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MetaBlock: A Revolutionary System for Healthcare Industry Fusing Metaverse and Blockchain

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***Abstract*— The Metaverse is like another world functioning parallel to the actual physical world. It merges physical reality with digital virtuality by the convergence of different technologies that enable interactions with virtual objects and environment. The complete immersive experience with metaverse generates huge data which comes with its own set of challenges, a major one being the security and storage of user centric data. Considerably, blockchain offers a significant solution due to its exceptional features of decentralization, immutability, and transparency. For a detailed insight into the role of blockchain in the metaverse, the paper explores its usage in the healthcare industry. The paper then proposes a healthcare system named MetaBlock that is a fusion of both the metaverse and blockchain techniques. The paper discusses the components of the system from a detailed technical interpretation, such as data acquisition, data storage, virtual object and space simulation, data sharing and data privacy protection. Finally, an important research direction in terms of distributed consensus mechanism is discussed.**

***Keywords*— Healthcare, Blockchain, Metaverse, Immutability, Distributed Consensus**

I. INTRODUCTION

Computer interaction with the physical world is essential and is rapidly changing with technological advancement. Initially, punch cards were used for input which was later replaced by keyboards, which are still an essential input device. With the invention of more sophisticated devices like interactive touchscreens, the mode of input changed to touch and gestures. The current wave of computing innovation is evolving around dimensional captivating technologies such as Virtual Reality (VR), Augmented Reality (AR), Mixed Reality (MR) and Extended Reality (XR) [1]. The concept of MetaVerse (MV) then emerged which is a technology which blends all these modern tools and techniques in the global context. This led to a creation of an artificial immersive digital world better known as the "virtual world" for the intended users. Users can have a two way communication with this virtual world using their twin in the digital world known as avatars.

Virtual Reality (VR) refers to a simulated environment where users get an illusion of being in a totally different world and can even interact with the environment using specialized multi-sensor gadgets such as immersive helmets, VR headsets and omni-directional treadmills. These gadgets give the user an experience incorporating the senses of vision, sound and feel [2]. Augmented Reality (AR) immerses digital inputs into the physical environment i.e. it merges the dimensions of the physical with the virtual world [3]. Mixed Reality (MR) is a more complex concept and is often perceived as an advanced AR as the physical world interacts in real time with the digital world using dynamically generated data [4] and hence, can be said to be a combination of both AR and VR. Lately, the term Extended Reality (XR) is being endorsed as an amalgamated term for AR, VR and MR techniques. With a leap breakthrough in the cost of devices and more powerful software, XR implementation has been welcomed by different communities [5]. Priory, the use of XR persisted in specialized domains but has now extended to include a wide range of applications like gaming [6], aviation [7], disaster management [8], industrial training [9], healthcare [10], medical practice [11], education and learning [12].

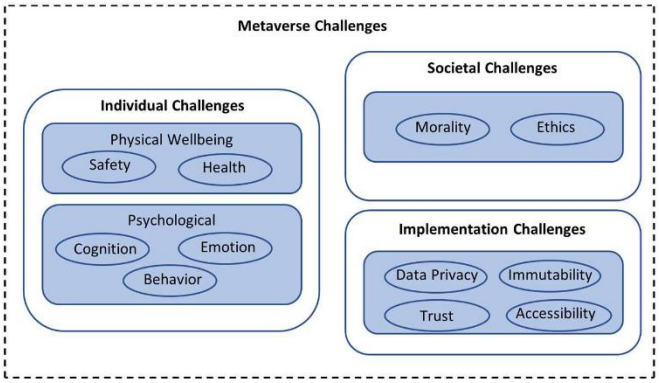

Figure 1. Challenges identified in Metaverse

As with any new technology, Metaverse also faces a number of challenges. The need for specialized equipment is definitely one of them but at the individual, societal and implementation level more challenges can be identified (Figure 1). The challenges identified in using Metaverse (MV) can be broadly classified into (i) Individual; (ii) Societal; and (iii) Implementation challenges.

- *Individual*: Prolonged and extensive use of MV may cause certain physical health concerns like motion sickness, nausea and dizziness, head and neck fatigue [1]. Further, it can lead to isolation and abstention from the real physical world and addiction. Another known drawback is its effect on users' cognition, emotions and behaviours as violent representations can trigger traumatic experiences [13].
- *Societal*: As with any open social world platform, antisocial behaviour like grieving, cyber-bullying, and harassment,

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MV is also affected by them [14]. Indulging into MV may give the users' a sense of falsity as the user may start relying on this virtual world and get disconnected from the real world [15]. Virtual violence and pornography will be readily available and might have significant social consequences [13] and hence, is a concern of morality and ethics [16].

- *Implementation*: On the implementation level of MV, data has a very pivotal role. Personal data acquisition, storage, use, sharing with third parties, achieving interoperability, immutability, and accessibility, preserving privacy and ensuring trust is of utmost importance as data is prone to be hacked or misused.

Consequently, blockchain is an encouraging solution due to its promising features that enables data protection, transparency as well as accessibility.

In line with the challenges identified, this paper explores the metaverse technique stressing on the importance of data privacy for which, blockchain is a viable solution. Data security and privacy of the users' is an essential aspect to consider in a MV based platform as specific laws pertaining to privacy protection plausible in the physical world might not be comprehensible in the virtual world [17]. In terms of privacy, security, and trust, Blockchain is considered as a revolutionary technique [18], although it was initially conceived for financial use. The most striking property of blockchain is its capability to operate without a centralized authority. Although the concept of metaverse can be dated back to 1990s [19], its implementation can be sought to [20], and MV has evolved a long way since. It is not until the current decade that metaverse and blockchain have been fused to bring up marvellous applications. As metaverse deals with vast amount of data, a notable use of blockchain is for secure data storage, sharing and interoperability. Financial dealings are synonym with blockchain and the same has been implemented in metaverse as well [21]. A layered architecture of blockchain fused with metaverse emphasized on the applications of this architecture in commercial usage [22]. The scope of MV is expanding day by day and it has a promising application in the domain of healthcare.

The remainder of the paper provides an insight into the use of metaverse and blockchain in the healthcare industry. Section 2 provides a summary of the existing use of metaverse and blockchain in healthcare management, highlighting what each has to offer. The next sections discuss the components of the proposed MetaBlock system, which is a fusion of metaverse and blockchain techniques and its application in healthcare. Section 4 and 5 highlights the scope for an important future directive in this domain followed by the conclusion.

II. Metaverse Or Blockchain For Healthcare Management

Electronic - Healthcare is evolving rapidly and the COVID-19 pandemic encouraged scientists, engineers, and health workers to devise techniques for providing services remotely. The use of metaverse could boost the healthcare sector and cause a significant improvement in future medical professionals' skills and knowledge bases [23]. Microsoft HoloLens 2 is enhancing patient treatment and enabling healthcare providers to work together more effectively and efficiently [24]. The activities of MV in medical domain is profound and varies from remote diagnosis, treatment planning, medical education, real time surgery assistance, medical marketing, to name a few. MV in healthcare can provide real like experience for remote online doctors and medical students in surgical procedures [25]. Such a simulated environment may significantly reduce surgical risks and can also offer worldwide expertise through medical practitioners online. Utilizing Health Metaverse can further provide doctors with an immersive scene, allowing doctors to enter virtual patient's body during the operation and perform high precision surgeries on subtle parts of the body's organs [26]. However, presently MV is primarily limited to health management and fitness applications in the medical field. The current need is to develop such a platform that can connect remotely different parties like doctors, patients, and administrators through a virtual environment [27]. Medical professionals and teachers can easily use MV technology to train medical students as it can provide a 360-degree holistic view of the anatomy. In addition, combined with hospital equipment information, immersive experience in a virtual world allows students to replay the experience of actual operation as if they were a surgeon themselves [28]. The Health Metaverse application can hence promote innovative medical education, surgery, medical treatment, and online health management [29]. However, the Health Metaverse also has problems and challenges such as difficulty in protecting patient privacy, data security, accessibility, interoperability, and monopoly of a centralized controller [30]. This issue prompted the authors to explore and understand the current context in which blockchain has been implemented in the medical domain. Understanding the congruity and significance of blockchain in medical services, the workplace of the World Economic Forum, made an ideation challenge for mentioning white papers on the expected usage of blockchain in medical care [31].

The main application can be summarized by a few use cases, for example, electronic clinical records, far off patient observation, drug store network and medical coverage (insurance claims). Often, the term Electronic Medical Records (EMRs) and Electronic Health Records (EHRs) are utilized reciprocally, but there is a distinction among both the terms. EMR is a computerized rendition of the prescription from the physician's office and contains the clinical and treatment or medical history of a patient in a single practice. EHRs centre around the complete well-being of the patient-going past standard clinical information gathered in the supplier's office and comprehensive of a more extensive view on a patient's consideration. From the planning study, blockchain innovation underpins the administration of EHRs. In this context, Ekblaw et. al. presented MedRec, an EHR-related execution that proposes a decentralized way to deal with oversee approval, consents and information dividing among medical services partners. MedRec utilizes Ethereum stage to empower patients to have information and data on the go and control access to who can access / view those data [32, 33]. A second application that incorporates EHR, is FHIRChain (Fast Healthcare Interoperability Records +

Blockchain). It is a blockchain-based application actualized utilizing Ethereum for sharing clinical information that centres around medical services record. FHIR-Chain gives answers for patients that meet the prerequisites from the ONC [34]. Further, Xia et. al. designed Medshare an Ethereum based application for frameworks that battle with an absence of joint effort for dividing information among cloud benefits because of the unfavourable dangers towards disclosure of confidential information. Medshare gives information provenance, evaluating, and control between large information elements for sharing clinical information in cloud archives [35]. Other blockchain-based EMR applications incorporate MedBlock and Blochie. MedBlock is a record search system that keeps up the location of blocks containing the records of a patient, assembled by a medical services supplier or division. Every patient record contains a reference to the relating record on the blockchain [36]. Blochie proposed by Jiang et. al. presents a medical services stage dependent on blockchain innovation [37]. To continue misusing existing information bases, Blochie consolidates both off-chain stockpiling, where information is put away in outside emergency clinics' information bases, and on-chain check. There is likewise another medical care blockchain-based structure, Ancile which utilizes Ethereum keen agreements to accomplish information protection, security, access control and interoperability of EMRs [38]. Roehrs et. al. present omniPHR, a circulated model that keep an interoperable single perspective on Close to home Personal Health Records (PHR) [39]. The proposed arrangement depends on a versatile, interoperable, and adaptable engineering of PHR information. Moreover, omniPHR assessment could guarantee the division of PHR into information blocks and its circulation in a steering overlay organization.

TABLE I. BLOCKCHAIN CONTRIBUTION IN HEALTHCARE APPLICATIONS

Ref No.	Highlights	
	Metaverse	**Blockchain**
[11]	Use XR devices offer new advantages to cardiology, where spatial reasoning is very important.	Not Mentioned
[17]	Uses XR devices, IoT devices, digital twins for surreal experience	Uses blockchain to provides trust in the system.
[22]	Creation of Virtual Environment	Distributed Storage, Data Transmission and consensus mechanism
[23]	Creation of virtual environment	Decentralization

It is evident from the discussion above that although blockchain alone had found vivid applications in healthcare domain [40-43], a fused approach of both MV and blockchain is very minuscule. A summary of the existing literature employing blockchain based technology has been listed in Table I. Table II then highlights what metaverse has to offer and how blockchain can contribute to make an efficient system in healthcare-based applications. The implementation details follow in the next section. The proposed concept and framework of Health Metaverse: MetaBlock, redefines the practice of traditional medical practices and promotes the transformation of providing service to users through a virtual world through an amalgamation of Metaverse and blockchain techniques to ensure utmost security and trust in the system.

TABLE II. SUMMARY OF METAVERSE AND BLOCKCHAIN CONTRIBUTION IN HEALTHCARE APPLICATIONS

Metaverse	**Blockchain**
Generates enormous data	Data Storage facility
Immersive real-life experience	Data security and privacy
Professional training and reduced surgical risks	Data Immutability and accessibility
Interactive environment	Data Availability and transparency

III. METABLOCK SYSTEM WORKFLOW

For blockchain applications in medical services, a significant trademark is permanence, which may strife straightforwardly with security rights along with healthcare protocols and standards that should also apply in a blockchain network. The intention of fusing metaverse is to provide real life like experiences to both the patients and the healthcare providers. Traditionally, patients leave information dispersed across different associations and the blockchain based framework may help address this issue by supporting the advancement of interoperability guidelines and prerequisites that address protection and empower the safe exchange of information across frameworks. The aim of such a framework is expected to arrange the patients' clinical datasets and characterize conventions for guaranteeing the consistency of the health care related data [44]. These are normally committed to normalizing the capacity of and managing clinical and segment information about patients. As metaverse deals with enormous amount of data, blockchain are a better mechanism to indefinitely store "ever-growing" patient medical records because apart from being immutable and secure, it also has the capacity to develop and change significantly all through its lifetime by adding new members and changing hierarchical connections, which is very likely to happen in the healthcare- based system. Keeping into consideration these factors, a metaverse and blockchain fused system architecture: MetaBlock, is designed to offer an immersive experience to the users of the system. MetaBlock intends to the give the users of the system an experience of physician consultation as if they are physically present in the hospital or clinician's office. The participating entities in the system are highlighted in Figure 2. The fusion of metaverse and blockchain is depicted in Figure 3 in terms of the metaverse and blockchain components. A detailed description follows in the subsequent sections.

A. Data Acquisition

Data acquisition in this setup includes data collection from users of the system (specifically patients) including their demographic details, past medical history, current ailments, etc. The data collection is metaverse enabled and backed by a blockchain network to build an immutable trustworthy system.

Metaverse Based: It is the preliminary step in any MV system as it helps create a more customized virtual experience. The data acquired for the MetaBlock virtual hospital would contain the user's personal details and medical case histories (acquired through different medical diagnostic tests). Such information is also vital in creation of digital avatars. Payment related details such as bank/credit card information are confidential but are needed to perform certain tasks. Hence, the data acquired is heterogeneous in nature [45] and can be acquired from a variety of sources like web forms, camera, images (medical reports), etc. The data generated in the metaverse is huge, dynamic and unstructured, hence data integrity becomes a challenge in metaverse as data reliability is in question [46] and inaccurate or redundant data also affects the system [47]. Acquiring valid data in MV will be made easier using blockchain technology as it allows validation of transaction records and tracing the data in the metaverse [48, 49].

Figure 2. Participants in MetaBlock

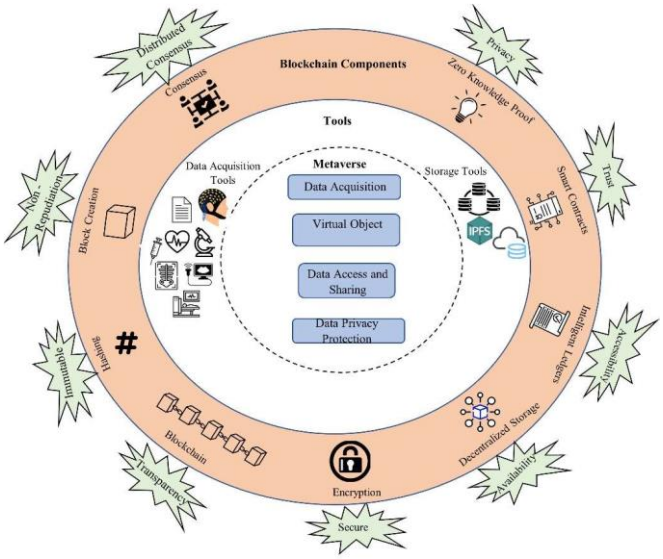

Figure 3. MetaBlock Components

Blockchain Solution: The information gathered through the metaverse is subjected to a validation process that is enabled using the consensus mechanism prevalent in a blockchain network [50, 51]. Distributed consensus can be provided through two widely used methods:

- Proof-of-work is the conventional mechanism for validating a block. Here, nodes compete to initiate the creation of the next block by using computational resources to crack a challenging mathematical problem. The first node to do so, broadcasts the solution to the other nodes on the network, which the remaining nodes verify [52].
- Proof-of-stake mechanism denounce the mathematical challenge, and few privileged nodes get the opportunity to create a block. The nodes are marked privileged based on its existing investment in the system [53].

Blockchain, thus allows a single record to be published on the network (as blocks) without requiring a central authority to approve. As the data in a blockchain is linked to the next block through means of a cryptographic hash, the chances of changing the data (immutable) and creation of duplicate block is negligible which ensures that there is no records are duplicated during data acquisition. Data collected through MV demands increasing storage space, as more data is collected over time. To address this issue in data acquisition systems, a decentralized off-chain storage mechanism is proposed in MetaBlock discussed in section 3.2.

MetaBlock implementation: The first step to implementation of such a framework begins with the patient's registration at the hospital. The data acquisition tools used here includes physical or web forms, medical prescriptions and medical reports (of different image modalities). Additionally, payment details may also be required. Blockchain creation is initiated as soon as a patient registers at the hospital.

[Patient view:] The registration process involves collection of the basic patient details and existing ailments if any. The patient may also choose to share some pre-existing medical reports or clinical imaging reports.

[Backend:] Upon successful registration each patient is assigned a unique id (PID). This PID is now used to generate a pair of keys as:

$$\text{KeyGeneration}(\text{Nonce}, \text{PID}) = (\text{KAdmin}, \text{KPatient})$$

where,

$$\text{KAdmin} =< ak0, ak1 > \text{ and } \text{KPatient} =< pk0, pk1 >$$

The key generation algorithm takes as input a nonce value as the initial seed point and the patient id and the output is a set of keys (KAdmin,KPatient). The key KAdmin consists of a public-private key pair <ak0, ak1> meant to be used by the admin (doctor) and a set of public-private key pair <pk0, pk1> to be used by the patient or user of the system. These key pairs generated will later aid in digitally signing the documents, encrypting/decrypting medical data records, searching through records, etc. A block is then created containing a header which includes a timestamp (the time the block has been created), nonce (a random number used only once), Merkle root (a hash of all the hashes of all the transactions). This block is termed as an Orphan block as it is not complete and is not a part of the blockchain yet, since it has not been validated. Proof- of-stake consensus mechanism has an advantage of validating a block with minimum effort. The node which creates a block will sign the message with the private key corresponding to that node's public key to validate the block [54]. Only after the consensus is achieved, is the block ready to be added to the network.

B. Data Storage

Due to the massive amount of data generated, an efficient storage system is required which not only provides storage space but should also support data retrieval quickly. With the

increase in the issue of data privacy, using a robust storage mechanism is an utmost priority in such a system. A blockchain based storage solution is hence employed as blockchain is known to be trusted, efficient and privacy preserving system.

Metaverse Based: It is obvious that the metaverse will require a massive amount of data storage as the data continues to grow with each interaction with the virtual world. This enormous data has a significant demand for data storage capacity in the physical world. As a consequence, data storage is a crucial issue while deploying metaverse applications and the MetaBlock system as well. Centralized storage solutions also come with their own set of drawbacks as third-party control over data, data leakage, tampering, or data loss.

Blockchain Solution: In blockchain, a new block is created for every transaction and is essentially tamper proof due to chaining through cryptography hashes [55]. An off chain decentralized data storage solution is proposed in the MetaBlock system hence boosting data reliability and transparency in the metaverse. Many blocks can now contribute to the data distribution task, thereby increasing data availability which is essential in applications like vital monitoring and life support alerts in the metaverse. Furthermore, in the metaverse, the blockchain provides data reliability, transparency, and availability [56].

MetaBlock implementation: The data collected during data acquisition needs to be secured and hence there is a need to encrypt it for security purpose. These details are stored in an encrypted database at the site of generation of the data. The distributed database provides an efficient storage solution which is essentially managed by the winning node (during consensus).

[Patient view:] Patient verifies the data by digitally signing it using his / her private key pk1. Figure 4 represents the steps for digitally signing a document by the user (patient).

[Backend:] Digital signatures are used to verify the integrity of data, and it supports non-repudiation. Figure 5 represents the verification of the digitally signed document at the receiver's end.

The hospital then encrypts the patient data R using public key ak0 such that

$$E(R, ak0) \rightarrow CR$$

which finalizes the creation of the initial orphan block. The cipher-files are stored in a repository and an index is generated for the same to facilitate further search strategies. The patient then visits the doctor for consultation and new records are generated. These records also must be validated and added to the blockchain.

[Patient view:] Patient upon consultation with a doctor receives new prescription and may need further medical diagnosis by means of imaging (X-Ray, CT scans, MRI, blood tests, etc.).

[Backend:] The newly generated data has to be validated before they can be added to the blockchain. These data are validated by the admin (doctor, pathologists, radiologists) following the process depicted in figure 5 using the admin private key ak1. A hash is then generated for the same that is stored on the blockchain and broadcasted as a transaction. This ensures the trust factor in the stored records, and it will be added to the existing blockchain network of the hospital from where the trusted third parties may have access to it.

Figure 4. Digital Signature on patient registration data

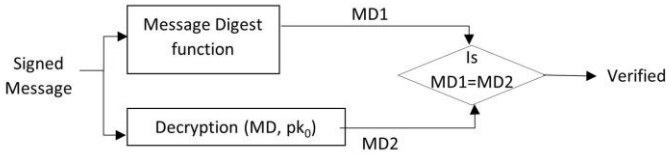

Figure 5. Digital Signature verification process

C. Metaverse Object and Virtual Space creation (Avatars/Digital Twins)

This is an essential component for a surreal experience in metaverse based system. Generation of the entire virtual space including avatar creation is dependent on the data collected and needs a lot of tools for creation.

This is an essential component for a surreal experience in metaverse based system. Generation of the entire virtual space including avatar creation is dependent on the data collected and needs a lot of tools for creation.

Metaverse Based: The avatar is a digital version of the user in the virtual world. Digital twins are advanced representations of different components of the physical world in the virtual world [57]. Representing each component thoroughly gives a better immersive experience to the users of the system. The construction of the virtual object / space creation is simulated using the data obtained from the user and other sources like sensors. The quality of data acquired readily affects the accuracy of the digital twin model used to create the system. Hence, it is essential that the data provided by the source must be authentic and of adequate quality [58].

Blockchain Solution: Blockchain encryption techniques and the data transparency achieved in blockchain validate the digital twins and enable secure data sharing. Real-world data is securely stored in distributed offchain storage locations and co-exist with their digital twins in the metaverse by means of an intelligent distributed ledger. Additionally, this also ascertains the privacy and security of the data. Every interaction of the digital twin in the metaverse will be recorded as a transaction on the blockchain, which is immutable and requires consensus to change [59]. The blockchain technology, thus ensures data trust, integrity, and safety concerns pertaining to the usage of data.

MetaBlock implementation: The use of immersive technologies like AR, VR, MR or XR is needed to mend the gap between the physical and virtual world. The MetaBlock system proposes a theoretical belief of blending the physical infrastructure to present a similar illusion in the virtual world. The need for navigation is critical on the hospital or clinic in the virtual world, where visitors can move freely in a complex

environment, such an internal navigation is a significant challenge [60]. Common tools and techniques as Bluetooth beacons, Wi-Fi, cameras, sensors, etc. are needed to accurately assess the user's location and pose. The use of Artificial Intelligence (AI) is another essential technique required to help in creation of accurate digital twins in the virtual world [61]. Figure 6 showcases the mapping on the real-world entities in the virtual world.

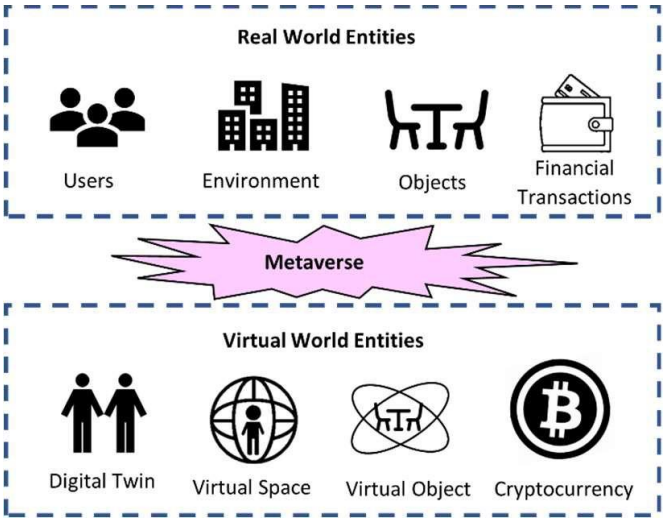

Figure 6. Physical vs. Virtual World entities

D. Data Sharing

Another essential component of the MetaBlock healthcare system is the efficient retrieval and sharing of data that too in a secure manner.

Metaverse Based: Data sharing is an implicit part of any metaverse based devices and sensors will be used to create personalized systems that are customized to the users' actions. Data analytic is also essential to understand and improve user experience. All these require massive data sharing which comes with its own risk of data compromise, theft and misuse. Sharing data via the traditional methods is highly mutable and scalability is another challenge [62].

Blockchain Solution: As discussed prior, blockchain is known to provide decentralized, immutable record of all transactions, and offers data transparency. Additionally, the data owner has complete control over their data and hence data validation is easier through blockchain. Data Availability can also be improved through Smart contracts [63].

MetaBlock implementation: Any participating entity requesting data (for a patient with PID) from MetaBlock system would place a data sharing request to the data generator which will be timestamped (Q(PID)t). Firstly, the requester's identity is verified, failing which access is denied. On successful verification the PID identifier is used to locate the record from the distributed database and the data can be decrypted using the key (ak1). Smart contracts are deployed to carry out the verification and access rights (Figure 7).

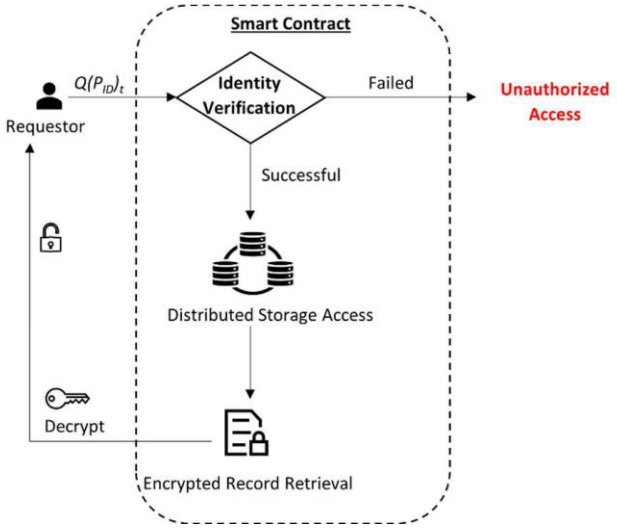

Figure 7. Smart Contract deployment in MetaBlock

E. Data Privacy Protection

Metaverse Based: The metaverse will generate massive data once functional, as more and more users will connect to the system. Sharing massive data gives rise to privacy concern to the users of the system. The metaverse ecosystem will be difficult to adapt if intruders will be able to steal sensitive and confidential data.

Blockchain Solution: Blockchain technology uses encryption technique by means of an asymmetric key pair to allow the user to control their data, effectively providing them ownership of their data. In the blockchain enabled metaverse, third-party providers do not have the permission to access the data. The concept of zero-knowledge proof on the blockchain permits a user to gain access of essential data in the metaverse while ensuring privacy protection and ownership rights. Zero-knowledge proofs in blockchain enables a user to persuade an application that information provided by them is correct and real without disclosing the actual information [64].

MetaBlock implementation: Zero-knowledge proof is a cryptographic technique, in which the data provider can convince the verifier about the correctness of the data without providing any classified data access. MetaBlock implements a zero-knowledge proof verification to ensure data privacy using a distributed ledger [65] (Figure 8).

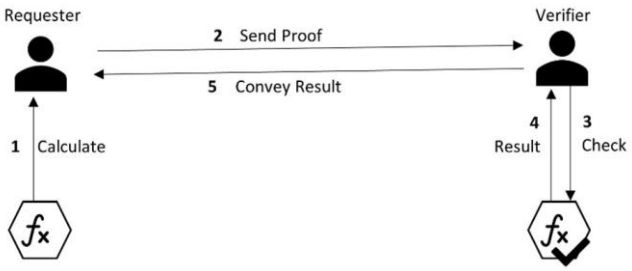

Figure 8. Zero Knowledge Proof mechanism in MetaBlock

To summarize this section, Table III lists the different components of MetaBlock along with the implementation challenges faced in metaverse and how blockchain comes to the rescue using its basic primitives.

TABLE III: METAVERSE FEATURES

Metaverse Challenges	Blockchain primitive used	Features
Data Acquisition		
Heterogeneity Unstructured	Consensus Algorithm Smart Contract	Distributed Consensus Non repudation, validation
Storage		
Massive Evergrowing	Cryptographuc promitives (Hashes) Decentralized Distributed Storage	Immutable Availability
Virtual Object / Space Creation		
Secure Data access	Intelligent Distributed Ledger	Integrity
Data Sharing		
Risk of data tampering, theft and misuse	Smart Contracts	Security and Trust

IV. FEATURES OF METABLOCK

1. Distributed Consensus: Blockchain are essentially distributed systems and are hence not managed by a central authority. A distributed consensus algorithm is well suited for the MetaBlock system as the active nodes can collectively detect transactions and seek to reach a global optimum [66]. Reaching a global consensus eliminates the issues associated with local communication between few nodes. Through iterative updates, a global decision can be made involving all the active nodes in the system. A distributed consensus algorithm will generally offer a fast convergence rate.
2. Non - repudiation: As discussed previously, MetaBlock receives data from multiple sources related to healthcare. The system relies on this data for creating digital twins and virtual environment, arriving at decisions and enabling data quality. The system possesses a validation mechanism to eliminate the chances of data duplication and false data, hereby increasing the data quality.
3. Immutable: Due to chaining of blocks using a hash function, like blockchain, MetaBlock also offers to be tamper resistant and hence, immutable. Changing a block is nearly impossible as that would require a change in all consequent blocks.
4. Transparency and Trust: Transparency ensures accessibility and trust in the system. In MetaBlock, it refers to the availability of patient centric data and clinician reports to the participants of the system. Lack of transparency can lead to safety and trust issues among the users of the system.
5. Privacy and Security: MetaBlock collects voluminous data for providing a real life immersive environment. The system with its authentication, validation, access control rights and distributed consensus mechanisms provides the user complete control of their data. Encryption techniques and hash functions also contribute to maintaining the secrecy and privacy of the data [67].
6. Sharing, Availability and Accessibility: The continuous availability of data is essential in healthcare industry as it is necessary for quick decision rendering for treatment. Uninterrupted data availability and accessibility are a primary focus of the MetaBlock network as well. Blockchain enabled decentralized and distributed storage backs the promise of data availability and access control mechanism ensure the security and privacy.

V. FUTURE SCOPE

The paper has proposed a metaverse and blockchain system for application in healthcare industry, namely MetaBlock after thorough analysis of the role and impact of metaverse and blockchain in healthcare industry. Besides making a conclusion in the next section, worth mentioning is a vital topic that can provide some future research directions as this field is still nascent. Blockchain in general has shown good potential to revolutionize the healthcare industry but incorporating it with an immersive experience to build a virtual world has its own set of challenges. Apart for hardware limitations, implementation challenges are discussed here to provide an insight for future research directions. In a metaverse + blockchain enabled system, a revolutionary breakthrough will be to arrive at an application specific consensus algorithm. Many variants of consensus techniques have been proposed and compared to achieve high throughput and low latency [68], but in the context of a metaverse enabled system, it is still a research initiative to develop and tune some intelligent consensus algorithms. Another serious global issue is high energy consumption due to a large number of participating nodes in a network. As metaverse is growing day in and out, a hybrid consensus mechanism should also consider the limit on the number of nodes participating in the process without effecting the trust in the system.

VI. CONCLUSION

The Metaverse and blockchain individually are not a new concept. However, fusing them unleashes a plethora of creativity applicable to various application domains. The paper discusses the role of metaverse and blockchain, individually in the healthcare industry. It later proposes an architecture by fusing the metaverse and blockchain technology, to come-up with MetaBlock. This system promises to have a rich, immersive experience to its users and can be used for diagnosis, training, surgery simulation, etc. as it is capable of giving its users an experience like the actual physical world. The system relies on MV tools to gather data and gives the user a real like feel and vastly relies on blockchain for reliability in the system. More importantly, the system deploys essential blockchain components of consensus, smart contracts, distributed ledgers, cryptographic primitives fused with metaverse components for successful implementation. The system also has features compatible with the implicit blockchain features of immutability, security, privacy, trust, non - repudiation to name a few. Actual implementation of the system will take some time as it extensively depends on high end hardware devices for immersive virtual reality / augmented reality experience.

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AUTHORS` CONTRIBUTIONS

All authors have participated in drafting the manuscript. All authors read and approved the final version of the manuscript.

CONFLICT OF INTEREST

The authors certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

DATA AVAILABILITY

The data supporting the findings of this study are available upon request from the authors.

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