VWs) where people interact with each other and their environment, using the metaphor of the real world but without its physical limitations.	18
	Mitchell & Deepak [38]	Metaverses use the metaphor of the real world but without its physical limitations. A virtual world is a specific instantiation of a metaverse, also referred to as a virtual space or virtual world environment. Virtual worlds provide virtual team members with new ways of managing and overcoming geographic and other barriers to collaboration. These types of environments allow for rich and engaging collaboration among team members.	1
	Dionisio et al. [1]	The word Metaverse is a portmanteau of the prefix "meta" (meaning "beyond") and the suffix "verse" (shorthand for "universe"). Thus it literally means a universe beyond the physical world. More specifically this "universe beyond" refers to a computer-generated world, distinguishing it from metaphysical or spiritual conceptions of domains beyond the physical realm. In addition, the Metaverse refers to a fully immersive threedimensional digital environment in contrast to the more inclusive concept of cyberspace that reflects the totality of shared online space across all dimensions of representation. The progression of development culminates in a complete Metaverse that involves multiple MetaGalaxies and MetaWorld systems. A standardized protocol and set of abilities would allow users to move between virtual worlds in a seamless manner regardless of the controlling entity for any particular virtual region.	173
	Nevelsteen [17]	A future topology for multiple virtual worlds 'metagalaxies' or the "Metaverse". The key difference between the Internet and the Metaverse, is that the Metaverse would support Rt. Because the Internet is already mixed reality (e.g., with video conferencing, web cameras depicting a live video feed of cities in the physical world, tele-operations, and projections from the net onto buildings), it is possible to conclude that the Metaverse will be necessarily mixed as well.	41
	Duan et al. [11]	Metaverse is a combination of "meta" (meaning beyond) and the stem "verse" from "universe", denoting the next-generation Internet in which the users, as avatars, can interact with each other and software applications in a threedimensional (3D) virtual space.	64
	Lee et al. [6]	Metaverse, combination of the prefix "meta" (implying transcending) with the word "universe", describes a hypothetical synthetic environment linked to the physical world.	71
	Gökçe Narin [39]	When the metaverse is brought to life as it was designed, it will be possible to perform many daily activities such as working, traveling, shopping, going to school, having fun by creating a 3d avatar in a digital universe. Any change users make in the metaverse will be permanently visible to almost everyone, thus providing users with greater identity and continuity of experience.	7
	Park & Kim [18]	Metaverse is a compound word of transcendence meta and universe and refers to a three-dimensional virtual world where avatars engage in political, economic, social, and cultural activities.	38
Engineering	Han et al. [40]	However, though it provides a 3D view of the home, it is less realistic than a 3D virtual world, such as a 'metaverse' in which a user can walk around realistically through an avatar.	73
Environmental Science	Li et al. [41]	There is no single, unified entity called the metaverse. Rather, there are multiple mutually reinforcing ways in which virtualisation and 3-D web tools and objects are being embedded everywhere in our environment and becoming persistent features of our lives.	30
Medicine	Chen & Zhang [42]	The most representative definition of Metaverse is that the Metaverse is a virtual world parallel to and independent of the real world. Metaverse is also considered as an online virtual world that mirrors the real world.	1
Social Sciences	Taylor [19]	In this world [Metaverse] individuals interact through a perceived three dimensional landscape by creating avatars (artistically created virtual representations of individual users) that need a limited connection to the appearances of the people they represent. Each avatar is visible to all other users, and avatars interact with each other in this communal virtual space through software-specified rules.	124
	Friedman [43]	"The metaverse," a kind of cyberspace world that could be considered a glorified chat room with total-body surround made possible by a sophisticated system of earphones and goggles that allowed individuals to live and act in a cyberspace peopled by iconic representations known as "avatars". These avatars could be crude artifacts with little reality, rented by the hour. In hour. In appearance these down-market avatars are some what wooden icons like those we use today. They could also run all the way up to dramatically realistic or specially constructed representations created by talented hackers either for their own use or for sale to wealthy clients.	12
	Ondrejka [44]	Technological advances in three-dimensional graphics, network connectivity, and bandwidth have just begun to enable online spaces that embody the Metaverse concepts of user creation and broad use.	257
	Kemp & Livingstone [45]	The Second Life, SL, system by Linden Lab is a persistent 3D world, or "metaverse". Users access the online system with a proprietary client and interact with content and other "residents." Unique features include simple tools for constructing 3D objects and scripting tools for interactive content - including connectivity with external web-pages and internet resources.	332
	Rehm et al. [46]	In particular, we consider the role of a Metaverse, understood as a globally accessible 3D virtual space and computing infrastructure—and today still a conceptual vision—as a mediator between technology trends and societal and business applications.	16

we decided to realize a holistic approach, also addressing definitions from the scientific literature which may reflect more personal views, opinions, and ideas of the authors. Thus, a more broad and forward-looking foundation for the analysis can be built, which reflects the core ideas of the Metaverse reducing the risk of overlooking key concepts.

For the 13 final hits, a backward search was carried out using the WebofScience database. After also removing duplicates and papers in a language other than English, we compared the remaining papers with already screened articles from the initial search process.

We reviewed the abstracts and keywords of the remaining 571 hits. We identified 3 final hits based on the outlined criteria. Following this approach, we also carried out a forward search on the initial final hits using the Google Scholar database. Through the conducted back- and forward search, 15 additional final hits could be defined, whereby 2 final hits [6], [42] are still preprints without a full peer review but were included for this analysis due to the topicality and the growing professional interest in the Metaverse. Furthermore, these preprints appear to be scientifically plausible based on our precise review. The final number of final hits is consequently 28.

C. PROCESS OF THE ANALYSIS

We examined the collected definitions and descriptions systematically following the definition analysis of Girard & Girard [27] and then synthesized using word frequencies to answer RQ2. For this purpose, we used the text parsing library spaCy [47] for the Python programming language. In the first step, the respective definition was divided into a list of individual words. In the second step, all special characters were removed from this list. In the third step, we used a standardized stop word list provided by spaCy to filter out and remove all stop words from the word list of the definition. In the fourth step, all words in the list were lemmatized and thus summarized to their root word. In the fifth step all word duplicates were removed so that for every definition, each emerging word is only counted once. In addition, a further step involves weighting the individual definition word lists to work out the relevance of the definitions over time. For this purpose, we counted the word lists from the last five years (2017-2022) three times, while we counted the words from the previous five years (2011-2016) twice. Word lists of definitions from years prior to 2011 are of lesser currency, and therefore, we counted them only once.

IV. FINDINGS

Twenty-eight definitions and descriptions were extracted and included in the following collection to answer RQ1. Table 1 provides each author's definition, the year, the scientific discipline, and the papers citations quote. We used the online tools SCImago Journal Rank [48] to assign the scientific disciplines and Google Scholar to assign the citations at the time of June 2022 [49]. Our research includes scientific definitions and descriptions of the Metaverse covering the time from 1997 to 2022. Thereby, the definitions and descriptions differ in their frame of reference and their professional depth. Based on the observed applications and the number of citations in the analyzed literature corpus, the most predominant definition is arguably that of Davis et al. [21]. Nevertheless, this definition refers primarily to the Second Life platform and, therefore, may not fully correspond to contemporary notions of a Metaverse. Furthermore, at the time of writing, two definitions from preprints are included [6], [42] to reflect the current developments around the topic of Metaverse.

V. RESULTS

The following excerpt (Table 2), comprising 32 words, represents the most frequently occurring words (by weighted count), with all words occurring six times or more shown here. We combined the words ''3D'', ''three-dimensional'', and ''threedimensional'' into the word ''three-dimensional'' due to synonymity. The following simplistic holistic definition can be established and proposed if all words that occur at least 10 times are considered. Since the terms ''user'' and ''people'' are generally used synonymously, only the term ''user'' is used here as a proxy:

Metaverse, a crossword of "meta" (meaning transcendency) and "universe", describes a three-dimensional online environment in which users represented by avatars interact with each other in virtual spaces decoupled from the real physical world.

This more open definition allows a comprehensive application of the term Metaverse without omitting the most crucial foundational characteristics found in the word analysis. However, this definition may not have the professional depth for some applicants, as other characteristics that may be important in the future are missing. Thus, some definitions state that the Metaverse is also persistent or permanent, meaning that it is accessible at all times [10], [39], [41], [45].

Furthermore, the concept of the Metaverse opens up the possibility of a new economy that may be a kind of a virtual real economy. For instance, the trade of new digital goods and services could open up new business areas [15], [18], [29], [34].

Overall, it should also be mentioned at this point that the users of the Metaverse are not just external observers but actively participate in the Metaverse by being able to shap and transform it [10], [18], [29]. This refers in particular to the creation and sharing of user-generated content, where every user has the opportunity to be creative in a totally new depth. The users can then present, share, or even sell customized goods to a broader audience within the domain of a virtual real economy. These customized goods do not only have to be single objects but can also be entire virtual worlds with even alternative physical properties. This can lead to the initiation of innovative scenarios and approaches, e.g., in the field of gaming or the implementation of events and learning environments in an educational setting [15].

It has been difficult to work out whether a Metaverse needs to be immersive. While some definitions describe the Metaverse as fully immersive [1], [10], [35] or may not entirely define the degree of the immersion [16], [21], [37], also MR experiences are taken into account [17].

Another characteristic that will most likely have to be included here is the aspect of decentralization. It is expected that Web 3.0, and thus the Metaverse as a possible essential part of it, will be structured in a decentralized

TABLE 2. Definitions of the term metaverse.

Word	Quantity	Word	Quantity
metaverse	44	social	9
world	34	immersive	8
virtual	32	life	8
three-dimensional	28	possible	8
space	17	provide	8
avatar	16	word	8
environment	16	internet	7
physical	15	application	6
universe	15	combination	6
user	15	consider	6
meta	13	create	6
people	11	digital	6
real	11	multiple	6
interact	10	software	6
online	10	transcendence	6
activity	9	way	6
refer	9		

manner [6], [50], [51]. In particular, the use of blockchain technologies as enablers for the establishment and operation of decentralized structures could lead the way towards this goal. Thus, the majority of the system would no longer be in the hands of large organizations alone, but of each individual user. For instance, the technology of non-fungible tokens (NFTs) that is based on the blockchain technology could help to unambiguously regulate the ownership of digital goods in the future [6].

Based on these findings, the previous definition can be expanded to a more specified definition.

Metaverse, a crossword of "meta" (meaning transcendency) and "universe", describes a (decentralized) three-dimensional online environment that is persistent and immersive, in which users represented by avatars can participate socially and economically with each other in a creative and collaborative manner in virtual spaces decoupled from the real physical world.

From a social point of view, the Metaverse offers many opportunities, but also several issues that need to be considered. Social interaction in the Metaverse takes place primarily by using avatars. This means that every user has at least one customized character that represents the individual in the Metaverse [18]. The use of customized avatars can thereby significantly reduce discrimination and thus act as a safe space for people with e.g., different skin color, gender, or social status in our physical world [18]. This can also foster the general inclusion of people with disabilities so that they too can participate in the virtual environment, wherein every user has the same low entry requirements. Therefore, as many users as possible should be given access on a technical level to ensure greater inclusivity [31]. This can increase social interaction not only in the virtual world but also in the physical world [34]. The boundaries between the virtual and physical worlds become blurred as people socialize in new groups and form their own social networks [29], [34]. In this process, interconnectivity also takes place via social content or virtual objects, where multiple users interact together with [29]. However, the organizations that offer these spaces also have a certain social responsibility and are obliged to offer their services within an ethically appropriate framework so that all users are equally protected [31].

The traditional industrial (physical) economy has undergone a transformation in recent decades and has expanded to incorporate an informational (virtual) economy. The informational economy is defined by information, knowledge and intelligence as a resource [34]. With the introduction of a unified Metaverse, this informational economy could reach a new level of escalation. The spatial (virtual) expansion of a yet unimaginable scale could result in a much larger economic and also social implication beyond what is tangible today. Many virtual spaces and worlds will be created, where new dimensions would be added to the physical and electronic world. These would then be limited only by technical feasibility and the human imagination [41]. This suggests that the success of the Metaverse depends on, and will be strongly influenced by, the overall and economic activity [18]. When considering this economic activity there are yet unresolved macro- and microeconomic issues, regarding e.g., national economic output and activity, currency exchange rates, taxation and many more [41]. As with the social side, this would also need to be guided by clear policy-making [34], [41]. Especially the currency issue raises fundamental questions here. For a general idea, the introduction of cryptocurrencies could serve as an economic bridge between the Metaverse and the real world [18]. The Metaverse may be virtual, but the currency will be real. In this manner, a new universal decentralized Metaverse currency, based on the design of cryptocurrencies, could be introduced, which however still remains stable in its value development through a regulated framework, and is backed by virtual goods with virtual real countervalue. This virtual currency could then be freely traded and exchanged for a physical currency by indexing it, e.g., through an exchange market existing in the Metaverse [15], [34].

VI. DISCUSSION AND FUTURE WORK

It should be noted that there might not be a common consensus between the scientific and the corporate view of the Metaverse, which in turn opens new research questions. For this purpose, researchers could investigate which large companies are currently working on Metaverse projects and how these companies understand the term Metaverse. It is essential to understand whether companies working on this are just building virtual spaces in an online environment or whether

they are pursuing a long-term goal and, if so, which one. This question leads to the fundamental challenge of whether the Metaverse will exist as the Internet does in the future. For this, the development of the major Metaverse projects should be actively monitored by the public to ensure that all companies follow a common path creating a unified Metaverse instead of acting exclusively in private interests. Because such a development might be contrary to a role model of the Internet being a fundamental principle of the Metaverse, where there would be its own open standards. Thus, instead of websites, there could be separate platforms in the form of three-dimensional virtual domains or worlds in the Metaverse, that could be created and managed decentralized by companies, institutions, organizations, or private individuals. From an infrastructural perspective, this might involve blockchain technology as an enabler of decentralized functioning, thus allowing for an open and fair Metaverse [4], [6], [11]. Only then the term Web 3.0 as e.g. proposed by Cheng et al. [4] would also most likely be applicable here, otherwise it may would not qualify as the next generation of the Internet.

In this context, another fundamental is how immersive a Metaverse will or should be. For example, it must be clarified whether there will be multiple entry points, where each user can decide individually with which end devices they will participate [4], [6]. This question might also be a decisive factor for the success of the Metaverse and especially its inclusivity, if a fully immersive VR station is required or if the users can also access it with their smartphones.

If users interact with each other not only on a social level but also on an economic level in the Metaverse, it should also be examined whether it is necessary to create a new set of socio-economic rules specifically for this purpose. Because if a new form of virtual real economy [6], linked to a virtual financial economy, were to be created, it would be crucial to examine the extent to which existing laws are applicable at all for a Metaverse ecosystem. One would imagine building, buying, and selling real estate in the Metaverse closely linked with an own equity market. Another idea could be an NFT-based art market, where the art that was created in the Metaverse is also exclusively traded and accessible (i.e., viewable) in the Metaverse, but traded with a real currency.

While this study only adopts the social and economic spheres at first, Park and Kim [18] also include a political and cultural sphere in their definition. However, it is debatable what influence a Metaverse will have on the political sphere or whether a cultural identity will be created or transformed. Nevertheless, it seems necessary to investigate what social impact a Metaverse could have, primarily because of the Internet and smartphone eras still unresolved questions. For example, the extent to which the increasing dependence and duration of use of these technologies in everyday life affects the human being. However, there is also a great deal of potential that a Metaverse could offer in the future of a technologized society. In addition to the creation and exploration of completely new economic segments, a Metaverse can establish a whole new way of coming together. People from all over the world, regardless of their socio-economic background, could interact with each other and enter a new form of exchange that would have been difficult to achieve using previous solutions.

When analyzing the basket of literature, it initially contains promising approaches and ideas for shaping the Metaverse. However, when analyzing the selected literature over the publication period it becomes clear that the Metaverse is still in a very early and underexplored stage, although the trend of a recent rapid concretization is recognizable. From the analyzed literature, two main challenges can be derived, namely the societal implications and the technical implications. Table 3 summarizes the main challenges and issues identified from the basket of literature and offers recommendations and directions for future research.

From an overall societal perspective, major issues become apparent. From the social viewpoint, it may be necessary to investigate how the underlying social framework should be designed so that a Metaverse could become feasible, by making the Metaverse accessible to as many users as possible, while complying with the overall societal, ethical, and legal boundaries. From the economic viewpoint, the main challenge is to understand the possible introduction of a new economic sphere, or at least to understand the accompanying change in existing economic procedures. Thus, it is reasonable to investigate which economic actors will interact with each other, how they will interact, and what will be exchanged.

From a technical perspective, there will be many challenges that cannot be clearly defined at this point as these are linked to the ongoing technical development being made by the industry, which is still at an early stage. Nonetheless, one of the biggest challenges will be the interoperability between all the different components, both in software and hardware. Addressing this issue, the Metaverse Standards Forum was founded in June 2022 by leading global organizations from academia and the tech industry [52].

To better classify the resulting definitions of the Metaverse, it is important to distinguish them from supposedly similar definitions of computing approaches. In particular, the definitions of Web 3.0, Internet of Things (IoT) and Immersive Virtual Environment (IVE) should not be confused with the concept behind the Metaverse, as these terms are often used in context of the Metaverse and may be mistaken for it on first sight.

Web 3.0 is defined by Liu et al. [53] as an ''era of computing where the critical computing of application is verifiable''. Accordingly, it comprises an entire interconnected set of technologies of the emerging computing and Internet generation, which can be subdivided into different layers [54]. The Metaverse is one of many Web 3.0 technologies (like blockchain or decentralization) that are partially interdependent. From this perspective, the Metaverse can be seen as a possible interface or platform of Web 3.0, and is thus not to be equated but rather one part of Web 3.0.

TABLE 3. Research agenda.

Main Challenges	Issues	Research Recommendations
Societal Implications	Social	Identification of the necessities for an enhanced accessibility for end-users
		Investigation of the impact on interpersonal interaction and human-machine interaction
		Determination of the overall ethical boundaries
		Investigation of the impact on privacy
		Investigation of the alignment of cultures regarding the amplification of globalization effects
		Investigation of the emergence of a Metaverse culture resembling the Internet culture
	Economic	Investigation of the change on financial markets and goods markets
		Investigation of the change of financial transactions and the transfer of digital goods
		Investigation of the change of economic processes through use of further Web 3.0 technologies such as blockchain or decentralization
Technical Implications	Open Standards	Identification of the necessities for an enhanced interoperability between Metaverse platforms
		Identification of the necessities for an enhanced uniform utilization of further Web 3.0 technologies such as blockchain or decentralization
	Hardware	Identification of the necessities for an enhanced interoperability between different end-user devices such as smartphones, tablets, and personal computers as well as other AR, MR, and VR devices

IoT can be defined as a ''group of infrastructures interconnecting connected objects and allowing their management, data mining and the access to the data they generate'' [55]. IoT thus describes a technology set of mainly interconnected hardware, which can be another element of Web 3.0 alongside the Metaverse [54]. IoT and Metaverse can also be used interlocking in their respective parallel roles. A possible example could be the use of AR glasses in an industrial scenario, where these AR glasses act as a hardware component in an IoT network. Via an exemplary industrial Metaverse Platform, embedded in Industry 4.0, maintenance information could be collected by the installed IoT network, processed by the Metaverse Platform, and communicated to a maintenance worker wearing AR glasses. In this case, the AR glasses would be one of many possible gateways between the user, the IoT network and the Metaverse.

An IVE can be defined as followed: ''An Immersive Virtual Environment (IVE) is an interactive smart computer-based system that provides a three-dimensional virtual world. The virtual world may be imaginary, symbolic or a simulation of an aspect of the real world'' [56]. An IVE can be a possible basic building block, meaning a potential immersive user interface of one of many Metaverse platforms, within the Metaverse. Therefore, in relation to the concept of the Metaverse, the concept of IVE must be subordinated to that of the Metaverse.

To summarize, based on the literature, we estimate that the Metaverse will be a single three-dimensional online environment with many Metaverse platforms, in which each Metaverse platform is embodied in the form of virtual spaces.

VII. CONCLUSION AND LIMITATIONS

First appearing in a science fiction novel in the 1990s, the term Metaverse has become a vision in a technologized society. With the development of available technologies, the understanding of the term has also evolved. Even though the current definitions of the Metaverse have many commonalities, they are fuzzy and not always definitive. With a systematic literature search, 28 representative definitions and descriptions were found and analyzed textually according to topicality. This analysis yielded two possible definitions of the term Metaverse: One definition provides broader applicability, and a second definition provides a stronger focus on applicability to the current contemporary events of technology corporations. The proposed definitions of the Metaverse form a bridge across all the definitions analyzed. Users of the definitions are hereby given the opportunity to use uniform scientific definitions without omitting the most critical underlying characteristics of the Metaverse.

The underlying definitions and descriptions considered for the analysis are heterogeneous but originate from the scientific literature. However, it is questionable to what extent each definition or description can be considered scientific, as they also reflect less well-founded personal views and ideas of the authors. This should be noted as a possible limitation.

Furthermore, there is another limitation to the significance of the technical quality of the two resulting definitions. The technical implementation of the Metaverse is still in the very beginning phase and in large parts has yet to be created. The result is a lack of standards in industry and academia. However, technical standards should form one part of the foundation for these kinds of definitions to make them more proper. With the inclusion of especially recent literature (see the explanation of the second more extended definition), an attempt was made to counteract this limitation, which is why the two definitions developed are nevertheless most likely to provide suitable guidance. Therefore, the two definitions developed are certainly applicable but should be tested and reevaluated in the future regarding their technical significance as soon as a broad and standardized technology framework has been created by industry and academia.

While the proposed definitions are based on the textual analysis of the 28 definitions and descriptions found, there are also other valid approaches for analysis. Another concept-centered method, such as that of a concept matrix [57], would perhaps have yielded a different result. To counteract this challenge, we carried out a weighting according to the topicality, based on the date of publication of each analyzed paper. In contrast, it may have been reasonable to carry out the weighting using the number of citations. Furthermore, the value of old definitions is questionable (e.g., the possible abstinence of disruptive technologies like Artificial Intelligence or Blockchain). Additionally, the selection of the found literature is to be considered only representative and may not be fully exhaustive. Furthermore, new or other relevant literature may not have been found or selected in the

selection process. We counteract these issues by carrying out a forward search and a backward search, which also resulted in the finding of further definitions. However, it remains to be noted that there may still be a residual bias and degree of subjectivity for all efforts at neutrality. In order to develop a definition that is suitable and well-founded for scientific purposes, the inclusion of gray literature was dispensed with for the time being, even though it might have provided further insights here.

While the research agenda has already addressed immediate challenges of the Metaverse, issues regarding the Information and Computing Technology (ICT) infrastructure should also be addressed in a farsighted manner. A digital transformation, among which the Metaverse could be seen, should tackle the challenges of general readiness and preparation of the ICT infrastructure, especially that of the network infrastructure (namely broadband) and the computing infrastructure (namely data centers) [58].

When looking at the network infrastructure, it should be examined how the Metaverse will change the requirements for mobile broadband (for example, 5G) and stationary broadband (for example, fiber optic). Not only the number of devices, but also the respective data throughput of the individual devices, will increase. In addition, low latency is crucial in many AR, MR, and VR use cases [59], [60].

Furthermore, it is projected that the workload on the existing computing infrastructure in data centers worldwide will increase, regardless of the adoption of the Metaverse [61]. The likely increased load on cloud computing due to the Metaverse, for example, could be partially mitigated by the edge computing approach, in which certain complex computing tasks are performed decentrally and closer to end-user devices, thus reducing the general infrastructural load [62]. Nonetheless, it is expected that the total ICT infrastructure will be responsible for between 7% and 20% of the global energy demand by 2030, thereby raising questions about the overall sustainability of the Metaverse [61].

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