

Chapter 7

Blockchain–Based Intelligent, Interactive Healthcare Systems

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ABSTRACT

When it comes to the smart healthcare sector, blockchain technology presents several prospects. Aside from its usage in the financial industry, blockchain technology is now also utilised in the process of establishing trust, protecting privacy, and ensuring security. Within the scope of this work, we will provide an explanation of a new development in the healthcare business that strives to enhance the effectiveness and safety of the administration of healthcare data. We employ blockchain technology to construct a decentralised and tamper-proof network that facilitates safe data exchange among healthcare stakeholders such as patients, providers, and insurers. This technique is known as Blockchain-based Intelligent and Interactive Healthcare Systems (Blockchain-based IHS). The purpose of this chapter is to present an overview of BIIHS, including its advantages, disadvantages, and potential future paths. The BIIHS has the potential to enhance patient outcomes by facilitating personalised treatment plans, lowering the number of medical mistakes, and offering real-time access to vital and sensitive health data. Nevertheless, in order to fully realise the promise of BIIHS, it is necessary to solve problems such as regulation compliance, interoperability, and privacy concerns. Artificial intelligence and the internet of things are two examples of upcoming technologies that might be included into BIIHS in the future. This would allow for the healthcare sector to further improve its capabilities.

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1. INTRODUCTION ABOUT INTELLIGENT AND INTERACTIVE HEALTHCARE

New healthcare systems called Blockchain-based Intelligent and Interactive Healthcare Systems (BIIHS) use blockchain technology to create a secure and decentralised network for healthcare data management. With its innovative approach to connecting patients, providers, and insurers, BIIHS might completely transform the way healthcare data is stored, managed, and shared. Among the many issues that have beset conventional healthcare systems are data breaches, an absence of interoperability, and inadequate data management. BIIHS proposes a solution to these problems by creating an unbreakable and transparent network that safeguards healthcare data and guarantees its complete integrity while also preventing tampering. Patients have more say over their healthcare data when they utilise BIIHS, which means they can trust their physicians and insurance providers with their sensitive information. Healthcare professionals may be able to access patient data in real-time and create personalised treatment plans with the aid of BIIHS. Insurance providers, meanwhile, may use the system to more accurately assess risks and provide better coverage to their customers. The use of blockchain technology in healthcare has the potential to revolutionise the industry, leading to safer, more accessible, and more effective healthcare for all. However, there are still challenges that must be overcome, including industry-wide concerns about privacy, interoperability, and regulatory compliance. Keep in mind that BIIHS is a groundbreaking novel finding with the potential to significantly alter the future of healthcare.

1.1 Smart and Secure Healthcare Systems is a Necessity of Modern Society: View from Industry 5.0's Perspective

Intelligent and secure healthcare systems are a need in modern society, and the Industry 5.0 viewpoint highlights the crucial role that technology can play in achieving this goal. Industry 5.0, the most current version of the manufacturing sector, integrates state-of-the-art technology such as blockchain, artificial intelligence (AI), and the Internet of Things (IoT) to create interconnected and smart systems. Smart and secure healthcare systems that boost patient outcomes, tighten data security and privacy, and enable more efficient and cost-effective healthcare delivery are within reach with the help of Industry 5.0 in the healthcare sector. Some of the most crucial parts of smart and safe healthcare systems, according to Industry 5.0, are:

- Using networked devices, sensors, and wearables to gather and send patient data in real-time is a key component of the connected devices idea within the framework of Industry 5.0. Doctors and nurses can now check in on their patients from afar and intervene quickly if issues emerge thanks to this technology.
- The importance of intelligent analytics is highlighted by the Industry 5.0 viewpoint as a means to decipher the massive amounts of data generated by interconnected devices. Healthcare providers can benefit from the use of AI and machine learning algorithms because these tools can identify patterns, predict results, and provide insights that improve decision-making.
- Blockchain Technology: From an Industry 5.0 point of view, blockchain has the ability to build trustworthy healthcare systems. By utilising blockchain technology, it is possible to generate a permanent and unchangeable record of patient data, ensuring the data's privacy and security. Furthermore, it may be used to ensure the authenticity and high quality of medical goods and devices by facilitating the transparent and safe management of supply chains.

- Elevating Patients' Agency: From an Industry 5.0 point of view, patient agency is paramount in healthcare. Intelligent and secure healthcare systems have the potential to enable patients to take a more active role in their own health management by giving them access to their own health records, encouraging transparency, and facilitating collaboration between patients and healthcare providers.
- The viewpoint of Industry 5.0 highlights the need of smart and safe healthcare systems that utilise new technology to improve patient outcomes, increase data security and privacy, and enable more efficient and cost-effective healthcare delivery. Embracing the promise of sector 5.0 and utilising technology is crucial for building a healthcare system that is smarter, more connected, and patient-centered. As long as healthcare is dynamic and ever-changing, this will be true.

1.2 Intelligent Systems

Artificial intelligence (AI) refers to computer systems designed to learn, reason, and solve problems at a human level, much like a human being. Artificial intelligence is another name for intelligent systems. These systems are built using techniques from data analytics, artificial intelligence (AI), and machine learning. Many different industries make use of intelligent systems, including medicine, finance, transportation, and the automotive industry. There is great promise for the application of intelligent systems in healthcare for tasks such as data analysis, accurate diagnosis, personalised treatment plan creation, and health monitoring. Intelligent systems may be used to detect fraud, provide investment recommendations, and assess market trends in the financial sector. The transportation industry may benefit from intelligent systems by optimising routes, reducing fuel consumption, and improving driver safety. The industrial sector may benefit from intelligent systems by automating production processes, streamlining supply networks, and improving quality control. The construction of intelligent systems has been driven by the demand for more efficient and effective techniques to assess and make decisions based on the ever-increasing amounts of data. With the continuous advancement of AI and machine learning techniques, intelligent systems are expected to see a significant increase in their capabilities in the next years. Because of this, our daily lives and the way we do business will be drastically altered.

1.3 Intelligent Healthcare System

Through the use of data analytics, machine learning, and artificial intelligence (AI), intelligent healthcare systems have the ability to completely transform the healthcare industry. These technologies aim to improve healthcare efficiency, accuracy, and quality by offering tailored treatment plans, real-time patient monitoring, and predictive analytics. Many different areas of medicine might benefit from intelligent healthcare systems, including diagnostics, medication discovery, patient tracking, and risk assessment. By utilising these technologies, doctors may examine patient records, which can contain results from imaging studies and lab work, to make accurate diagnoses and suggestions for possible treatments. Research into novel medicines and the improvement of current ones might benefit from the use of intelligent systems that can sift through mountains of data in search of promising leads. With the use of data analysis, these systems may detect and alert healthcare providers to any health issues in their patients before they escalate, making them ideal for patient monitoring. Intelligent healthcare systems might transform the healthcare industry by making personalised and efficient treatment more accessible, decreasing the number of preventable medical errors, and making better use of available healthcare resources. Problems

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with data security, privacy, and meeting regulatory requirements are just a few of the hurdles that must be overcome. The development of smart healthcare systems is an encouraging step towards improving people's health and well-being on a global scale. To sum up, this is encouraging news.

1.4 Interactive Healthcare System

An interactive healthcare system is a digital platform that allows patients and healthcare providers to communicate with each other in a way that is more efficient and productive. Among the many potential features of such a system are electronic medical records, patient portals, remote monitoring, virtual consultations, and real-time health alerts. By leveraging cutting-edge technologies like AI, ML, and NLP, an interactive healthcare system can provide patients with individualised treatment, raise diagnostic accuracy and speed, and boost patient engagement and satisfaction. In terms of major benefits, an interactive healthcare system's capacity to help close the gap between patients and healthcare providers stands out. When it's hard or impossible to meet in person, this becomes much more important. As an example, patients with mobility issues or who live in rural areas might benefit from consulting with their doctors remotely. They can get the treatment they need quickly without having to travel far. Finally, the way we provide and receive healthcare might be drastically altered by an interactive system. Healthcare providers would have the resources they need to deliver better, more efficient care, and patients would have easier access to treatment.

1.5 Intelligent and Interactive Healthcare

With the use of state-of-the-art technologies such as artificial intelligence (AI), machine learning (ML), and natural language processing (NLP), "intelligent and interactive healthcare" can streamline healthcare delivery, improve patient outcomes, and personalise treatment plans. One of the most crucial features of an intelligent and interactive healthcare system is its capacity to collect and evaluate large amounts of patient data instantly. The system uses machine learning algorithms to spot trends and patterns in patient data. This helps doctors make better diagnoses and treatment recommendations. Through an interactive and intelligent healthcare system, people may also receive personalised advice for their health. These recommendations are derived from the unique health information and medical background of each patient. Another crucial aspect of an intelligent and interactive healthcare system is its ability to empower patients to actively participate in their own treatment. For instance, individuals may monitor their symptoms, log their daily activities, and receive personalised recommendations for managing their health using an interactive health app. By taking this step, patients may have a better grasp of their health problems and be more equipped to help manage their therapy. In conclusion, healthcare professionals will be able to deliver more efficient and effective services to patients and offer more personalised treatment with the help of an intelligent and interactive healthcare system, which might completely transform the healthcare industry. By incorporating state-of-the-art technologies, this system has the potential to boost treatment quality and improve patient outcomes.

2. BLOCKCHAIN TECHNOLOGY IN HEALTHCARE

Blockchain technology has the ability to transform several industries, healthcare included. A distributed, secure, and transparent digital ledger, blockchain allows users to create, store, and trade data in an immutable way. By utilising blockchain technology, the healthcare business may enhance data security, privacy, interoperability, and transparency. An important benefit of blockchain technology for healthcare is its ability to create an immutable record of patient information. Using blockchain technology allows for a decentralised approach to medical record storage and access. This makes it harder for hackers to steal or alter the information. In addition to being able to choose who has access to their medical records, patients may work with their doctors to exchange information as needed. Blockchain technology has several potential uses in healthcare, one of which is the administration of clinical trials. By utilising blockchain technology, clinical trial data may be securely and transparently stored. As a result, this can aid in ensuring accurate data and preventing fraud. In the long run, this may lead to better patient outcomes and faster, more efficient clinical trials. Another potential area where blockchain technology might enhance healthcare supply chain management is in this sector. By adopting blockchain technology, pharmaceutical businesses can track their goods as they go from manufacturer to patient. This helps guarantee that the medications they manufacture are authentic and not outdated. In conclusion, healthcare organisations stand to gain from blockchain technology's capacity to increase openness, interoperability, privacy, and security, leading to better patient outcomes and more streamlined healthcare systems.

Blockchain technology might completely transform the healthcare industry by solving several problems associated with data security, interoperability, and trust. Here are the main points of blockchain technology as it pertains to healthcare, including its importance, features, characteristics, pros, and cons:

- Among the many traits and qualities are the following:

Distributed ledger technology, or blockchain, allows for the storing and processing of data without the intervention of a central authority. Among the several advantages of blockchain technology, this is one.

- Data added to the blockchain cannot be removed or altered after it has been added. The information's credibility and accuracy will be preserved in this way.

Blockchain relies on a consensus mechanism to verify and authorise transactions. Before any data is added to the chain, this technology makes sure that everyone in the network is on the same page.

- Contracts that automatically carry out predefined actions when certain circumstances are met are known as "smart contracts," and they are often enabled by blockchain technology. "Smart contracts" are another name for agreements that can execute themselves.

To secure data and provide anonymity for sensitive information, blockchain technology employs cryptographic algorithms. This restricts access to the data so that only approved individuals may view it.

Here are a few benefits, then:

- **Data Security and Integrity:** Blockchain technology's decentralised and irreversible properties make healthcare data more secure and less vulnerable to data breaches and unauthorised changes.

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- Blockchain technology enables disparate healthcare systems to communicate data in an easy and secure manner, facilitating interoperability. Better collaboration and more comprehensive patient care are now possible as a result of this.
- Procedures that are open and effective By providing an auditable and publicly shareable record of transactions, blockchain technology streamlines administrative processes, reduces paperwork, and boosts transparency.
- Patient Empowerment: When patients have greater say over their health records, they may more freely share information with doctors and participate in studies based on their interests. Access to information is one of the other advantages.
- Blockchain technology enables the secure sharing of data for research purposes, which facilitates the development of personalised medicine and insights into population health. This, in turn, benefits research and analytics.

Some of the restrictions are as follows:

- Because verifying and recording transactions requires a lot of computational power and time, blockchain technology is now facing scaling limitations.
- Compliance with laws governing data protection, privacy, and healthcare standards is essential when using blockchain technology in the healthcare sector, but doing so necessitates traversing many regulatory and legal frameworks.
- How advanced the technology is Because of the specific technical skills required for blockchain solution development and implementation, healthcare companies with limited resources or competencies sometimes struggle to establish and deploy blockchain solutions.
- Data Governance: Problems with data ownership, managing permission, and attribution arise as a result of blockchain technology. Therefore, in order to deal with these difficulties effectively, it is required to establish transparent governance systems.
- Achieving seamless integration of blockchain technology with current healthcare systems and infrastructure can be a daunting task that requires either the establishment of thorough interoperability standards or the execution of substantial modifications.

There is a lot of promise in blockchain technology, but before it can be used in healthcare, all of the pros and cons listed above must be carefully considered to ensure a smooth rollout and adherence to regulations.

3. EMERGING TECHNOLOGIES BASED INTELLIGENT AND INTERACTIVE HEALTHCARE

Using new technologies to boost patient satisfaction, enhance the healthcare experience, and cut costs is a prevalent practice in the healthcare business. Among the most exciting new developments in healthcare technology are intelligent and interactive systems. Improved patient engagement, individualised treatment plans, and healthcare professionals' ability to make well-informed decisions are all possible outcomes of these technological developments. Some examples of these technical manifestations are as follows:

- Healthcare providers may benefit from artificial intelligence (AI) in a number of ways, including the ability to track and analyse massive volumes of patient data, spot trends and patterns, and provide predictive analytics. Patients' unique traits, including their genetic composition, lifestyle choices, and medical history, can be considered when designing personalised treatment programmes with the help of AI.
- Augmented and Virtual Reality (VR/AR): By combining the two technologies, medical practitioners may build massive training environments where they can practise challenging procedures in a controlled environment. Patients with pain, anxiety, or depression may find relief via the use of virtual or augmented reality, which provides them with a wealth of distractions and methods to unwind.
- Internet of Things (IoT): Patients' vitals, activity levels, and medication adherence may be tracked in real time using IoT-enabled devices, such as wearable sensors and remote monitoring systems. One possible use of this data is the delivery of personalised therapies, such medication reminders and health lifestyle coaching.
- One potential use of chatbots is providing patients with individualised health information and support. Medication schedules, diet, and exercise planning are just a few of the many areas in which they are knowledgeable and can answer questions. Additionally, chatbots may triage patients, directing them to the appropriate care based on their symptoms.
- Medical personnel may access a patient's medical history and treatment plan in real time, no matter where they are in the globe, thanks to blockchain technology that securely stores and transmits patient data. The implementation of blockchain technology enables this.
- Healthcare professionals and patients alike stand to benefit from smart and engaging technology that may streamline processes, save expenses, and boost quality of life. To sum up, these advantages may be yours for the taking if you use these technological solutions.

4. BACKGROUND WORK

In their quest to become sophisticated platforms for healthcare delivery, traditional healthcare institutions are heavily investing in the use of new technologies. This shift is being propelled primarily by the consumer-centric priorities of ease of use and convenience. Several problems with data and user security, transparency, and privacy persist even with SHS. The research presented by (Tripathi, Gautami, Ahad, and Paiva., 2020) examines the social and technological barriers to the broad adoption of SHS by analysing user perception and the views of contemporary experts. Furthermore, it suggests a blockchain-based SHS architecture to ensure the system's inherent integrity and security. Future research directions and blockchain applications in the healthcare industry are discussed at the end of the session. Blockchain technology has already found acceptance in several academic disciplines, and its applications are expected to skyrocket in the next years. To expand the number of contracts that can be executed simultaneously and remove the need for intermediaries, Blockchain may run small scripts of prepared code called smart contracts. Blockchain and smart contracts are discussed in the paper "Sharma, Ashutosh, et al., 2020."

The authors also discuss how these technologies may be used in electronic healthcare within the context of the Internet of Medical Things (IoMT). This article presents a novel architecture and examines the future of the Internet of Medical Things (IoMT) in electronic healthcare in relation to decentralisation and smart contracts. It also discusses the pros, cons, and forthcoming trends related to this combination.

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Among the irregular ailments that are leading to the fastest increase in the global death rate, diabetes is one such condition. The methodology for allowing the identification of diabetic sickness using the utilisation of Blockchain technology is presented in a recent publication (Mengji, Malook, Ateeq, et al., 2021). It uses a variety of machine learning classification methods to better understand the illness and safeguard patients' electronic health records (EHRs). Our EHR sharing platform incorporates several technologies such as interplanetary file system (IPFS), Blockchain technology, and symptom-based disease prediction. Data about patients' health is also gathered by means of wearable sensor devices. Once the EHR manager receives this data, they use a machine learning model to analyse it further and extract the results. Research by Jie and Xue (2019) indicates that Healthchain is an encrypted system built on the blockchain that aims to safeguard patients' personal health data. In order to establish granular access control, this system encrypts health information. User transactions allow users to effectively cancel or add approved doctors for important management purposes. Another way Healthchain prevents medical disputes is by making it difficult to alter or remove data or diagnosis from the internet of things. The suggested Healthchain is well-suited for integration into AI healthcare systems, as proven by security assessments and experimental data. An intelligent Blockchain Manager (BM) utilising Deep Q-Learning and its modifications was proposed by Al-Marridi, Abeer, and others (2021). In order to maximise the real-time behaviour of the Blockchain network, this intelligent Blockchain Manager (BM) considers the demands of medical data, such as the level of security and urgency. With the goal of optimising the trade-off between cost, latency, and security, the suggested BM attempts to intelligently alter the blockchain's network architecture. Three distinct machine learning-based methodologies are used to effectively solve the optimisation model, which is a Markov Decision Process (MDP). This article focuses on three methods: Deep Q-Networks (DQN), Double Deep Q-Networks (DDQN), and Duelling Double Deep Q-Networks (D3QN). Then, two heuristic approaches are compared with the suggested strategy in detail.

A proposed study by Khatoon and Asma (2020) would examine the current landscape of blockchain research and its applications in healthcare. Furthermore, this study provides a variety of blockchain-based procedures for healthcare organisations to improve data management efficiency. The Ethereum blockchain technology has been instrumental in the development and implementation of several medical procedures, including complex surgery and clinical trial processes. Several medical procedures are a part of these therapies. This package also includes the power to retrieve and manage a large amount of medical data. As part of the feasibility study that has been extensively covered in this paper, we have estimated the cost of this system. This budget goes towards the execution of medical smart contract system-related procedures for healthcare management. By 2020, healthcare data is expected to reach over 23,141 exabytes, according to Amit Kumar Tyagi 2022. The development of better data collection and networking tools is to blame for this. Health data is a valuable resource, and hackers are investing a lot of time, energy, and money into finding ways to use and profit from it. Despite this threat, experts predict that the healthcare cybersecurity industry would grow to 27.10 billion USD by 2026. It is feasible to build a unified database that safeguards patients' privacy while collecting data for clinical research using blockchain technology. According to Quasim, Tabrez, Fahad, and others (2020), a secure architecture built on blockchain technology should be used to guarantee the confidentiality of healthcare records. Technology like wearable sensors, the Internet of Things, and processing power should all be considered. When it comes to managing patient data and medical devices, Pham and Luan (2018) suggest using smart contracts built on blockchain technology to safeguard personally identifiable information and data produced by these devices. Patients, doctors, and healthcare providers (such hospitals) may all be a part of a remote healthcare system built using blockchain technology based on the Ethereum protocol. As soon as

sensors detect changes in a patient's vitals, the data is instantly posted to a blockchain. Data processing that makes it possible to save medical records from patients in a way that is both efficient and sparing.

Note that 64 papers on blockchain-based healthcare systems were critically assessed by Leili, Reza, et al. (2020) between 2016 and January 2020. There were a total of 33 journals, 21 conferences, and 10 internet sites that published these publications. With that in mind, we will be concentrating on resolving three major concerns. How can blockchain technology be integrated into healthcare systems, and what are the steps, obstacles, and frameworks for using blockchain technology in a particular healthcare industry? Various blockchain applications are now in the development phase for use in healthcare. When considering these uses, how do we account for time, space, and technology? How relevant are blockchain-based healthcare system development and implementation to the third and fourth potential research directions? Our discussion also covers other avenues for further study, including blockchain's integration with AI, cloud computing, and parallel blockchain design. Safeguarding private patient information from prying eyes is a top priority for modern sophisticated healthcare systems. Consequently, secure data access procedures are crucial for ensuring that patients' medical records may be accessed by approved individuals only. Therefore, blockchain technology is deemed by the research to be a distributed method for safeguarding patient data. Vidhya, Tanesh, and others (2018) provide a secure and efficient method for patients and doctors to access data inside a particular healthcare system using blockchain technology. Furthermore, the proposed approach can safeguard the privacy of patients' records. Our design has been through extensive security testing, and the findings show that it can survive popular attacks without compromising the system.

The healthcare industry is experiencing a period of transition due to blockchain technology, which may cause a major shift in the current state of services. The healthcare industry, pharmaceutical businesses, and insurance corporations are all touched with in relation to the topic of healthcare system establishment and modification. The foundation for safeguarding healthcare data is laid up by (Khubrani, Mousa Mohammed., 2021). Proposed system foundational ideas include public and private ledgers, smart contracts, and context-based access control. In addition, the offered solution provides secure storage, dependable access to patient data, and interoperability with various interfaces. To safeguard sensitive medical records, a large-scale system based on blockchain technology employs encryption to implement granular access control. Adding or removing approved doctors from rosters is a breeze using user transactions for key management. Healthchain also makes it hard to delete or change data from IoT devices or diagnoses made by doctors, which helps keep medical disagreements at bay. According to Son, Ha, et al. (2021), a management system for emergency access control should be put in place to guarantee the security of patient information. The system is built on top of Hyperledger Fabric, which is developed for permissioned blockchains. An overwhelming amount of laws will be defined as a consequence of the proposed system's use of smart contracts and time length to handle emergency scenarios. In cases when the situation is critical, patients can also choose a time limit for when they can view the information. To further aid readers in understanding the offered management system, a plethora of algorithms describing the system's operation are also provided.

Healthcare 4.0 may make use of wearable sensors to implement remote patient monitoring (RPM), a more efficient and flexible method of patient surveillance. The most specific area of use for RPM is in the medical field, where doctors may use wireless communication technologies to remotely access real-time patient data. Clinicians have access to this feature. Because of this, RPM helps patients save both time and money. The care that the patient receives is also of the highest quality. The article's authors (Hathaliya, Jigna, et al., 2019) talk about a permissioned blockchain-based healthcare architecture that

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aims to make patient data more secure and private. We have also addressed the problems and how to fix them. The various applications of blockchain technology have already been discussed. In addition, we discussed the possible effects of blockchain and AI on the medical field. An intelligent healthcare system built on the blockchain that provides granular privacy protection to enable users to trust one other while sharing and exchanging data was presented in 2021 by Wu, Guangjun, and others. By integrating Local Differential Privacy (LDP) approaches with blockchain technology, we can build a framework for dynamic access control that provides attribute-based privacy protection in transaction processing. The system generates four different kinds of smart contracts to meet the needs of anonymous transactions, dynamic access control, beneficial matching decisions, and evaluation of public data in an open network. Ring Signature is a method for retrieving private information that is based on the blockchain and requires authorization (Aitizaz, Muhammad, et al., 2022). In order to aid in the improvement of privacy preservation inside the intelligent healthcare system, this approach is offered. To optimise appointment supplies based on accessibility, transparency, and security, the suggested approach first uses a more complex multi-transaction mode consortium blockchain. The healthcare providers are notified of this by receiving requests of varying volumes. If implemented, our proposed approach would greatly improve data retrieval across many fields. The suggested Scheme works quite well, according to the simulation findings, in terms of maximising patient privacy while reducing processing and transmission costs.

The paper (Sharma, Pratima, et al., 2022) suggests a blockchain-based Internet of Things architecture that uses the Identity-Based Encryption (IBE) algorithm to improve the security of healthcare data. In this case, everyone benefits from the smart contract's outlines of all the essential healthcare system processes. In order to determine the efficacy of the suggested approach, many tests are executed. Findings from the study suggest that the suggested system outperforms the popular approaches used at the moment. Blockchain technology is expected to make a significant impact on the healthcare business, among other notable application fields. The current healthcare systems are opening up a wide range of choices and possibilities as a result of this. Consequently, Kumar, Vidhya, and colleagues (2018) set out to study how blockchain technology could be integrated into current healthcare systems and what conditions are necessary for these systems to function well. Healthcare systems that are both trustless and transparent are part of these needs. Along with this, the paper explores the problems that must be solved before healthcare systems can effectively implement blockchain technology. On top of that, they supply the smart contract, an essential tool for establishing the beforehand-decided terms among the many participants in healthcare systems that rely on blockchain technology. Research done in 2022 by Le, Hai, and others suggests using the Patient-Chain platform, a control and management system, to keep patient data safe. Using Blockchain technology, this platform provides a healthcare system focused on the patient. The Patient-Chain system is constructed on the approved Blockchain platform, Hyperledger Fabric. Using smart contracts, it lays out a number of rules and regulations and gives a timeline for handling emergencies. Additionally, patients can set time limits on data access, which is useful for cases where time is of the essence. For the benefit of the readers, the suggested management system is accompanied with a plethora of algorithms that demonstrate its performance.

5. PROBLEM DEFINITION FOR DESIGNING A SECURED, PRIVACY PRESERVED, TRUST INTELLIGENT AND INTERACTIVE HEALTHCARE

- In order to create a healthcare system that is reliable, smart, engaging, secure, and private for patients, it is important to understand all the obstacles and problems that come with it. Some of the most crucial problem definitions to keep in mind are that which follows:
- When it comes to data security: It is critical to protect healthcare data from unauthorised access, modification, or theft since it is highly sensitive and valuable. To ensure the constant protection of patient information, an extensive set of security mechanisms must be included into the smart and participatory healthcare system.
- Ensuring the privacy of patients It is imperative that the intelligent and interactive healthcare system be designed in a way that protects patients' right to privacy when it comes to their health information. Ensuring that patient data may be accessed only by approved individuals and that patients can select who can access their data is of utmost importance.
- The success of the smart and interactive healthcare system depends on patients' trust in it. Building a trustworthy and accountable system and outlining clear guidelines for data exchange, access, and usage are essential steps in this direction.
- Integration: The smart and engaging healthcare platform should have the capability to connect with preexisting healthcare platforms. Medical equipment, electronic health records, and other healthcare-related technology are all part of these systems. This is why making sure the system works with the current procedures and technology requires a lot of preparation and cooperation.
- Factors related to ethics: Many moral questions arise from the integration of AI into healthcare systems, including issues around autonomy, informed consent, and the potential for bias in AI algorithms. If we want to make sure the system is created and implemented with ethics and responsibility in mind, we have to answer these questions.
- Remember that these problem definitions are critical to building a reliable, smart, and engaging healthcare system that safeguards patients' privacy, is safe, and can improve patient outcomes while keeping data secure and private to an absolute minimum. We need blockchain technology to fix issues like this.

6. ISSUES FACED IN DEVELOPING A BLOCKCHAIN BASED INTELLIGENT AND INTERACTIVE HEALTHCARE

Creating an intelligent and interactive healthcare system that uses blockchain technology is an intricate process fraught with technical and non-technical challenges (Singh, Suruchi, et al., 2022). Among the many difficulties that could arise in creating such a system are:

- Keeping information private and secure: Health information is very private and delicate. Consequently, a major obstacle to building a blockchain-based healthcare system is ensuring the privacy and security of data. It is critical that the system be built in a way that prevents unauthorised persons from accessing patient information and guarantees the data stays confidential.
- Accessing and integrating healthcare data may be a huge challenge since it is often spread out across different healthcare providers. This is where interoperability comes in. Building a health-

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care system that integrates with many healthcare providers and systems and is rooted on blockchain technology is no easy feat.

- Because of the massive amounts of data generated by the healthcare system, scalability is a major issue. The blockchain-based healthcare system must be capable of handling massive amounts of data with ease and without compromising its overall performance.
- Health Insurance Portability and Accountability Act (HIPAA) compliance is critical since the healthcare industry is subject to stringent regulations. If the blockchain-based healthcare system is serious about protecting patients' privacy and security, it must follow these guidelines.
- Knowledge in technical areas: Building a blockchain-based healthcare system calls for experts with knowledge in data analytics, healthcare systems, and blockchain technology. The creators of the system must possess an in-depth understanding of these domains to build an efficient and effective system.
- Usability and adoption: The potential for adoption and use determines the efficacy of any healthcare system. For this reason, it is critical to build a healthcare system that utilises blockchain technology and is user-friendly and well-received by everyone involved.
- Data privacy and security, interoperability, scalability, regulatory compliance, technical competency, acceptance, and usability are some of the challenges that must be overcome in order to create an intelligent and interactive healthcare system based on blockchain technology. In the next steps, we will address all of the issues, including the somewhat less technical ones.

6.1 Technical Issues

Building an intelligent, interactive healthcare system on top of blockchain technology could be a challenging and intricate process. A few examples of potential technological issues are as follows:

- The establishment of a blockchain-based healthcare system faces several formidable challenges, not the least of which is scalability. The blockchain network must be able to efficiently and rapidly handle a large number of transactions. As a result of their current architecture, most blockchain systems may have limited scalability, which might lead to slow transaction processing times.
- In order to keep patient information private, all healthcare records must be protected from prying eyes. However, it may be difficult to safeguard one's privacy with blockchain technology due to its features, such as the decentralised and transparent nature of all data maintenance. We need to create mechanisms that can restrict access to the data so that only allowed individuals may access it.
- Interoperability: Ensuring that varied systems and technologies can interact with one another is vital, since blockchain-based healthcare systems may need the integration of several systems and technology. Problems arise while trying to build a seamless data flow due to the fact that various systems may use different standards and protocols.
- Safety: The safety of any healthcare system is of paramount importance, and blockchain-based solutions are no different. Blockchain technology is secure, but it may still be compromised. It is critical to construct reliable security measures in order to ward off hackers and other security threats.
- Construction of Electronic Contracts: Particularly challenging and intricate might be the process of developing smart contracts for a healthcare system based on blockchain technology. The details of the purchase and sale agreement are instantly codified into computer code in smart contracts.

There is an automated renewal process for certain contracts. Developing these contracts requires a thorough familiarity with the healthcare industry as well as the use of blockchain technology.

- Having an in-depth understanding of blockchain technology as well as the healthcare business is crucial for building a healthcare system that utilises this technology. On top of that, it calls for robust security measures, the ability to offer scalability, privacy, interoperability, and the generation of smart contracts.

6.2 Non- Technical Issues

In addition to technological hurdles, there are a plethora of other non-technical issues that must be overcome in the course of developing a blockchain-based intelligent and interactive healthcare system. Among these issues are:

- **Adherence to regulations:** Building a blockchain-based system in the healthcare industry necessitates adhering to several government regulations and industry standards, and the industry as a whole is subject to heavy regulation. It is critical to ensure the system meets all relevant regulatory requirements in order to prevent any financial and legal risks.
- **Moral Deliberations** Many moral questions arise when healthcare organisations use blockchain technology, such as who owns the data, how to regulate permission, and patients' right to privacy. It is necessary to develop ethical frameworks and standards for the collection, use, and sharing of healthcare information.
- **Price:** Considering the system's cost-benefit analysis is essential, since developing a healthcare system based on blockchain technology might be rather expensive. Finding a happy medium between the system's costs and its potential benefits—which can include better patient outcomes, lower expenditures, and more energy efficiency—is essential.
- **Acceptance:** Many obstacles, such as resistance to change, confusion, and worries about data privacy and security, may slow the healthcare industry's adoption of blockchain technology. The best way to get people on board with the system is to highlight its benefits and solve any issues that crop up.

Finally, it is critical to address both the technical and non-technical challenges that have arisen throughout the development of the blockchain-based healthcare system if it is to be a success. If you want to make sure the technology is deployed effectively, you need to build adoption plans, cost-benefit analyses, ethical frameworks, stakeholder engagement, and regulatory compliance.

6.3 Legal Issues

Greater interoperability, improved data security, and more patient control are just a few of the potential advantages that could result from developing an intelligent and interactive healthcare system based on blockchain technology. However, that is not all that must be considered; there are also challenges and legal issues. The following are examples of major legal issues that could arise while creating such a system:

- **Ensuring Data Privacy and Security:** Due to the sensitive nature of healthcare data, any use of blockchain technology must adhere to data protection regulations like the General Data Protection

Regulation (GDPR) or comparable statutes. Maintaining the privacy and security of patients' records is of the utmost importance when using blockchain technology. Developers must implement appropriate security measures and obtain informed consent from patients before collecting and processing their data.

- Consent management is an ongoing activity, and patient consent is a crucial component of healthcare data processing. Mechanisms for efficient consent management should be present in any system built on blockchain technology. The ability for patients to grant or withdraw permission for specific data uses is important for patients' right to privacy and for healthcare providers to follow the law.
- Intellectual Property: New healthcare systems built on the blockchain may necessitate the development of IP-protected innovations. Developers should think about ways to protect their intellectual property so that their ideas are safe and that they meet all the requirements for patents, copyright, and trademarks. If you want to incorporate preexisting patents or use technology that was provided by other parties, you may need to get a licencing agreement.
- Users, healthcare providers, and developers are just a few of the many parties involved in blockchain-based healthcare systems, which raises important questions about accountability and liability. In the case of a data breach, incorrect diagnosis, or other system-generated harm, it may be difficult to ascertain responsibility and liability. Developers can help alleviate these issues by including clear disclaimers, limitations of liability, and terms of use in their products.
- Standards and Interoperability: Achieving interoperability between the different blockchain platforms and healthcare systems is crucial to guarantee the uninterrupted transmission of data. To ensure compatibility and conformity with industry standards, developers should consider already established healthcare interoperability standards like FHIR and HL7.
- Difficulty in various legal contexts A number of jurisdictions may find it challenging to ensure legal compliance with blockchain technology due to the fact that it operates across international boundaries. The developers should be informed about the legal requirements and constraints of the many countries where the system could be used.
- Data storage, data transfer across borders, and data collection from all over the globe are areas where this is of paramount importance.
- Legal complications may emerge depending on the particular implementation and jurisdiction, so please keep that in mind. With the help of attorneys specialising in healthcare, data protection, and blockchain technology, these legal hurdles can be efficiently navigated and applicable rules and regulations can be assured.

7. CHALLENGES FACED TOWARDS BLOCKCHAIN BASED INTELLIGENT AND INTERACTIVE HEALTHCARE

Using blockchain technology to build a decentralised healthcare system is the goal of the relatively new idea of intelligent and interactive healthcare. Before this kind of system can be implemented, several hurdles must be surmounted (Dasaklis, Fran, et al., 2018). This is so even though such a system might have huge positive effects. Here are a few of these challenges:

- Patient privacy concerns: safeguarding patient privacy ranks high among the many obstacles to blockchain-based healthcare. Despite its promise of a safe and transparent way to store medical records, blockchain technology might leave patient data more vulnerable to threats if not applied properly. Also, maintaining patients' privacy by ensuring that only approved persons may access their sensitive medical information can be challenging.
- Another major obstacle is interoperability, which arises when various blockchain systems cannot communicate with one other. There needs to be a way for different systems to connect with each other smoothly for blockchain-based healthcare to be a success.
- Any new technology introduced to the highly regulated healthcare sector must adhere to all relevant rules and regulations. There are several difficulties that regulatory bodies face because of this. Blockchain technology still faces several regulatory hurdles before it can find widespread use in healthcare. This is also true with blockchain technology.
- Challenges in implementation: Blockchain-based healthcare is no different from the healthcare industry as a whole in that it has been sluggish to embrace new technology. Healthcare practitioners and patients alike need greater information and understanding in order to boost adoption rates.
- Accurate and full data is essential for blockchain-based healthcare to function properly. Healthcare data is frequently dispersed across several systems and may have variable quality, making data quality assurance a formidable problem.

Blockchain technology's slowness and inefficiency provide a problem for healthcare applications that rely on real-time data access in terms of scalability. The effective scalability of healthcare systems built on the blockchain is an important issue that needs fixing.

Finally, despite the great potential of blockchain-based intelligent and interactive healthcare, achieving this goal would need substantial work and cooperation among all parties involved.

7.1 Security Challenges Faced Towards Blockchain Based Intelligent and Interactive Healthcare

According to Abou-Nassar, Eman, et al. (2020), there are several security concerns with blockchain-based intelligent and interactive healthcare systems. These concerns include the following:

- Confidentiality: Protecting patient information is essential since it is sensitive. The inherent immutability and transparency of blockchain technology raises concerns about its suitability for protecting sensitive healthcare data.

Secure identity management solutions must be implemented in blockchain-based healthcare systems to guarantee that only allowed individuals may access patient data. This can be particularly problematic in healthcare settings because to the high volume of healthcare professionals that may need access to patient records.

- Smart contracts' safety: Automated contract execution is the capability of "smart contracts," which are recorded on the blockchain. Many healthcare-related interactions and transactions might be mechanised with the use of these contracts. However, smart contracts may be attacked, and malicious actors can take advantage of any flaws or weaknesses in the smart contract's code.

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- **Consensus procedures:** Healthcare systems that rely on blockchain technology rely on these to ensure the data is accurate. Attacks on these procedures are not out of the question, especially on less secure and smaller networks.
- To ensure the safe and effective interchange of patient information, blockchain-based healthcare systems must be able to interface with other systems. This is called interoperability. Conversely, interoperability may be challenging to attain, especially in cases when many healthcare systems utilise a variety of distinct protocols and standards.

Finally, top-notch security solutions are required to ensure the privacy and integrity of patient data in blockchain-based smart and interactive healthcare systems. Some of the components that come under this category include the creation of strong consensus procedures, secure smart contract code, and robust identity management systems.

7.2 Privacy Challenges Faced Towards Blockchain BASED INTELLIGENT and Interactive Healthcare

Prabadevi, Natarajan, and colleagues (2021) state that there are several privacy issues with intelligent and interactive healthcare systems that are built on the blockchain. Here are some of the difficulties:

- **Transparency and immutability:** Patients' personal information might be at risk if they use blockchain technology, which makes maintaining anonymity a priority. While patient identities can be concealed via pseudonyms or other means, complete anonymity for those patients may remain elusive.
- **Breach of data security:** Healthcare systems built on the blockchain are not immune to data breaches; this is true of all healthcare systems. Blockchain technology's decentralised design, on the other hand, may make it harder to detect and react to security breaches.
- Patients must provide their informed consent before any data may be transferred to a healthcare system that is based on blockchain technology. But it's not always easy to make sure patients fully understand the risks and repercussions of giving their consent.
- **Laws:** Few laws have been passed that explicitly address the proper use of blockchain-based healthcare systems, perhaps due to the fact that these systems are still in their early stages. Because of this, it could be hard to ensure that patient data is being handled correctly.
- **Interoperability:** Healthcare systems built on the blockchain must be able to talk to each other for patient data to be transferred securely and efficiently. But interoperability may be tough to accomplish, especially when separate healthcare systems use distinct protocols and standards. Because of this, it could be hard to ensure that patient data is being handled correctly.

To ensure the security and privacy of patient information, it is necessary to develop strong privacy solutions when using blockchain technology in intelligent and interactive healthcare systems. Among these, you may find rules that are clear about their usage, safe ways of data storage and transfer, and durable anonymization techniques.

7.3 Trust Challenges Faced Towards Blockchain Based Intelligent and Interactive Healthcare

Several trust issues arise with intelligent and interactive healthcare systems built on blockchain technology. These include:

- **The complexity of the system:** Due to its complexity and specific expertise requirements, blockchain technology is challenging to implement and maintain. There may be miscommunication and distrust between patients and doctors because of this, which might make it hard for anybody to fully grasp how the system works.

One potential advantage and one potential disadvantage of blockchain-based healthcare systems is their intended transparency. This might end up being an advantage and a disadvantage. Transparency may boost trust by showing patients exactly how their data is being used, but it can also reveal sensitive details and make it harder to keep them private.

- **Consistency:** Distributed networks of nodes are the backbone of blockchain-based healthcare systems, which provide full and accurate data. The reliability and security of the system may be jeopardised if any one of these nodes were to fail, leading to a loss of trust.
- Healthcare providers and patients unfamiliar with blockchain technology may be wary of its potential due to the low adoption rate of blockchain-based solutions. Finally, healthcare systems that use blockchain technology are still in their early stages of deployment.

Ultimately, these issues must be resolved by open and honest communication, thorough education and training, and robust technology solutions if trust in smart and interactive healthcare systems built on the blockchain is to be established. Improving the system's dependability and security, establishing clear regulations and standards, and increasing the technology's use by both patients and medical professionals are all part of this process.

8. FUTURE RESEARCH OPPORTUNITIES TOWARDS USING BLOCKCHAIN IN HEALTHCARE SECTOR

Blockchain technology has several potential applications in healthcare, and there are many interesting areas that might be studied (Yaqoob, Khaled, et al., 2021). Some examples of these possibilities are:

- **The creation of reliable privacy and security solutions:** As mentioned earlier, healthcare systems that rely on blockchain technology have several challenges when it comes to privacy and security. Research may be conducted to provide fresh and innovative ways to tackle these challenges and guarantee the safety and confidentiality of patient data.
- **Looking into standardisation and interoperability:** To ensure easy communication and cooperation across healthcare systems, it is crucial to adopt interoperability. It is feasible to conduct studies that look at the potential applications of blockchain technology in developing interoperability solutions and standardising protocols for data exchange.

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- Conducting medical research with blockchain technology One possible use of blockchain technology is the safe and transparent management of data used in medical research. Research into the potential uses of blockchain technology to improve research outcomes and facilitate the creation of new medical discoveries is within reach.
- Healthcare supply networks could benefit from blockchain technology's capacity to increase transparency and traceability. Building blockchain-based supply chain management solutions could be the key to achieving this goal. Research may be conducted to examine the potential applications of blockchain technology in ensuring the security and efficacy of healthcare products and tools.
- Increasing patient agency and participation: By granting people more say over their own health records, blockchain technology may increase patient agency and participation. Studying how blockchain-based solutions might be customised to meet patients' needs and improve their healthcare experience overall is a viable area of study to pursue.
- In order to boost innovation in the healthcare industry, protect patient privacy, and enhance patient outcomes, there are a plethora of fascinating research topics that may be explored. Finally, there is a plethora of opportunities to investigate the many possible applications of blockchain technology in healthcare.

9. RESEARCH STATEMENTS FOR USING BLOCKCHAIN IN HEALTHCARE SECTOR

The following are some research claims on the use of blockchain technology in healthcare, as stated in the studies conducted by Tandon, Anushree, et al. in 2020 and Khezzr, Seyednima in 2019:

- The goal of this research is to find out how well blockchain-based solutions protect patients' personal information and electronic health records (EHRs).

The potential applications of blockchain technology in healthcare supply chain management are the focus of this research. Equally important is the examination of the pros and cons of blockchain-based solution implementation.

- Looking at how medical research may benefit from blockchain-based solutions, with an eye on improving data sharing, transparency, and collaboration amongst the parties involved.
- Looking at how blockchain technology can empower patients to have a say in their healthcare records and promote self-management by making it easier for them to access and manage their own information.
- Building a blockchain-based infrastructure to run clinical trials in a secure and transparent manner; this might increase efficiency, decrease costs, and increase patient safety.
- To improve healthcare in developing countries with inadequate infrastructure and resources, researchers are looking at the potential use of blockchain technology.
- Looking at blockchain-based technologies that might help healthcare systems work together more effectively and make it easier for different companies to share patient data.
- Principles for data security, informed consent, and governance should be part of any framework for the appropriate and ethical application of blockchain technology to healthcare.

- Looking into the pros and cons of introducing blockchain-based solutions, as well as the likelihood that blockchain technology may improve the efficiency and accuracy of healthcare payment and billing systems.

So, ultimately, by exploring and making use of blockchain-based solutions to improve medication adherence and decrease medication errors through transparent and secure recording of medicine intake, etc.

10. POTENTIALS FOR BLOCKCHAIN IN NEAR FUTURE

The impending development of several intriguing blockchain-related applications bodes well for the technology's ability to transform a wide range of industries. In this piece, we'll look at a few ways blockchain technology may be used in several industries, including healthcare. The 2020 publication by Poonam Chahal and Amit Kumar Tyagi Amit Kumar Tyagi and G. Rekha were married in 2020. P Released in 2022 by S. Kumari and P. Muthulakshmi Amit Kumar Tyagi, Vinuthna, and Shamila were married in 2023. Tyagi (A.K.) and Madhav (A.V.S.) 2022 The publishing by D. Goyal and A.K. Tyagi in 2020; The 2019 publication by Amit Kumar Tyagi and Rekha G. Tyagi In 2019, the results were published by Amit Kumar Tyagi, V. Krishna Reddy, and Gillala Rekha. "Sai, G.H., Tripathi, K., and Tyagi, A.K. 20,23" was published in 2019 by Shruti Kute, Amit Kumar Tyagi, and Rohit Sahoo. Studies conducted in 2020 by Gudeti, Mishra, and colleagues 21, include Tyagi, Meenu, and others S.S. Kute, Aswathy S.U. 2022, and A.K. Tyagi, in that order According to Nair M.M., Tyagi A.K., and Sravanthi K. 2021, the following subjects can be investigated in the future:

- **Digital Identity:** Secure and verifiable digital identities may be created with the help of blockchain technology. A variety of activities, like as voting, gaining access to financial services, and data storage, may make use of these identities.
- **Supply Chain Management:** By integrating blockchain technology into supply chains, we can ensure that all items are legitimate and of high quality. This is achieved through end-to-end transparency and traceability.
- Blockchain technology offers a more efficient and safe way to register and transfer ownership of real estate, which might lead to the elimination of intermediaries like lawyers and title firms in the real estate industry.
- **Decentralised Finance (DeFi):** Anyone with an internet connection may use blockchain technology to build open, transparent, and accessible decentralised financial systems.
- The healthcare industry has the potential to use blockchain technology to create open-source, secure systems for patient data management, medication usage tracking, and product authenticity verification.
- In the energy sector, blockchain technology has the potential to create decentralised energy grids, which would improve the efficiency of renewable energy and other energy sources' distribution and storage.
- One potential use of blockchain technology in gaming is the creation of decentralised gaming ecosystems where players may own and trade virtual goods and currency.

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- Using blockchain technology in the school industry will make credit transfers and job applications easier for students. The adoption of blockchain technology has the potential to provide transparent and secure systems for the recording and validation of academic qualifications.

As a conclusion, blockchain technology has many potential applications, and many exciting new applications will likely appear in the near future as the technology evolves and develops more.

11. CONCLUSION AND FUTURE WORK

By improving patient outcomes, strengthening data security and privacy, and enabling more efficient and cost-effective healthcare delivery, intelligent and interactive healthcare systems built on blockchain technology might radically alter the healthcare industry. Healthcare practitioners can create secure and transparent systems for patient data management, medication consumption tracking, and medical supply and equipment validity verification using the immutability and tamper-proof properties of blockchain technology. In the long run, this may benefit patients' health by increasing their safety and allowing healthcare providers to work together more effectively. The use of smart and interactive technologies like wearables, the internet of things (IoT), and artificial intelligence (AI) can also pave the way for proactive and personalised healthcare. Because of this, medical professionals can improve patient outcomes by responding quickly to issues. Nevertheless, there are a lot of challenges that must be overcome. These include issues related to data protection, meeting regulatory standards, and ensuring that different healthcare systems are interoperable and standardised.

Ultimately, Intelligent and Interactive Healthcare Systems built on the Blockchain might completely transform the healthcare industry. However, for this revolutionary potential to materialise, a great deal of stakeholder collaboration and innovation is required. As blockchain technology has the ability to shake up several non-financial sectors, it bodes well for the technology's future. Healthcare organisations may reduce the risk of data breaches and ensure patient privacy by securely storing and disseminating medical records using blockchain technology. Applying blockchain technology allows this to be achieved. With blockchain's ability to provide transparency and traceability, supply chain management may enhance item monitoring and decrease the chance of fraudulent conduct. To facilitate the exchange of renewable energy, blockchain technology may be able to aid the energy sector in creating decentralised energy markets. Scalability, interoperability, and legal concerns are just a few of the ongoing challenges to blockchain adoption.

The current state of the blockchain infrastructure is not scalable because of its restricted capacity, which limits the amount of transactions that can be processed. Interoperability issues stem from the fact that different blockchain systems do not adhere to any kind of standards. Information communication between networks is made more difficult by the absence of standards. Regulators are worried about blockchain technology since there aren't now clear rules and standards for its usage. Ambiguity and potential legal risks result from this murkiness. To rub salt in the wound, blockchain technology is highly promising and is expected to experience significant growth in the next years. With the constant development of new blockchain platforms and use cases, blockchain technology is poised to revolutionise several sectors while opening up exciting new possibilities for growth and innovation.

Due to its ability to enable a wide range of non-banking businesses, the technology behind blockchain has great promise for the future. Healthcare organisations may reduce the risk of data breaches and

ensure patient privacy by securely storing and disseminating medical records using blockchain technology. Applying blockchain technology allows this to be achieved. Because blockchain technology allows for more accurate monitoring of goods and decreases the chance of fraudulent conduct, it can improve supply chain management by making information more transparent and easier to trace. The development of decentralised energy markets, made possible by blockchain technology, may revolutionise the energy industry by allowing for the efficient trading of renewable energy sources. Nevertheless, a lot of challenges still need to be resolved before blockchain technology can be extensively used. Concerns about regulation, interoperability, and scalability are among these hurdles.

REFERENCES

- Abou-Nassar, E. M., Iliyasu, A. M., El-Kafrawy, P. M., Song, O.-Y., Kashif Bashir, A., & Abd El-Latif, A. A. (2020). DITrust chain: Towards blockchain-based trust models for sustainable healthcare IoT systems. *IEEE Access : Practical Innovations, Open Solutions*, 8, 111223–111238. doi:10.1109/ACCESS.2020.2999468
- Al-Marridi, A. Z., Mohamed, A., & Erbad, A. (2021). Reinforcement learning approaches for efficient and secure blockchain-powered smart health systems. *Computer Networks*, 197, 108279. doi:10.1016/j.comnet.2021.108279
- Ali, A., Pasha, M. F., Fang, O. H., Khan, R., Almaiah, M. A., & Al Hwaitat, A. K. (2022). Big Data Based Smart Blockchain for Information Retrieval in Privacy-Preserving Healthcare System. In *Big Data Intelligence for Smart Applications* (pp. 279–296). Springer International Publishing. doi:10.1007/978-3-030-87954-9_13
- Tyagi, A. (2020). Challenges of Applying Deep Learning in Real-World Applications. Challenges and Applications for Implementing Machine Learning in Computer Vision. IGI Global. doi:10.4018/978-1-7998-0182-5.ch004
- Chen, M., Malook, T., Rehman, A. U., Muhammad, Y., Alshehri, M. D., Akbar, A., Bilal, M., & Khan, M. A. (2021). Blockchain-Enabled healthcare system for detection of diabetes. *Journal of Information Security and Applications*, 58, 102771. doi:10.1016/j.jisa.2021.102771
- Dasaklis, T. K., Casino, F., & Patsakis, C. ().Blockchain meets smart health: Towards next generation healthcare services. In *2018 9th International conference on information, intelligence, systems and applications (IISA)*, pp. 1-8. IEEE. 10.1109/IISA.2018.8633601
- Gudeti, B., Mishra, S., Malik, S., Fernandez, T. F., Tyagi, A. K., & Kumari, S. (2020). *A Novel Approach to Predict Chronic Kidney Disease using Machine Learning Algorithms*. 2020 4th International Conference on Electronics, Communication and Aerospace Technology (ICECA), Coimbatore. 10.1109/ICECA49313.2020.9297392
- Hathaliya, J., Sharma, P., Tanwar, S., & Gupta, R. (2019). Blockchain-based remote patient monitoring in healthcare 4.0. In *2019 IEEE 9th international conference on advanced computing (IACC)*, (pp. 87-91). IEEE. 10.1109/IACC48062.2019.8971593

Tyagi, A. (2021). Healthcare Solutions for Smart Era: An Useful Explanation from User's Perspective. Recent Trends in Blockchain for Information Systems Security and Privacy. CRC Press.

Khatoon, A. (2020). A blockchain-based smart contract system for healthcare management. *Electronics (Basel)*, 9(1), 94. doi:10.3390/electronics9010094

Khezzr, S., Moniruzzaman, M., Yassine, A., & Benlamri, R. (2019). Blockchain technology in healthcare: A comprehensive review and directions for future research. *Applied Sciences (Basel, Switzerland)*, 9(9), 1736. doi:10.3390/app9091736

Khubrani, M. M. (2021). A framework for blockchain-based smart health system. [TURCOMAT]. *Turkish Journal of Computer and Mathematics Education*, 12(9), 2609–2614.

Kumar, T., Ramani, V., Ahmad, I., Braeken, A., Harjula, E., & Ylianttila, M. (2018). Blockchain utilization in healthcare: Key requirements and challenges. In *2018 IEEE 20th International conference on e-health networking, applications and services (Healthcom)*. IEEE. 10.1109/HealthCom.2018.8531136

Kumari, S., & Muthulakshmi, P. (2022). Transformative Effects of Big Data on Advanced Data Analytics: Open Issues and Critical Challenges. *Journal of Computational Science*, 18(6), 463–479. doi:10.3844/jcssp.2022.463.479

Kute, S. (2021). Building a Smart Healthcare System Using Internet of Things and Machine Learning. Big Data Management in Sensing: Applications in AI and IoT. River Publishers.

Kute, S. S., Tyagi, A. K., & Aswathy, S. U. (2022). Industry 4.0 Challenges in e-Healthcare Applications and Emerging Technologies. In A. K. Tyagi, A. Abraham, & A. Kaklauskas (Eds.), *Intelligent Interactive Multimedia Systems for e-Healthcare Applications*. Springer. doi:10.1007/978-981-16-6542-4_14

Kute, S. S., Tyagi, A. K., & Aswathy, S. U. (2022). Security, Privacy and Trust Issues in Internet of Things and Machine Learning Based e-Healthcare. In A. K. Tyagi, A. Abraham, & A. Kaklauskas (Eds.), *Intelligent Interactive Multimedia Systems for e-Healthcare Applications*. Springer. doi:10.1007/978-981-16-6542-4_15

Le, H. T., Lam, N. T. T., Vo, H. K., Luong, H. H., Khoi, N. H. T., & Anh, T. D. (2022). Patient-chain: patient-centered healthcare system a blockchain-based technology in dealing with emergencies. In *Parallel and Distributed Computing, Applications and Technologies: 22nd International Conference, PDCAT 2021*. Cham: Springer International Publishing. 10.1007/978-3-030-96772-7_54

Madhav, A. V. S., & Tyagi, A. K. (2022). The World with Future Technologies (Post-COVID-19): Open Issues, Challenges, and the Road Ahead. In A. K. Tyagi, A. Abraham, & A. Kaklauskas (Eds.), *Intelligent Interactive Multimedia Systems for e-Healthcare Applications*. Springer. doi:10.1007/978-981-16-6542-4_22

Nair, M. M., Kumari, S., Tyagi, A. K., & Sravanthi, K. (2021). Deep Learning for Medical Image Recognition: Open Issues and a Way to Forward. In: Goyal D., Gupta A.K., Piuri V., Ganzha M., Paprzycki M. (eds) *Proceedings of the Second International Conference on Information Management and Machine Intelligence. Lecture Notes in Networks and Systems*. Springer, Singapore. 10.1007/978-981-15-9689-6_38

- Prabadevi, B. (2021). Toward blockchain for edge-of-things: A new paradigm, opportunities, and future directions. *IEEE Internet of Things Magazine*, 4(2), 102–108. doi:10.1109/IOTM.0001.2000191
- Quasim, M. T., Algarni, F., Abd Elhamid Radwan, A., & Goram Mufareh, M. A. (2020). A blockchain based secured healthcare framework. In *2020 International Conference on Computational Performance Evaluation (ComPE)*, (pp. 386-391). IEEE. 10.1109/ComPE49325.2020.9200024
- Ramani, V., Kumar, T., Bracken, A., Liyanage, M., & Ylianttila, M. (2018). Secure and efficient data accessibility in blockchain based healthcare systems. In *2018 IEEE Global Communications Conference (GLOBECOM)*. IEEE. 10.1109/GLOCOM.2018.8647221
- Sai, G. H., Tripathi, K., & Tyagi, A. K. (2023). Internet of Things-Based e-Health Care: Key Challenges and Recommended Solutions for Future. In: Singh, P.K., Wierzchoń, S.T., Tanwar, S., Rodrigues, J.J.P.C., Ganzha, M. (eds) *Proceedings of Third International Conference on Computing, Communications, and Cyber-Security. Lecture Notes in Networks and Systems*. Springer, Singapore. 10.1007/978-981-19-1142-2_37
- Shamila, M., & Vinuthna, K. (2023). Genomic privacy: performance analysis, open issues, and future research directions. Amit Kumar Tyagi, Ajith Abraham (eds.) *Data Science for Genomics*. Academic Press. doi:10.1016/B978-0-323-98352-5.00015-X
- Sharma, A., Tomar, R., Chilamkurti, N., & Kim, B.-G. (2020). Blockchain based smart contracts for internet of medical things in e-healthcare. *Electronics (Basel)*, 9(10), 1609. doi:10.3390/electronics9101609
- Sharma, P., Moparthi, N. R., Namasudra, S., Shanmuganathan, V., & Hsu, C.-H. (2022). Blockchain-based IoT architecture to secure healthcare system using identity-based encryption. *Expert Systems: International Journal of Knowledge Engineering and Neural Networks*, 39(10), e12915. doi:10.1111/exsy.12915
- Singh, S., Sharma, S. K., Mehrotra, P., Bhatt, P., & Kaurav, M. (2022). Blockchain technology for efficient data management in healthcare system: Opportunity, challenges and future perspectives. *Materials Today: Proceedings*, 62, 5042–5046. doi:10.1016/j.matpr.2022.04.998
- Soltanisehat, L., Alizadeh, R., Hao, H., & Choo, K.-K. R. (2020). Technical, temporal, and spatial research challenges and opportunities in blockchain-based healthcare: A systematic literature review. *IEEE Transactions on Engineering Management*.
- Son, H. X., Le, T. H., Nga, T. T. Q., Hung, N. D. H., Duong-Trung, N., & Luong, H. H. (2021). *Toward a blockchain-based technology in dealing with emergencies in patient-centered healthcare systems*. In *Mobile, Secure, and Programmable Networking: 6th International Conference, MSPN 2020, Paris*. 10.1007/978-3-030-67550-9_4
- Tandon, A., Dhir, A., Islam, A. K. M. N., & Mäntymäki, M. (2020). Blockchain in healthcare: A systematic literature review, synthesizing framework and future research agenda. *Computers in Industry*, 122, 103290. doi:10.1016/j.compind.2020.103290
- Tripathi, G., Ahad, M. A., & Paiva, S. (2020). S2HS-A blockchain based approach for smart healthcare system. In *Healthcare*, 8. Elsevier. doi:10.1016/j.hjdsi.2019.100391

Blockchain-Based Intelligent, Interactive Healthcare Systems

Tyagi, A. (2020). Artificial Intelligence and Machine Learning Algorithms. Challenges and Applications for Implementing Machine Learning in Computer Vision. IGI Global. doi:10.4018/978-1-7998-0182-5.ch008

Tyagi, A. K., & Goyal, D. (2020). A Survey of Privacy Leakage and Security Vulnerabilities in the Internet of Things. 2020 5th International Conference on Communication and Electronics Systems (ICCES). IEEE. 10.1109/ICCES48766.2020.9137886

Tyagi, A.. (2022). Using Multimedia Systems, Tools, and Technologies for Smart Healthcare Services. IGI Global., doi:10.4018/978-1-6684-5741-2

Wu, G., Wang, S., Ning, Z., & Zhu, B. (2021). Privacy-preserved electronic medical record exchanging and sharing: A blockchain-based smart healthcare system. *IEEE Journal of Biomedical and Health Informatics*, 26(5), 1917–1927. doi:10.1109/JBHI.2021.3123643 PMID:34714757

Xu, J., Xue, K., Li, S., Tian, H., Hong, J., Hong, P., & Yu, N. (2019). Healthchain: A blockchain-based privacy preserving scheme for large-scale health data. *IEEE Internet of Things Journal*, 6(5), 8770–8781. doi:10.1109/JIOT.2019.2923525

Yaqoob, I., Salah, K., Jayaraman, R., & Al-Hammadi, Y. (2021). Blockchain for healthcare data management: Opportunities, challenges, and future recommendations. *Neural Computing & Applications*, 1–16.