

## A Review on Blockchain for Metaverse

<sup>1</sup>Mohan Kumar, <sup>2</sup>Chandan Kumar Yadav, <sup>3</sup>Sagar Kumar, <sup>4</sup>Ajit Kumar, <sup>5</sup>Mr. Kamlesh Kumar Yadav

<sup>1,2,3,4</sup>BCA V Semester

<sup>5</sup>Assistant professor Faculty of computer science & IT

<sup>1,2,3,4,5</sup>Kalinga university, Naya Raipur (C.G.)

<sup>1</sup>mohansahu042006@gmail.com

<sup>2</sup>rathorechandan854@gmail.com

<sup>3</sup>sagarzx987@gmail.com

<sup>4</sup>ajitkr7520@gmail.com

<sup>5</sup>kamlesh.yadav@kalingauniversity.ac.in

### Abstract

The emergence of the metaverse as a new standard for social networks and 3D virtual worlds has raised concerns about the security of user data and content. To address this issue, blockchain technology is being considered due to its decentralized, immutable, and transparent features. In this survey, we provide a comprehensive overview of the potential applications of blockchain in the metaverse. We first explain what blockchain and the metaverse are and why blockchain is relevant to the metaverse. Then, we discuss how blockchain can help address technical challenges related to data acquisition, storage, sharing, interoperability, and privacy in the metaverse. We also examine how blockchain can impact key enabling technologies, such as IoT, digital twins, immersive applications, AI, and big data. We provide examples of ongoing projects that showcase the role of blockchain in metaverse applications and services. Finally, we suggest some future research directions to further explore the use of blockchain in the metaverse.

**Keywords** Blockchain Technology, Metaverse, Data Privacy, Interoperability.

**1. Introduction:** The approach produces a replicated digital environment that prosumers can experience as an immersive virtual world. In accordance with the duality principle, users can engage with this virtual eco system via their digital avatars [2]. In particular, the Avatars are the virtual representations of users, and have the same legal authority in the metaverse as one's legal rights in the actual world; this makes the avatar liable for any transactions conducted within the virtual domain, and prevents the avatar from repudiating any committed activity. Under the minimum capability, anyone with a VR/AR equipped immersive device, such as a headset or a glass, can acquire access [3]. Fullbody haptic bodysuits, on the other hand, such as the Teslasuit or HoloSuit, have the potential to maximise the immersive experience by tracking motions, extracting haptic input, and transcending biometrics.

Despite the fact that the metaverse was created and designed to improve the capabilities of social media, its potential for various industrial, commercial, societal, educational, medical, military, and governmental sectors is enormous. A well-known disadvantage of online remote access and control systems is the lack of immersive experience. Controlling Supervisory Control and Data Acquisition (SCADA) or Programmable Logic Controller (PLC) based remote automation systems [4], fitting on apparel, perception in commercial real-estate or architecture, understanding Three-Dimensional (3D) visualisation in medical/engineering/or architectural education, remote controlling of unmanned aerial/naval/or ground vessels, and experiencing digital entertainment

beyond the two dimensions are all examples.

Whilst AR and VR technologies provided stand-alone solutions in these domains, an all-in-one platform or environment to mix these tools was absent. The metaverse provides this digital ecosystem to the globe, opening up an infinite number of possibilities. The concept of Digital Twins (DTs) enables remote operation and control of machinery or vehicles through greater visualisation and coordination, which benefits both the industrial and military sectors [5].

Three-dimensional representation is paving the way for greater accuracy and comprehension of the context, which will assist both educational and entertainment applications. Furthermore, the metaverse platform enables unique directives such as AR-based remote robotic controlling and AR-based remote surgery [6]. Furthermore, concepts such as bitcoin [7], digital-biometrics [8], and explainable artificial intelligence [9] have been proposed (XAI) When it comes to implementing there are inescapable problems, such as connecting with current systems, compatibility, interoperability, legal and ethical issues. Because the metaverse is a new environment, employing these tactics throughout the design stages would provide more confidence on security and privacy for its users, as well as a better service experience.

Despite the metaverse is marketed as a panacea for future digital expansion, it is not without its problems and practical issues. The most essential issue is the lack of a functional digital infrastructure to provide guaranteed services and applications with associated processing and networking capabilities.

Even if such infrastructure exists, the access technologies required to provide the desired standards are only feasible with developing 5G mobile technology, which is still at the experimental stage and has not yet been deployed globally. Before releasing the metaverse, the compatibility and interoperability between the virtual and physical worlds must be understood and standardised. It is evident that, even with a formidable degree of processing capabilities at the metaverse engines, resources may not be sufficient to meet demand given its size.

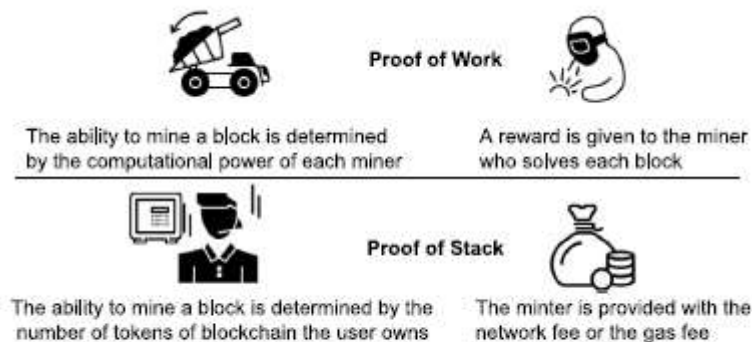


Fig. 1. Popular consensus mechanisms.

The social-media backbone provides promise and scalability. As a result, optimal processing and operation solutions must be implemented to reduce processing, storage, networking, and financial costs. Such techniques are only viable through automated AI-based methodologies, which necessitate additional assimilation and study. Because

a person must have a headset or an AR glass to enter the metaverse, the larger the personal investment.

Investment turns it into a privileged service rather than an open system for all. Furthermore, user security and privacy are critical considerations, as certain privacy rules that exist in the real world may not be applicable in the virtual domain, whereas significant biometrics in the real world can be mirrored within the digital realm. As a result, adopting the metaverse in a pragmatic setting necessitates far more research and correct standardisation.

### 1.1.Related works and contributions

Over the past few years, there has been a significant increase in studies and surveys related to the

metaverse, which is a virtual world where people can interact with each other and digital objects in a shared space. However, despite the potential of blockchain technology to enable various applications within the metaverse, there is a lack of studies on this topic. In one of the first scientific publications to discuss the metaverse in a broader technical context, the authors of a comprehensive survey identified blockchain as one of the seven technological enablers. They also highlighted the potential uses of blockchain in data storage, data sharing, and data interoperability within the metaverse. However, further research and development are needed for the widespread adoption of blockchain technology in the metaverse.

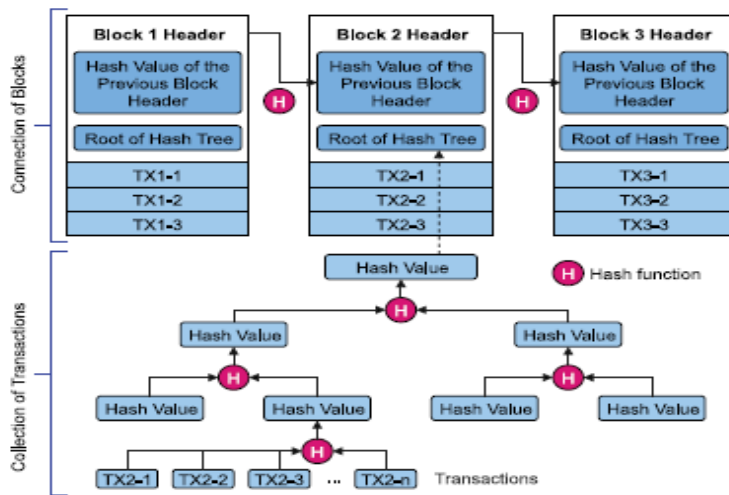


Fig. 2. General structure of a blockchain, in which blocks connected with each other through their respective hash codes.

A deeper study was not conducted on blockchain as the scope of the paper is quite wide. The important position blockchain holds in the metaverse inception is discussed in [2] concerning governmental and economic sectors while its possible utilization for virtual reality object connection is specified. However, this survey fails to build on those specified facts descriptively. The idea of fusing blockchain and AI for the metaverse development was presented in [1] as a survey. This

paper discusses the potential correlation between the metaverse and blockchain through the layered architecture composed of data, network, consensus, incentive, contract, and application layers. Though the authors present four blockchain empowered applications, they are mostly focused on the commercial usage of blockchain. Contribution of blockchain and AI for the metaverse was presented in [3], where handling and reusing high quality/rich data, stabilizing the decentralized network, privacy of data, and handling of economic related data are discussed briefly. In addition, there are various studies [4–6] that mention blockchain as a requisite for the metaverse, though fails to discuss them rigorously. Table 1 emphasizes the contribution of this paper. To the best of our knowledge, there has not been a study that discusses the utilization of blockchain for the metaverse applications. Thus, our study presents diverse potential applications for the metaverse where blockchain integration would enhance their efficiency, and impact of blockchain for enabling technologies.

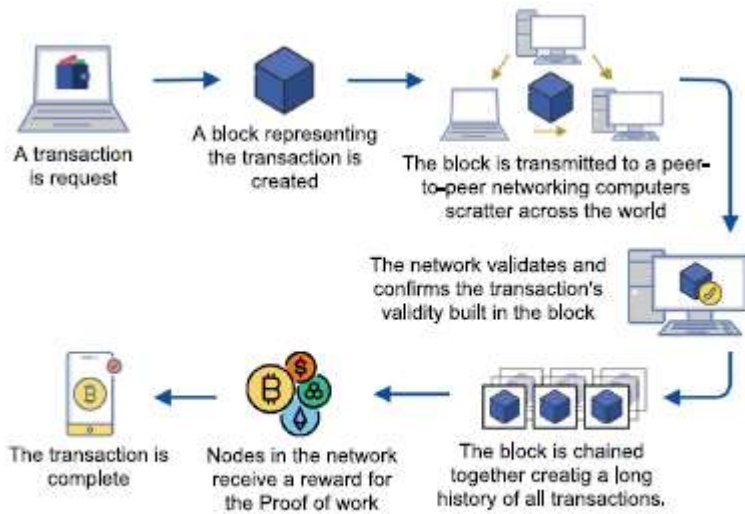


Fig. 3. Illustration of a transaction processed by the blockchain technology.

The main contributions of this survey are:

Firstly, we present a brief overview of blockchain and the metaverse, followed by the motivation behind integration of blockchain in the metaverse.

Secondly, we discuss application of blockchain for addressing the challenges faced by several technical aspects of the metaverse including, data acquisition, data storage, data sharing, data interoperability, and data privacy preservation.

Thirdly, we discuss about the impact of blockchain on some of the

key enabling technologies in the metaverse such as Internet of Things, digital twins, multi-sensory XR and holographic telepresence, AI, and the big data.

Fourthly, we discuss about some of the interesting projects such as Decentraland, Sandbox, Axie Infinity, and Illuvium that leverage blockchain in the metaverse. Finally, we conclude the paper with some potential future research directions.

## 2. Blockchain and Metaverse : The preliminaries

The metaverse is a term used to describe a virtual world that is fully immersive and interactive, where users can engage in various activities such as gaming, socializing, and even commerce. With the advancement of virtual reality and augmented reality technologies, the metaverse is becoming more realistic and accessible than ever before. However, one of the challenges facing the metaverse is the issue of digital ownership and asset management. This is where blockchain technology comes in.

Blockchain is a distributed ledger technology that allows for secure, transparent, and decentralized record-keeping. It has gained popularity in recent years due to its use in cryptocurrencies such as Bitcoin and Ethereum. Blockchain technology can also be applied to the metaverse to create a decentralized virtual ecosystem where users have complete control over their digital assets and interactions.

The combination of blockchain and metaverse technologies has the potential to create a new paradigm in digital ownership and asset management. In a blockchain-based metaverse, users can own and trade digital assets such as virtual real estate, avatars, and in-game items without the need for intermediaries such as game developers or marketplaces. This creates a more open and transparent market for digital assets and eliminates the risk of fraud or centralization.

Blockchain also enables the creation of decentralized autonomous organizations (DAOs) in the metaverse. These are self-governing entities that operate based on predefined rules and regulations encoded on the blockchain. DAOs can be used to govern virtual worlds, manage digital assets, and make decisions that affect the entire ecosystem. This creates a more democratic and community-driven metaverse that is not controlled by a single entity.



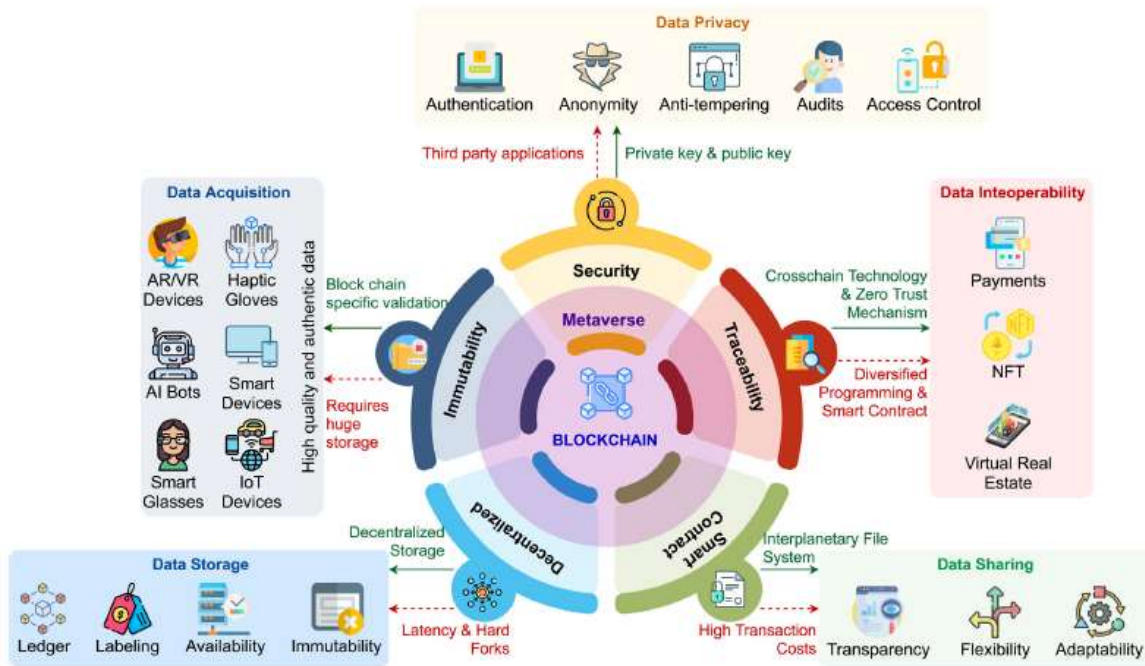


Fig. 4. Blockchain for technical aspects in the metaverse.

### Challenges and Opportunities:

While the potential benefits of blockchain and metaverse are clear, there are also several challenges that need to be addressed. One of the main challenges is the scalability of blockchain technology. The current generation of blockchain networks such as Ethereum can only handle a limited number of transactions per second, which may not be sufficient for a fully immersive metaverse with millions of users.

Another challenge is the issue of interoperability between different metaverse platforms. Currently, each metaverse operates as a separate entity with its own digital assets and economy. There is a need for standardization and interoperability protocols to enable seamless asset transfer and cross-platform interactions.

Despite these challenges, the blockchain and metaverse convergence also presents several opportunities for businesses and individuals. For businesses, this presents a new market for digital assets and services, as well as opportunities for innovation in decentralized governance and community-driven models. For individuals, it provides a new way of engaging with digital assets and virtual worlds, as well as new opportunities for self-expression and creativity.

### Implications for Society:

The convergence of blockchain and metaverse has far-reaching implications for society as a whole. It creates a new paradigm in digital ownership and asset management that is more secure, transparent, and democratic. This has the potential to disrupt traditional industries such as gaming, entertainment, and finance, and create new opportunities for innovation and entrepreneurship.

However, it also raises questions about the future of work, privacy, and social interaction. As more people engage in virtual worlds, there may be a shift towards remote work and digital nomadism. This could also lead to new forms of social isolation and addiction. There is also a need for robust

privacy and security protocols to protect users' data and prevent

### 3. Conclusion and research directions

The paper has comprehensively investigated and analyzed the roles and impacts of blockchain for the foundation and development of applications and services in the metaverse. The fundamental concepts of blockchain and the metaverse were sketched at the beginning of this work, along with the role of blockchain regarding the foundation and development of the metaverse. Later in this work, several prominent technical aspects and use cases of blockchain in the metaverse were investigated exhaustively besides the insightful challenge analysis and applicability discussion given. Finally, some technical improvements of blockchain were provisioned for the metaverse, which in turn enhances the performance and practicality of potential applications and services in the virtual world. Besides making the conclusion, we sketch out some future research directions as below.

Relying on the systematic investigation of blockchain for the metaverse in both the technical and use case perspectives, blockchain had showed a great potential to revolutionize the immersive experience with various applications and services built in the virtual world. Many technical and applicable aspects of all current blockchain versions have been attracting much more research activities, including consensus algorithms, network management, and blockchain interoperability. As consensus algorithms ensure the agreement of states of certain data among authorized nodes in a distributed network, numerous variations of consensus mechanisms have been introduced to achieve high throughput and low latency, but security, scalability, and decentralization could not be obtained concurrently [2]. In this context, it is necessary to develop and sharpen some hybrid innovative consensus algorithms (e.g., Proof-of-Capability, Proof-of-Burn, and Leased Proof-of-Stake) to effectively handle the above-mentioned issues. As a serious global issue noticed by many governments and blockchain communities, high energy consumption and greenhouse gas emission derived by the operation of a large number of participating nodes in a network has caused negative climate and environmental impacts. For a sustainable solution, the Stellar consensus protocol [3] allows authenticating transactions based on a set of trustworthy nodes rather than running the authentication process for the whole network as PoW or PoS algorithm, which in turn accelerates the speed and reduces energy in use. Nowadays, numerous networks and blockchains have been designed for specific applications and services under the umbrella of different community organizations and government departments; therefore, interconnecting existing and new chains is necessary to boost the development of emerging technologies in the metaverse. Cross-chain is introduced as the ultimate solution to obtain the interoperability between different chains, which allows users to execute transactions (with value and information) successfully between different blockchain networks [1]. For instance, users would be able to send the information from an Ethereum blockchain to a Polygon blockchain and vice versa. This interoperability technique also actuates the increasing development of fully decentralized systems with cross-chain bridges. For a long-term evolution of blockchain to reach multi-chain interoperability, omni-chain [10], which is defined as a blockchain as-a-service platform to interact with a wide variety of enterprise networks, can provide blockchain-based applications and services (including asset management, smart contract, transaction management, and shared data ledger) with many appreciated benefits, such as greater transparency, enhanced security, improved traceability, and better efficiency and speed. In traditional organizations adopting classical company hierarchy, most of the important decisions have been made by directors and area managers, which are usually risky and faulty due to human mistakes. To overcome these problems, DAOs are introduced

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