Metaverse: Opportunity, Challenge and Technology

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Abstract. Nowadays, with the global outbreak of Covid-19, people are starting to pay more attention to the Internet and its related products, and the Metaverse has become popular in public discussion. Metaverse aims to use current technologies such as blockchain and extended reality to create a virtual world with a similar operating mode to the real world and to achieve decentralization and reasonable distribution of wealth in it. As the underlying technologies mature, the realization of the Metaverse is getting closer and closer to us. This paper will discuss the four cutting-edge technologies that support the metaverse system: artificial intelligence, blockchain, cloud services, and extended reality. At the same time, the challenges faced by the current development of the Metaverse and its opportunities will also be analyzed in order to summarize the current development of the Metaverse and predict its future development.

Keywords: Metaverse · Artificial Intelligence · Extended Reality · Blockchain · marketing · social structure

1 Introduction

The Metaverse is one of the leading cutting-edge technologies with great potential for the future. According to research [1], it is a created world in which people can 'live' under the creator's rule. The extended reality (ER) is the foundation of the Metaverse, which means it can be based on virtual reality (VR) technology, augmented reality (AR) technology, or even use Mix reality system [2, 3]. Although many current advanced technologies will be used, the concept of the Metaverse is not recent. As early as 1992, Neal Stephenson proposed the idea of the Metaverse in his science fiction work Snow Crash [32]. Later, with the popularization of the World Wide Web and the development of core technologies such as blockchain and artificial intelligence, the Metaverse gradually began to take shape and was used in some game applications [4].

Currently, the Metaverse mainly relies on the following five technologies—Artificial Intelligence, Extended Reality, Block Chain, Cloud& Big Data, and Advanced Game Engine. To be precise, it is not a novel technology; on the contrary, it is a fusion of a large number of technologies. According to research [5], blockchain and AI fuse and bring considerable changes to the industry. The core concept of blockchain is decentralization.

It considers every single user as a unique host on the internet and distributes computation resources to them to create values. Such an economic system can avoid the monopoly of wealth and create more opportunities for ordinary people. At the same time, AI technology can provide powerful computing ability to solve a large number of problems, and it can even bring solutions to problems that have plagued humankind for a long time. Therefore, the fusion of AI and Blockchain technology provides the technical foundation for the Metaverse's concept of equality for all and also creates a new electronic currency economic structure, which can be widely used in the Metaverse.

AI and Blockchain technologies provide a theoretical basis for the Metaverse. At the same time, extended reality provides the hardware foundation. Virtual Reality (VR) and Augmented Reality (AR) enable new experiences for users and use-case by organizations [6]. Extended Reality technologies have covered all forms of VR and AR technologies and are often used interchangeably with mixed reality [7]. These technologies have been applied to many fields, including medicine, education, engineering, etc. They help experts to solve problems related to reality and bring lots of conveniences. However, its application potential will be infinitely enlarged when they come to Metaverse. They will be used as the interface between the Metaverse and the real world. Through them, people can see, hear or even feel the things in the Metaverse. To explore the functions of Extended Reality (ER), game engines, such as Unity 3D and Unreal Engine, are great platforms [8]. On these platforms, the primary library and other plugins of the application of Extended Reality are provided by the development company. For example, EPIC Game company developed and is still updating the Unreal Engine. As a result, game engines give developers the platforms to explore and realize the development and application of ER technology.

The last core technology is the Cloud &Big Data technology, which provides the ability to maintain a large-scale database because of the wide range of Metaverse's target users. To realize it, efficient algorithms must be proposed to reduce the network traffic load and ensure that the Metaverse systems keep functioning as the number of users grows [9]. The core technologies mentioned above are all technologies that have been developed or are under development. With the rapid development of the Internet and multimedia technology in today's world, the realization of the metaverse technology level will soon come. However, in addition to technical issues, there are still many challenges for the Metaverse actually to enter the market.

The challenges besides technical challenges can be divided into social challenges, such as the impact on social structure or policy environment, and ethical challenges, such as privacy or morality concerns [10]. The development of the Metaverse has dramatically exceeded expectations due to Covid-19. Due to the restrictions of the epidemic, the opportunity for people to move in reality has dropped significantly, and the trend of using digital cities instead has become more and more popular. People work, meet, study, and play at home through the internet. The original social and economic structure has also been significantly impacted and even threatened the current political situation. The popularization of digital cities like the Metaverse will inevitably impact the current political structure because the idea of decentralization it advocates undoubtedly goes against the ideas of many current governments [11]. For the ethic challenge, to a certain extent, the Metaverse is an artificial world that is independent and special from reality,

so the ethics and morals constrained by the rules of the real world cannot be reproduced entirely in the Metaverse. Due to the anonymity of blockchain technology, the issue of personal privacy is also crucial considering the various privacy leaks on the internet now. As the realization of the Metaverse gets closer, more problems will be exposed to people's vision. In order to make the application of the Metaverse better help human development, more moral factors should be considered when setting the rules. At the same time, upgrading infrastructure is also a meaningful way to deal with some problems.

On the other hand, the Metaverse brings countless opportunities. Some experts believe that Metaverse will revolutionize the way designers work, whether it is graphic design or product design, or even in the fields of architecture, art sculpture, etc. [12]. Moreover, the Metaverse is also believed to bring opportunities to world marketing. It will revolutionize the "value function" of nearly every industry and company, from healthcare, consumer products, entertainment, and business-to-business technology solutions to payments. Additionally, entirely new industries, markets, and resources will be created to enable this future, as will new types of skills, professions, and certifications [13]. Meanwhile, the current social structure is both a challenge and an opportunity for Metaverse. Whether it can propose changes and create value on the premise of maintaining the stability of the social structure is the standard to measure its development.

This paper is organized as follows, the technologies will be described firstly, and it will mainly focus on Artificial Intelligence, Blockchain, Cloud, and Extended Reality. The challenges will be discussed in the next section, which includes privacy and moral concern, social structure, and technical stability. The following section will focus on the opportunities of the Metaverse, especially in architecture, marketing, and social aspects. In the end, a conclusion about the future development of Metaverse will be drawn to reflect its development direction and weigh the pros and cons.

2   Literature Review

2.1   Technology

2.1.1   Artificial Intelligence

Artificial Intelligence is a general idea of computer science, representing a technology that can simulate human behavior. In Artificial Intelligence, there are lots of methods and subsets, and machine learning is one of them. Unlike other programming methods, machine learning programmers do not create solutions directly to different questions. Instead, they focus on the methods to build models that can solve a large number of problems. In a machine learning algorithm, massive data needs to be trained to get a model so that it can do prediction or classification for other data. Typically, machine learning can be divided into two kinds, the first one has supervised learning and the second one is unsupervised learning. Prediction is the supervised model's function, while classification is the unsupervised model's function.

In machine learning algorithms, many famous and influential methods exist, such as SVM, Logistic Regression, Neural Networks, etc. However, the most widely used algorithm is called Deep learning, which is based on the neural network. According to experts [14], deep learning allows computational models composed of multiple processing layers to learn representations of data with multiple levels of abstraction. Each node

in a layer is considered as a neuron in a human brain and is able to process and pass electrical signals to the next neuron. Deep learning uses back-propagation algorithms to discover complex structures in large datasets to instruct the machine how to change its internal parameters, which are used to compute each layer's representation based on the previous layer's representation. Therefore, deep learning can analyze and adapt to the data more comprehensively and obtain a model with higher accuracy than other machine learning algorithms.

The Metaverse is a virtual world with its own independent rules. People can have a unique identity in it and can create or obtain virtual items or currency. Therefore, massive amounts of data need to be processed in order to maintain the stability of the basic rules of the Metaverse. Usually, people cannot process such a large amount of data effectively, so AI will be the preferred way for people to process and maintain data. Meanwhile, deep learning used in the Metaverse can increase its intelligence [5]. For example, the intelligent assistant can perform facial recognition on the user, capture the user's facial expressions and infer their mood, and simultaneously provide different styles of voice assistance according to the user's mood. Alternatively, intelligent voice assistants can quickly identify languages and translate them so that users worldwide can communicate without any problems. Therefore, AI plays an indispensable role in the Metaverse.

2.1.2 Block Chain

According to research [15], a blockchain consists of datasets that consist of chains of packets (blocks), where a block contains multiple transactions. A blockchain is extended by each additional block and thus represents a complete ledger of the transaction history. The network can cryptographically verify blocks. In addition to the transaction, each block contains a timestamp, the hash of the previous block (the "parent"), and a nonce, which is the nonce used to verify the hash. This concept ensures the integrity of the entire blockchain up to the first block. In short, blockchain can be viewed as a public ledger in which all submitted transactions are stored on a blockchain. This chain keeps growing as new blocks are appended to it. Blockchain technology has vital properties such as decentralization, persistence, anonymity, and audibility [16]. As a result, blockchain also has higher security and efficiency.

A most famous example of the application of blockchain is Bitcoin, which has already enjoyed colossal market size: the scale of the capital market in 2016 reached 10 billion US dollars [17], and Bitcoin price nearly broke through $20,000 currently after the plunge sparked by latest inflation report. However, the rise of bitcoin has also had a massive impact on real currency, so in some countries, bitcoin is regarded as a virtual product rather than a virtual currency. This also reflects the impact of blockchain technology on the current system. As a result, the Metaverse may use a combination of blockchain and AI as its foundation.

According to Jeon, blockchain builds the economic system in Metaverse because it can avoid monopoly or wealth control by oligopoly [18]. At the same time, AI ensures the security and stability of the whole system. The blockchain also provides a safer environment with massive, scattered datasets for AI algorithms, which can increase efficiency and reduce the risk of being hacked. The blockchain system decomposes a problem or task into sub-problems or sub-tasks and then assigns them to specialized

agents for processing; the agent-based partial solutions are then coordinated to form a solution to the problem. There is no need to share resources, capabilities, and calculations with centralized servers or intermediaries through control permissions. AI in blockchain can maximize the capabilities of terminal and edge devices and resources to achieve the highest efficiency in resource use [19].

2.1.3 Cloud

Cloud has gained a lot of popularity these years and has been applied to many fields. Typically, the cloud has three main services. The first service is called Software as a Service (SaaS), which provides the service that allows users to access some applications they already have. The second service is Platform as a Service (PaaS), which provides the tools and platform to let users develop applications for themselves. The last service is infrastructure as a Service (IaaS). It is used as an environment for users to test their code and deploy visual machines [20].

In the development of the Metaverse, private clouds are widely used to intensify the process of decentralization [19]. At the same time, the cloud provides new methods for the realization of the visual system, including the VR and ER systems. Users can have access to VR applications by using the cloud service, and the developer can take the cloud as a platform to create and develop their extended reality application [21]. Moreover, there is a conjecture that cloud service can be incorporated into the blockchain because blockchain is expected to be an indispensable tool to fulfill cloud systems' performance expectations with minimal costs and management overheads [22]. For example, blockchain-based IaaS can focus on storage management and computational resource management and provide more efficient data access controls or provide data searchable encryption [22].

Although the cloud is an excellent way to provide solutions to some problems in metaverse development, it still has challenges, including scalability, safety, and inefficiency. They are also the future development of the cloud.

2.1.4 Extended Reality

According to experts, extended Reality (XR) technology is the most prominent new development in information systems, processing, and management [7], which builds the foundation of the whole metaverse system because at the core of the Metaverse stands the vision of an immersive Internet as a gigantic, unified, persistent, and shared realm [21].

Typically, ER includes virtual reality, augmented reality, and mixed reality, and the hardware system will be connected to multiple human sensory systems to build a realistic virtual world. For example, the skin-like material can produce haptic feedback to the users [23].

Currently, the VR system has got relatively mature technologies, but it still needs the users to use the head-mounted device and haptic controller. At the same time, AR and MR technologies are also widely used in industrial, military, and medical training and design. Furthermore, it promotes the birth and the trade of virtual properties, such as the NFT [24]. As a result, the transformation of traditional media to new media in the ER environment has become a significant trend. Coupled with the gradual maturity

of other cutting-edge technologies such as blockchain and artificial intelligence, many large companies have begun to build the prototype of the Metaverse, such as Facebook, rebranding its umbrella company as Meta to underscore its focus beyond traditional social media, which is dedicated to the ambitious concept of creating a metaverse [25].

In a word, extended reality technologies have been the future trend for social media, and many large companies have taken advantage of their pre-developed extended reality system foundation to try to hold the market. However, as long as the main idea of the Metaverse is decentralization, there cannot be a monopoly to control the whole market. Moreover, the ER technologies also need to be applied to other essential technologies mentioned above, especially the blockchain, to ensure the correctness and stability of the future Metaverse.

2.2 Challenges

With all of the cutting-edge technologies used in Metaverse development, there also exist many potential challenges.

The first challenge is the ethical challenge related to Artificial Intelligence, or, to be more specific, the discrimination of people due to bias [26]. For example, when AI is widely used in Metaverse, who will be responsible for setting up the ethical standard? The programmer? Or the AI itself?

The second challenge is from the blockchain. Every day, there are countless data transmitted by blockchain, and all the transactions are stored in the blockchain, so countless new blocks are created, and the blockchain may become increasingly heavy as it develops [16]. At the same time, blockchain is facing the problem of privacy leakage. Though it is believed to be very safe due to the decentralized structure, the blockchain cannot guarantee transactional privacy since the values of all transactions and balances for each public key are publicly visible. Moreover, Biryukov show that there exist methods to link user pseudonyms to IP addresses. So safety assessments are still considered to be essential. At the same time, blockchain promotes the development of a virtual economy, which is a challenge to the current real economy and even government management [27].

Meanwhile, the cloud service is also facing a similar problem as the blockchain—scalability. For current cloud services, when tens of thousands of users are downloading or streaming metaverse materials, the highly interactive, multi-user nature of virtual worlds is far more demanding - supporting even a hundred users in the same region simultaneously is considered an achievement [28]. Moreover, the cloud service requires a central host to provide these services, which is contrary to the purpose of the Metaverse. Although the appearance of personal cloud solves part of this problem, the main services, such as PaaS or SaaS, still cannot achieve the goal of decentralization.

To sum up, the challenges of the development of Metaverse not only come from the technologies' hidden dangers, including privacy, efficiency, scalability, or even morality, but also from its main idea of decentralization which could influence the current social structure and the designers of the Metaverse must strictly consider its impact on the real world to ensure the stability and development of real life.

2.3 Opportunities

Despite the massive uncertainty of the Metaverse from its challenges, the opportunities that the Metaverse can provide are apparent.

With the emergence of Covid-19 in recent years, people's physical contact has been dramatically reduced, more and more schools have begun to adopt online teaching methods, and companies have also allowed employees to work from home. Although it seems that people's lives are transferred to the Internet, which is also in line with the theme of the Metaverse, the current immature social media makes this transition not smooth.

According to doctors, since the epidemic, the incidence of mental illness and the death rate in various countries have risen significantly [29]. Reasons for this include fears of infection, stay-at-home orders, school closures, cessation of outdoor activities, social distancing, and concerns about more significant threats such as a global financial recession and related impacts [30]. In other words, there is currently a sense of loss in people's socializing on the Internet, making it impossible to match real socialization.

However, as the Metaverse grows, there will also be significantly less social loss people experience on the internet. Meanwhile, Metaverse is also able to improve the efficiency of online working or learning with its ER technologies that create the whole virtual world [31]. Technically speaking, Metaverse can overcome the main problems of current social media and qualitatively improve its efficiency and security. This also indicates that the Metaverse is the trend of the future development of all multimedia.

On the other hand, the decentralized nature also brings many unprecedented opportunities to the Metaverse. This decentralization can promote social democracy and also promote the rational distribution of social goods. Due to the enormous computing resources on the Internet, the Metaverse is able to create a virtual world that even has more resources and wealth than in reality, which also contributes to everyone's equal self-worth [19]. Under such circumstances, all can enjoy better and more educational resources, and the monopoly of wealth will also cease to exist. Everyone will exist in the Metaverse as an individual, only to obey the basic rules and not need to be monitored or controlled by the government. That is precisely what the Metaverse was all about - to create a virtual world where everyone is equal without discrimination.

3 Conclusion

To sum up, the Metaverse is a decentralized virtual world based on artificial intelligence, blockchain, cloud services, extended reality, and other technologies. It aims to use the vast resources of Internet technology to create a world where resources and power can be reasonably distributed. In the development of Metaverse, AI and blockchain technology provide the necessary network structure for decentralization, while ER technology has made outstanding contributions to the user's immersive sensory experience, and cloud services are for these technologies. The development provides a platform and an environment. Therefore, the Metaverse can be said to be a product developed by integrating all the current cutting-edge Internet technologies, so it will also face many challenges and opportunities.

Since it uses a lot of cutting-edge technologies, some of which may not yet be mature, how to ensure the stability and scalability of the metaverse system is the primary problem

facing the current metaverse development. Different technologies are fused together, such as AI and blockchain, cloud technology and ER, etc., and new representations are developed based on current technologies to solve this problem.

In addition, social and moral issues in the Metaverse are also a challenge. In order to achieve decentralization and rational distribution of resources, a set of ethical and moral standards different from the real world will be applied in the Metaverse, and AI will also be widely used in it. So how to set limits for users and AI will become a very urgent problem. In addition, the virtual currency and virtual items produced in the Metaverse also have a considerable impact on the real market. The best way at present is to use this new type of media to make virtual currency and products serve the real market so as to promote and motivate the real market.

While facing challenges, the Metaverse also presents immeasurable opportunities for our future development. First of all, it has created a new media that far surpasses all current social media, which can shorten the distance between people in a real sense compared to the previous social media. At the same time, with the development of technology, its security, efficiency, scalability, and stability can far exceed other media, which also enables it to bring significant benefits to people in work, study, and entertainment. Secondly, it brings a kind of social change to human beings. It uses a decentralized method to solve the problem of wealth and power monopoly that has plagued human beings for a long time in reality. Although the future of this new change is immeasurable, it is also the first step in human progress. In the future, the Metaverse will also be the benchmark for the development of science and technology and society.

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