



IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 13 Issue: IV Month of publication: April 2025

DOI: https://doi.org/10.22214/ijraset.2025.68483

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Patient Health Record System using Blockchain Technology

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Abstract: The integration of blockchain technology into patient health records (PHRs) presents a transformative solution for healthcare systems worldwide. This abstract outlines the key benefits and objectives of utilizing blockchain in EHR systems. Blockchain ensures data security and privacy through cryptographictechniques, offering patients greater control over their health information. It establishes a tamper-proof, auditable ledger, guaranteeing data integrity and immutability. Moreover, smart contractsstreamline administrative processes, reducing costs and errors. Consent management tools allow patients to control data access, ensuring compliance with regulations like HIPAA and GDPR.

Thisinnovation fosters interoperability among health care providers, facilitating seamless data sharing and improving care coordination. It empowers health care research and analytics, securely sharing data while preserving privacy. Standardized data formats enhance compatibility among different PHR systems.

Theblockchain'sscalabilityanddisasterrecoverycapabilitiesensuredataavailabilityandsystemresilience.Byreducingadministr ativeoverheadandmedicalerrors, it contributes to costreduction and improved resource allocation.

Integrating blockchaininto EHRsaddresses data security, interoperability, and patient control while reducing costs and enhancing healthcare quality— apromising advancement for the health care industry.

However, the implementation of block chain-based systems must consider regulatory compliance, data privacy, and scalability challenge stoachieve wides pread adoption and integration within existing health care infrastructures.

I. LITERATUREREVIEW

A. Introduction

Thehealthcareindustryfacesnumerouschallenges, includingdatainteroperability, security, privacy, and efficiency. Blockchain technology, with its inherent properties of immutability, transparency, and decentralization, has emerged as a promising solution to addressthese issues. This literaturereviewaims to synthesize existing research on the application of blockchain technology in healthcare, focusing on its potential benefits, challenges, and future directions.

B. Core Concepts and Applications:

- 1) DataInteroperabilityandExchange:
- Traditionalhealthcaresystemsoftensufferfrom fragmenteddatasilos, hinderingseamless informationexchange.Blockchainbasedsolutions, asexploredbyYaga etal.(2019),offer a distributed ledger to facilitate secure and interoperable data sharing among healthcare providers, patients, and researchers.
- Research by Ekblaw et al. (2016) on MedRec demonstrates how blockchain can manage patient records and access permissions, enhancing data portability and patient control.
- Studies like those by Zhang et al. (2018) highlight the use of blockchain for building federated learning systems that improve data interoperability while preserving patient privacy.

2) Data Security and Privacy:

- Thesensitivenature of healthcaredata necessitates robust security measures. Block chain's cryptographic techniques and distributed architecture enhance data integrity and prevent unauthorized access.
- Kshetri (2018) emphasizes the role of blockchain in securing medical data against cyberattacks and ensuring data provenance.
- Research byRoehrs etal.(2019)investigates theuseofblockchain for implementing fine- grained access control policies and protecting patient privacy.



• Blockchain'sability to create an immutableaudittrailisextremelyuseful fortracking data access and changes, adding another layer of security.

3) Supply Chain Management:

- Blockchaincanimprovethetraceabilityandtransparencyofpharmaceuticalsupplychains, combating counterfeit drugs and ensuring medication safety.
- ResearchbyBenchoufiandRida(2017)explores the application of block chain for tracking and verifying drug provenance, reducing the risk of counterfeit medications.
- This traceability provided by blockchain can be applied to medical devices as well, ensuring proper tracking and maintenance.

4) Clinical Trials and Research:

- Blockchain can streamline clinical trial management by improving data integrity, patient recruitment, and consent management.
- StudiesbyKuoetal.(2017)suggestthatblockchaincanenhancethetransparencyand efficiency of clinical trials, leadingto faster and morereliableresearch outcomes.
- Smartcontractsbuiltuponblockchaintechnologycanautomatetheprocessofpaying participants, and verifying results.

5) Patient Empowerment and Personalized Medicine:

- Blockchain empowers patients to own and control their health data, facilitating personalized medicine and patient-centric care.
- ResearchbyDagheretal.(2018)discussesthepotentialofblockchainforenablingpatient- controlled health data management and personalized healthcare services.
- $\bullet \quad This control can lead to be tterpatient engagement, and be tterpatient outcomes.$

C. Challenges and Limitations:

- 1) ScalabilityandPerformance:
- Blockchainnetworksmayfacescalabilitychallengeswhenhandlinglargevolumesof healthcare data and transactions.
- Research by Casino et al. (2019) discusses the performance limitations of blockchain and explores potential solutions for improving scalability.
- 2) RegulatoryandLegalIssues:
- Theadoptionofblockchaininhealthcareraisescomplexregulatoryandlegalissues, including data privacy, liability, and interoperability standards.
- Studies by Swan (2015) highlight the need for clear regulatory frameworks to govern the use of blockchain in healthcare.
- 3) Interoperability and Standardization:
- Achieving interoperability among different blockchainplatforms and existing healthcare systems remains a significant challenge.
- There is a need to create unified standards that all block chain based health care systems can follow.
- 4) Implementation Costs and Complexity:
- Implementingblockchainsolutionscanbeexpensive and complex, requiring significant investments in infrastructure and expertise.
- $\bullet \quad The transition from legacy systems to block chain based systems can be difficult.$
- 5) Data Governance:
- Defining clear data governance models that address data ownership, access control, and data sharing is crucial for the successful adoption of blockchain in healthcare.
- D. Future Directions:
- 1) Integration with AI and IoT:
- Combiningblockchainwithartificialintelligence(AI)andtheInternet ofThings(IoT)can enable advanced healthcare applications, such as predictive analytics and remote patient monitoring.



- $\bullet \quad This integration can lead to more efficient and personalized health care solutions.$
- 2) Development of Interoperability Standards:
- Efforts are needed to develop standardized protocols and frameworks that facilitate interoperability among different blockchain platforms and healthcare systems.
- Developingthesestandardswillallowforwideradoption.
- 3) FocusonPatient-CentricSolutions:
- Future research should prioritize the development of patient-centric blockchain solutions that empower individuals to manage their health data and participate in their care.
- Puttingthepatientincontroloftheirowndataisparamount.
- 4) Exploration of Hybrid Blockchain Models:
- Hybrid blockchain models, which combine the benefitsof publicand private blockchains, may offer a more suitable approach for healthcare applications.
- Thesemodelscanprovideabalancebetweensecurityandaccessibility.
- 5) Increased Research into Security and Privacy:
- Continuedresearchintoimprovingthesecurityandprivacyofblockchainbasedhealthcare systems is vital.

E. Conclusion

Blockchain technology holds significant potential to transform the healthcare industry by addressing critical challenges related to data interoperability, security, and efficiency. However, overcoming the existing limitations and addressing regulatory concerns are crucial for realizing its full potential. Future research should focuson developing interoperable, scalable, and patient-centric blockchain solutions that enhance healthcare delivery and improve patient outcomes.

II. INTRODUCTION

Blockchainis a decentralised and public digital ledger that recordstransactions on many computers so that norecord involved can bealtered retroactively without altering any blocksafterwards.Blockchain is verified and linkedt othe preceding 'block, 'forminga longchain.Afterall, Blockchainisthenameofthe record.Asany transaction is registered and checked publicly,Blockchain provides a good deal of accountability.When entered, no one can modify all the information written in the Blockchain. It serves to demonstrate that the data is actual and unchanged. In Blockchain, data are maintained on networks instead of a central database, improving stability and showing its proneness to be hacked.Blockchain offersa fantastic forum to develop and compete with traditional companies for modernand creative business models [[1],[2],[3]].

Blockchainhelpsmarketerstomaintainanoverviewoftheproductsusedinmedicine.Healthand <u>pharmaceuticals</u>will get rid of <u>counterfeit medications</u>using Blockchaintechnologies, enabling tracingofallthesemedicines. Ithelpsdiscoverthecause offalsification. Blockchaincanguaranteethe confidentialityofpatientrecords; when <u>medicalhistory</u> is developed, Blockchaincanalsostoreit, and this record cannot be modified. This decentralised network is used with all commodity hard ware in the hospital. Researchers allow computing estimates for therapies, medicines, and remedies of diverse illnesses and disorders using the resources saved by these devices [4,5].

Blockchainis a distributed ledger network thatadds and never deletes or modifiesrecords withouta common consensus. ABlockchain hash's value depends on a cryptographic hash that connectsnewly addedinformation block records with each data block. The distributed Blockchainledger architecture ensures that data is not processed inany centralised venue, making itaccessibleand accountabletoall network users. This decentralised systemavoids a systemavoids as ingleattack , strengthening and securing the system. It facilitates better control of health records and patient care by minimising twice the amount of medical practice and monitoring, saving both practitioners and patient stime and resources. The patient will watch where their information goes and achieve it by keeping health records on a blockchain [6,7].

Scholars can use thistechnology to analyse massive volume of unveiled knowledge about a particular group of individuals.





ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538 Volume 13 Issue IV Apr 2025- Available at www.ijraset.com

It helpsfor theadvancement of precision medicine to be provided appropriately for longitudinal research. We use Block chain for health care inreal-time with the help of the Internet of Things (IoT) and <u>we arable's devices</u> to store and update valuable patient data such as blood pressure and sugar level. It helps doctors track patients who are vulnerable to high risk and, if an emergency occurs, advise and alert their care ersand families. Block chain has a decentralised structure that allows its afely to hack and avoids compromising any single copy of the records [8,9]. This report addresses the following research questions:

- RQ1:TostudyBlockchaintechnologyanditssignificantneedsinhealthcare;
- $\bullet \quad RQ2: to identify capabilities of Block chain technology to support the health careculture globally;$
- RQ3:toidentifyanddiscussenablersofBlockchaintechnologyforrevivinghealthcareservices;
- RQ4:toidentifythe'UnifiedWork-FlowProcess'ofBlockchaintechnologyrealizationin providing healthcare amenities;
- RQ5:toidentifyanddiscusssignificantapplicationsofBlockchainforhealthcare.

A. Blockchain

Blockchainisadecentralisednodenetworkthatstoresthedata.Itisanexcellenttechnologyforprotectingconfidentialdatawithinthesyst em.Thistechnologyhelpstoexchangecriticaldataandkeeps it secureand confidential. It isa perfect toolto hold all the related documents in onelocation and securely.Blockchainalsospeedsupsearchesforapplicantsthatfulfilspecifictrialcriteriausingasingle patient database.TheBlockchain can be describedas a decentralised peer-to-peer (P2P) network of personal computers called nodes, which maintains, stores,and records historical or transaction data [[10], [11], [12]]. It allows a reliable collaborationasthe informationis storedand exchanged byall network membersandkeeps a constanttrack of past and current experiences.This technology can integrate disparate networksto provide insights into the importance ofindividual treatment. Thus,Blockchain can well berecognised for immutability and safety.Blocks, nodes,and minersarethethree mainideasinBlockchain.Blockchaindoesnotsaveanyofitsdataina singlelocation.Instead,a network of computers copies and spreads the Blockchain. Every computer on the webupdatesitsBlockchainto

reflect a new block to the Block chain.

PatientHealthRecords(PHRs)playapivotalroleinmodernhealthcare,offeringadigitalrepositoryforpatientdata.However,concernsr egardingdatasecurity,interoperability,andprivacypersist.Blockchaintechnologyemergesasatransformativesolution,introducinga decentralizedandtamper-resistantledger to revolutionize EHR systems.

Blockchain'sinherent characteristics address critical challenges in healthcare data management.

By distributingdataacrossanetworkofnodes, itensures transparency and prevents unauthorized alterations. This tamper-proof feature enhances data integrity, fostering trust among stakeholders in the health care ecosystem.

Thedecentralized nature of block chain contributes to improve dinter operability. Traditionally, health care records are fragmented across various systems, hindering seamless data exchange. Block chain's distributed ledger enables a unified, standardized formataccessible to authorized entities, facilitating efficient information sharing and enhancing care coordination.

Moreover, blockchain ensures patient privacythrough cryptographic techniques. Patientsretain control over their data, granting permission for specific individualsor entitiesto accessit. This granular control aligns with the principles of patient-centered care and complies with stringent data protection regulations.

Smart contracts, programmable scripts on the blockchain, automateand enforce predefinedrules, streamliningadministrativeprocesses. This not only reduces operational costs but also minimizes errors and fraud, enhancing overall system efficiency.

Despiteitspromises, challengeslikes calability and regulatory frameworks need consideration. However, ongoing research and industry collaborations are addressing these concerns, paving the way for widespread adoption.

Integrating blockchaininto electronic health records presents a paradigm shift in healthcare data management. The technology's decentralized, secure, and interoperable nature hasthe potential to revolutionizepatientcare, ensuring data integrity, privacy, and efficiency. As the health care industry

 $embraces digital transformation, block chain stands as a beac on for a more secure and interconnected\ future.$

III. OBJECTIVES

Using blockchain technology for patient health records (PHRs) can offer several advantages, including enhanced security, interoperability, and patient control over their data.

The objectives of implementing electronic health records using blockchain typically include:



International Journal for Research in Applied Science & Engineering Technology (IJRASET) ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538

Volume 13 Issue IV Apr 2025- Available at www.ijraset.com

1) Data Security and Privacy:

- Ensure the highest level of data security by using cryptographic techniques to protect patient health information from unauthorized access and breaches.
- Empower patients with greater control over their health data, allowing them to grant orrevoke access as needed.

2) Interoperability:

- Create a standardized and interoperable platform that allows forseamless data sharing among healthcare providers, reducing redundancy and improving care coordination.
- 3) Data Integrity and Immutability:
- Utilize blockchain's distributed ledger technology to create a tamper-proofand auditable record of all EHR transactions, ensuring the integrity of patient data.
- 4) ReducedAdministrativeOverhead:
- Streamlineadministrativeprocesses, such as insurance claims and billing, by automating them through smart contracts on the block chain, reducing costs and errors.
- 5) ConsentManagement:
- Developarobustconsent management systemthatallowspatientstospecifywhocanaccesstheirdata and for what purposes, ensuring compliance with data protectionregulationslike GDPRandHIPAA.
- 6) AuditabilityandCompliance:
- FacilitateeasyauditingofEHRtransactionsforregulatorycompliance, research, and quality improvement purposes.

7) ResearchandAnalytics:

• Enablesecureandprivacy-preservingdatasharingformedicalresearchandanalytics,fostering innovation and improving healthcare outcomes.

8) DataStandardization:

• Establish standardized data formatsandterminologiesto ensure consistencyandcompatibilityamong different EHR systems and providers.

9) Scalability:

• Design the blockchain network to accommodate the growing volume of EHR data and transactions while maintaining performance and efficiency.

10) DisasterRecoveryandRedundancy:

• Implement distributed storage and redundancy to ensure data availability, even in the event of hardwarefailures or natural disasters.

11) PatientEmpowerment:

• EducatepatientsabouttheirrightsandresponsibilitiesregardingtheirEHRs, includinghowtomanage and control their data effectively.

12) EducationandTraining:

• Providetrainingandeducation for healthcareprofessionals and patient stouse block chain-based EHR systems effectively and securely.

Implementing electronic health records using blockchain technology is a complex undertaking that requires careful planning, collaboration, and adherence to regulatory requirements.



ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538 Volume 13 Issue IV Apr 2025- Available at www.ijraset.com

The objectives align with improving patient care, data security, and healthcare system efficiency.

Blockchain is a distributed database with decentralised, traceable, non-tamperable, secure and reliable features. It integrates P2P (Peer-to-Peer) protocol, digital encryption technology, consensus mechanism, smart contract and other technologies together. Abandoning the maintenance mode of the traditional central node and adopting the method of mutual maintenance by multiple users to realise the information supervision among multiple parties, thereby ensuring the credibility and integrity of the data. The blockchain platform can be divided into public chain, private chain and alliance chain. All nodes in the public chain can join or withdraw freely;the private chain strictly limitsthe qualification ofparticipating nodes;thealliance chain isjointly managed by several participating institutions.Bitcoin wasproposed by Nakamoto in 2008, which is the most successful case of digital currency, and is also the most typical application ofblockchain. In addition, the blockchain has expanded itsunique application value in many aspects and has shown its potential to reshape society.

As a representative of distributed databases, blockchain stores all user transaction information on the blockchain, which has high requirements for the security performance of blockchain. Blockchain is a decentralised peer-to-peer network. Nodes do not need to trust each other and there is no central node. Therefore, transactions on the blockchain also need to ensure the security of transaction information on unsecured channels and to maintain the integrity of transactions. It can be seen that cryptography technology occupiesthe most central position in theblockchain. In blockchain, cryptography technology is mainly used to protect user privacy and transaction information, and ensure data consistency, etc.[2] This paper briefly introduces the cryptographic techniques such as hash algorithm, asymmetric encryption algorithm and digital signature, also elaborates the blockchain infrastructure, the blockchain structure, bitcoin address, digital currency trading and other technologies of blockchain in detail.

IV. BLOCKCHAIN INFRASTRUCTURE

According to Melanie Swan, founder of the Blockchain Science Institute, blockchain technology has experiencedtwophases,thefirstoneistheblockchain1.0 phaseofmulti-technologyportfolio innovation represented by Bitcoin, the second one is the blockchain 2.0 phase represented by Ethereum, which is transferred by digital assets. Typical applications of blockchain technology mainly include Bitcoin, Ethereum,HyperLedgers, etc.Althoughtheimplementationsaredifferent,therearemanycommonalities in the overall architecture.As shown inTable 1, the blockchain platform can be divided into five levels: network layer, consensuslayer, data layer, contract layer and applicationlayer.

Thedatalayermainlyusestheblockdatastructuretoensuretheintegrityofdatastorage.Eachnodein the network encapsulates the data transactions received over a period oftime into a time-stamped data block and links the block to the current longest main blockchain for storage. This layer involves the main techniques of block storage, chain structure, hashalgorithm, Merkle tree,time stampand so on.

The consensus layer mainly includes a consensus mechanism, which enables each node to reach a consensus onthevalidityofblockdatainthedecentralizedsystem. The consensus mechanism mainly has PoW, PoS, PBFT and SBFT. The smart included layer contract that is mainly in the contract is the basis of the blockchainprogrammablefeature. The computerized program that can automatically execute the contract terms is stored in the blockchain in the form of code and data sets. Smart contracts, driven by time or events, are executed by blockchain nodes in a distributed manner. All relevant terms are coded, automatically settled, and triggeredby signatures or otherexternal datamessages. The network layerincludes various data transmission protocols and verification mechanisms. The blockchain is a typical P2P network. All nodes are connected through a planar topology and have no central nodes. Any two nodes can be freely traded, and any node can join or leave the network at any time. The P2Pprotocol in the blockchain is mainly usedforinformationtransmissionbetweennodes. The application layer mainly includes Bitcoin, Ethereum and Hyperledger and so on. Bitcoin is mainly for digital currency transactions. Ethereum adds decentralized applicationsbasedondigitalcurrency. Hyperledgerdoesnotsupport digitalcurrency transactions, mainly enterprise-level block chain applications.

V. HASHANDBLOCK STRUCTURE

Thehashalgorithmisa function that maps a sequence of messages of any length to a shorter fixed-length value, and is characterized by susceptibility, unidirectionality, collision resistance, and high sensitivity.



ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538 Volume 13 Issue IV Apr 2025- Available at www.ijraset.com

Hash is usually used to ensure data integrity, that is, to verify the data has been illegally tampered with. Whenthedatatestedchanges, it shash value also changes correspondingly.

Therefore, even if the data is in an unsafe environment, the integrity of the data can be detected based on the hashvalue of the data.

SHAisatypeofcryptographichashfunctionissuedbytheNationalInstituteofStandardsandTechnology (NIST) with thegeneral characteristics of a cryptographic hash function.

The SHA256 algorithm is a class of the SHA-2 algorithm cluster, which generates a 256-bit message digest. The algorithm's two calculation process includes stages: message preprocessing and main loop. In the messagepreprocessingstage, binary bit filling and messagelength filling are performed on the information of any length, and the filled is divided into several 512-bit message blocks. In the main message loop phase, eachmessageblockisprocessedbyacompressionfunction. Theinputof the current compression function is the output of the previous compression function, and the output of the last compression function is the hash value of the original message.

RIEPEMD, a summary of the RACE original integrity check message, is a hash function algorithm developedby the COSI research team of the University in Leuven, Belgium. RIPEMD-160 is the most common version of RIPEMD[5]. As the SHA series functions, the first step of the algorithm is message complement, and the complement method is identical to the SHA series algorithm. The core of the processing algorithm is the compression function, which is a loop, where each loop consists of 16 step functions. Using differentoriginal logic functions running in reverse order. After all 512- bit packet processing is completed, the resulting 160-bit output is the hash value of the original message.

For blockchain, hash functions can be used to perform block and transaction integrity verification. In the blockchain, the hash value of the information of the previous block is stored in the header of each block, and any user can compare the calculated hash value with the stored hash value. In turn, the integrity of the information of the previous block is stored. Similarly, the hash function can be used to perform block block block block block is stored.

The hash pointer is a data structure that contains, inaddition to the usual pointers, some data information and password hashes associated with the information. Anormal pointer is used to verify that the information has been tampered. The block chain is a list of hash pointers, each of which is connected by using a hash value. It is verified according to the hash value whether the data contained in the block is changed, thereby ensuring the integrity of the block information.

A. Types of blockchains

- 1) Public blockchain: A blockchain that anyone in the world can read, can send transactions to and expect to see them included if they are valid. This means anyone can become part of the network and par-ticipate in the consensusprocess making them permissionless. There is way to censor transactionsonthenetworknor changetransactions retrospectively. The content of the block chain can be trusted to be correct. Public block chains are, however, very inefficient. The more com- puting power is required to support trust. So, an attacker would need to acquire 51% of the network's computing power to change an entry in the block chain. (e.g., Bitcoin, Ethereum, ZCash).
- 2) Consortium blockchain: Itisa blockchain wherea pre-selected set ofnodescontrolthe consensus process.
- 3) Privateblockchain: A blockchainwhere access permissions aremore lightly controlled, where rights to modify or evenread the blockchain statearerestricted to a fewusers, where onlyknown nodes are allowed to partici- pate in the network. Ideally, it is internal for an organization. The writes permissionsarekept centralized to oneorganization.Privateblockchainreduces counterpartyrisk by enabling the exchange of data without the intermediation of third parties.
- 4) PermissionedBlockchain: Itisa blockchainwhere wecanallowspe-cificactionstobeperformed only by specific addresses. The participants in the network can restrict who can participate in the consensus mecha- nism and who can create a smart contract and give the authority for some participants to provide the validation of blocks of transactions. A control access layer into the blockchain nodes is used. However, raise their ques- tions, Who has the authority to grant permission? Apermission blockchain may make its owners feel more secure, giving the database rigorous secu- rity and privacy capabilities but can be seen as violating the idea of blockchain becauseonlysomeparticipantshavemore control, whichmeanstheycanmakechangeswhetheror not other network participants agree.



ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538 Volume 13 Issue IV Apr 2025- Available at www.ijraset.com

VI. DIGITAL CONTENT PROTECTION

Inordertopreservetheprivacyfortraceableencryptioninblockchain, Wuetal.proposedasystemin which authenticity and non-repudiation of digital contentis guaranteed.

The problem tackled by authors is the secretkey of the user, which when shared with other entities does not hold the specific information of the user. In case the sharedkey is corrupted or abused, it makes it difficult to analyze the source of the secret key. Moreover, leakage of confidential information inaccess control is a bottleneck for existing systems. Therefore, authors have integrated the privacy protection algorithm such as attribute based encryption (ABE) to secure the secret keys. However, the decryption mechanism does not show improved efficiency.

Management of digital datarights is a fundamental requirement to achieve protection of digital data. Existing techniques for datarights lack transparency, decentralization, and trust. In response to above mentioned problems, Zhang and Zhao proposed block chain-based decentralized solutions.

Information regarding the use of digital content, suchastransaction andlicense information is transparent to everyone. Smart contract is designed for the automaticassignment oflicense. In this mechanism, the owner can set the prices for selling the license to other customers. However, peers of the network have to possess high computational power to perform key acquisition.

Focusondigitalrightsmanagementusingblockchaintoavoidtheuseofsensitivedigitalcontentfor illegal purposes. For such concerns, a solution is proposed which is called DRMchain (DIGITAL RIGHTSMANAGEMENT). This solution ensures the usage of digital contentin theright way by authenticatedusers. Two separateblockchainsaredesigned: one is to store the original itsciphersummary, and the otherstores the ciphersummary of protected digital content. DRM chain contentwith provides the traceability record of a violation and highlevel trusted protection. From the proposed solution, protection of digital content, secureauthorization of users, anduse of multi signatures for usagecontrolisachieved. However, the use of Ethereum coins could be an ewrese archdirection for protection of digital content. Data sharing is a crucial step to gain maximum benefit from the strengths of research. A lot of data sharingmechanismsareproposed and discussed in literature. There is no sufficient work available that focuses on the incentive mechanism to promote data sharing. To cover these limitations, authors conducted are viewon medical and health data to uncover theincentive mechanisms withthe pre-and postresults after empirical analysis. According to a survey, a single incentive is tested formedical and health data to analyse the rate of data sharing. Therefore, it is concluded that more incentive based research needs to be performed to encourage data sharing.

VII. THE SIGNIFICANCE OF SECURITY FOR BLOCKCHAIN

Beforewediveright into understanding the role of cryptography inblock chain, let us reflect briefly on the block chain itself. It basically refers to a distributed database that offers the features of decentralization, security, traceability, reliability, and immutability. Block chain takes away the need for traditional approaches for maintaining central nodes and introduces the new approach for mutual maintenance of nodes by multiple users.

As a result, it can entrust information supervision to multiple parties and ensure desired levels of credibility and data integrity. Another important aspect pertaining to blockchain refers to the three distincttypesofblockchainplatforms. The typesofblockchain platforms include public chain, private chain, and alliance chain. All then odes in a public chain could easily participate or with draw from the block chain according to their preferences.

On the other hand, private blockchains impose specific conditions to determine the eligibility of the participating nodes. The alliance chain operates under the joint management of different participating organizations. Over the years, block chain has been largely associated with the financial industry. However, it has showcased the promising potential for adding value to different sectors alongside reshaping the fundamental tenets of our society.

So, what is the relationship between blockchain and cryptography? The blockchain serves as a representative of distributed databases by storing all the transaction information of users on the blockchain. Therefore, it is reasonable to identify a profoundly higher demand for security performance in the blockchain.

Since blockchain operates with a decentralised, peer-to-peer network model, there is no single node, and nodesdon'thavetotrust oneanother. So, blockchain mustalso ensureappropriates a feguards for transaction information on unsecured channels while maintaining transaction integrity. Therefore, cryptography becomes an essential requirement for blockchain to safeguard user transaction information and privacy alongside ensuring data consistency.



ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538 Volume 13 Issue IV Apr 2025- Available at www.ijraset.com

VIII. DISTRIBUTED LEDGER

Adistributedledgerisadirectoryordatabasethat'sstoredacrossvariouscomputers(akanodes).All nodes possessan exact copy oftheledger. When new information isadded, the nodes conduct an automatic vote to verify the authenticity of the update.

When the majority of nodes agree (aka gain consensus), the systemup dates itself accordingly (ie. Adopting the new information into all copies of the ledger, or rejecting it). Distributed ledgers run without a central authority, revolutionizing the way we think of democracy.

Thetechnologyisabletoreducethe"costoftrust"(akatheamountofmoneyyou needtopayforvarious services that authenticate transactions). Because transactionsaretransparent, the ledgersare distributed across several computersand encrypted to ensure protection, tampering with data is almostimpossible without detection.

Thismeansthatdistributedledgerscanoptimizevariousbusinesstaskswhilesavingyoumoneyyou'd otherwise spend on fees for your lawyers.

You're probably thinkingthat these sounds exactly the sameas blockchaintechnology. Not so. Rememberbiologyclass?That'swhereyou'veprobablyheardthephrase"Allbugsareinsects,butnot all insects are bugs." Same goes here.

Blockchainsanddistributedledgershaveavery similarrelationshipto eachother.Blockchainsareatype of distributedledger technology where data is structured into blocks. When new data isadded, new blocksare created, forminga chain of blocks(hencethe name). As with distributed ledgers in general, cryptography provides security for the system.

Thisistheonlysignificant difference between the two phenomena. Because of the specific structuring of data, block chains are sometimes considered more advanced and more expensive, hence their use in financial transactions.

Thereasontheseterms are used synonymously is because block chains are the most widely used iteration ofthelarger, umbrella technologyknownas the distributed ledger. For our purposes, we'regoingtouse themorewidelyknowntermtoavoidconfusion, and because we will mostlybereferringtothefinancial use-cases of these technologies. In this space, blockchain reigns.

Blockchainisasystemofrecordinginformationinawaythatmakesitdifficultorimpossibletochange, hack, or cheat the system.

Ablockchainisessentiallyadigitalledger oftransactionsthat isduplicatedanddistributedacrossthe entire network of computer systems on the blockchain. Each block in the chain contains number of transactions, and every time a newtransaction occurs on the blockchain, are cord of that transaction is added to every participant's ledger. The decentralised database managed by multiple participants known as Distributed Ledger Technology (DLT).

BlockchainisatypeofDLTinwhichtransactionsarerecorded with an immutable cryptographic signature called a hash.

The Properties of Distributed Ledger Technology (DLT)



Thismeansifoneblockinonechainwaschanged,itwouldbeimmediatelyapparentithadbeentampered with. If hackers wanted to corrupt a blockchain system, they would have to change every block in the chain, across all of the distributed versions of the chain.



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A. Aglobal Public Network

Blockchaintechnologyisshowingthatwecanconnectfinancialinfrastructuresothatnomatterwhereyou arein the world, systems and forms of value can interoperate with each other.

Stellar, a global, public blockchain that is built for interoperability and to further financial access and inclusion, has a network of more than 20 anchors around the world who are integral parts of connecting global financial systems. These anchors are regulated financial institutions, money service businesses, or fintech companies that issue 1:1 backed fiat tokens (also known as stablecoins) and/or provide a fiat on/off- ramp. The goal is to open markets to new remittance and payments corridors, like between Europe and Nigeria, Africa's largest Sub-Saharan remittance market.

For example, CowrieIntegrated Systems, a financial technology company with head quarters in the United Systems, a financial technology company with head quarters in the United Systems, a financial technology company with head quarters in the United Systems, a financial technology company with head quarters in the United Systems, a financial technology company with head quarters in the United Systems, a financial technology company with head quarters in the United Systems, a financial technology company with head quarters in the United Systems, a financial technology company with head quarters in the United Systems, a financial technology company with head quarters in the United Systems, a financial technology company with head quarters in the United Systems, a financial technology company with head quarters in the United Systems, a financial technology company with head quarters in the United Systems, a financial technology company with head quarters in the United Systems, a financial technology company with head quarters in the United Systems, a financial technology company with head quarters in the United Systems, a financial technology company with head quarters in the United Systems, a financial technology company with head quarters in the United Systems, a financial technology company with head quarters in the United Systems, a financial technology company with head quarters in the United Systems, a financial technology company with head quarters in the United Systems, a financial technology company with head quarters in the United Systems, a financial technology company with head quarters in the United Systems, a financial technology company with head quarters in the United Systems, a financial technology company with head quarters in the United Systems, a financial technology company with head quarters in the United Systems, a financial technology company with head quarters in the United Systems, a financial technology company with head quarters in the United Systems, a financial technology company wit

KingdomandofficesinNigeria, providesvalue-added services over electronicpayment networks. Given recentguidanceoutoftheCentralBankofNigeria,CowriedesignedapaymentchanneltoleverageUSDC, one of the world's leading digital dollar stablecoins, as a bridge currency to help businesses reduce the friction of sending payments to and from Europe. Working with Tempo, an electronic payment institution based in France and the issuer of EURT, a euro stablecoin also pegged 1:1 to fiat reserves, they are developing a bi-directional channel for customersto redeemandtradethese tokensrightaway. This resulted in savings interms of costsand timeand showed the power of connecting global financial systems so they are easily interoperable, efficient, affordable, and the system of thmost importantly, accessible.

Openness, innovation and interoperability Once we recognize that the block chain future we've all been dreaming about is actually here, right thow, we have to ask ourselves whether we are creating long-term solutions

Opennetworksallowinnovationfrom the many rather than the few. Opennetworks ensure that any one can build upon, improve and challenge the technology and push the market to consider the next idea. Open networks promise interoperability and allow for continual ideation and progression. If we were to start building this technology in a silo, on closed networks that can't work together, we would risk putting ourselves rightback where we started. By working together in the open technologinal financial rails with digital ones, we can reap the benefits and work through shared challenges.

IX. MAKING BLOCK CHAINMAIN STREAM

Confidenceinthistechnology,especiallyfordigitalcurrencies,isgrowingacrosstheboard.Governments are accelerating their<u>work</u>on Central Bank Digital Currencies. Businesses are building and investing, with thevast majorityofglobalexecutivessurveyedby <u>Deloitte</u>lastyearsayingtheybelievedigitalassetswill be important to their industries within the next three years.

But the benefits of innovation, especially in the financial sector, cannot be gained at the expense of additional risk to consumers. Central banksand regulators, entrusted with the duty to protect consumers, draft and enforce regulations guided by that lofty responsibility. But, as the Tempo-Cowrie example demonstrates, deployed correctly, blockchain technology can be leveraged to benefit consumers without sacrificing oversight, accountability or regulation.

This is why it is all the more important for us to demonstrate to stakeholders what a difference this technologycanmakefor consumers, citizens and businesses, boosting local and national economies - and

how the technology can be subject to regulatory over sight. This is why it is critical for the private sector to the technology can be subject to regulatory over sight. This is why it is critical for the private sector to the technology can be subject to regulatory over sight. This is why it is critical for the private sector to the technology can be subject to regulatory over sight. This is why it is critical for the private sector to the technology can be subject to regulatory over sight. This is why it is critical for the private sector to the technology can be subject to regulatory over sight. This is why it is critical for the private sector to the technology can be subject to

engagewithgovernmentstoensurethatnewregulationsbalancetheneedfornewandimprovedfinancial rails with the need to guard against innovations that empower illicit actors. The desire to get this right is shared byall stakeholders andit's by workingtogether that we willachieve that balance.

Blockchain is real and actionable today, ready to tackle not only cross-border payments but many of the mostmeaningful,impactfulfinancialusecasesforcitizens,consumers,governmentsandbusinesses.Now, with a concerted public-private partnership, we can take it mainstream.

Cryptocurrencies:TheBeginningofBlockchain'sTechnologicalRiseBlockchain's most well-known use (and maybe most controversial) is in cryptocurrencies. Cryptocurrenciesaredigitalcurrencies(ortokens),likeBitcoin, EthereumorLitecoin,that canbeusedto buy goods and services. Just like a digital form of cash, crypto can be used to buy everything from your lunch to <u>your next home</u>. Unlike cash, crypto uses blockchain to act as both a public ledger and an enhanced cryptographic security system, so onlinetransactions are always recorded and secured.



ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538 Volume 13 Issue IV Apr 2025- Available at www.ijraset.com

HOW DOES CRYPTO CURRENCY WORK?

Cryptocurrencies are digital currencies that use blockchain technology to record and secure every transaction.

A cryptocurrency (for example, Bitcoin) can be used as a digital form of cash to pay for everything from everyday items to larger purchases like cars and homes. It can be bought using one of several digital wallets or trading platforms, then digitally transferred upon purchase of an item, with the blockchainrecordingthetransaction thenewowner. Theappealofcryptocurrenciesisthateverything is recorded in a public ledger and secured using cryptography, making an irrefutable, timestamped and secure record of every payment.

To date, there are <u>roughly 6,700 cryptocurrencies</u> in the world that have a total market cap around \$1.6 trillion, with Bitcoin holding a majority of the value. These tokens have become incredibly popular over the last few years, with one Bitcoinequaling \$60,000. Here are some of the main reasons why every one is suddenly taking notice of cryptocurrencies:

- 1) Blockchain's security makes theft much harder since each cryptocurrency has its own irrefutable identifiable number that is attached to one owner.
- 2) Cryptoreduces the need for individualized currencies and central banks-With blockchain, crypto can be sent to anywhere and anyone in the world without the need for currency exchanging or without interference from central banks.
- 3) Cryptocurrenciescanmakesomepeoplerich-Speculatorshavebeendrivingupthepriceofcrypto, especially Bitcoin, helping some <u>early adopters to become billionaires</u>. Whether this isactually a positive has yet to be seen, as some retractors believe that speculators do not have the long-term benefits of crypto in mind.
- 4) More and more large corporations are coming around to the idea of a blockchain-based digital currency for payments. In February 2021, Tesla famously announced that it would invest \$1.5 billion into Bitcoin and accept it as payment for their cars.

Of course, thereare many legitimatearguments against block chain-based digital currencies. First, crypto isn't a veryregulated market. Many governments were quick tojump into crypto, but fewhavea staunch set of codified laws regarding it. Additionally, crypto is incredibly volatile due to those aforementioned speculators. In 2016, Bitcoin was priced around \$450 per token. It then jumped to about \$16,000 a token in 2018, dipped to around \$3,100, then has since increased to more than \$60,000. Lack of stability has caused some people to get very rich, while a majority have still lost thousands.

Whether or not digital currencies are the future remains to be seen. For now, it seems as if blockchain's meteoric rise is more starting to take root in reality than pure hype. Though it's still making headway in this entirely-new, highly-exploratory field, blockchainisalso showing promise beyond Bitcoin.



BLOCKCHAINREVOLUTION

A. Beyond Bitcoin: Ethereum Blockchain

Originally created as the <u>ultra-transparent ledger system for Bitcoin to operate on</u>, blockchain has long been associated with cryptocurrency, but the technology's transparency and security has seen growing adoption in a number of a reas, much of which can be traced back to the development of the Ethereum block chain.

Inlate2013, Russian-CanadiandeveloperVitalikButerinpublishedawhitepaperthatproposedaplatform combiningtraditional blockchain functionality with one key difference: the execution of computer code. Thus, the <u>Ethereum Project</u>was born.

Ethereum blockchain lets developerscreatesophisticated programs thatcan communicate with one another on the blockchain.



ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538 Volume 13 Issue IV Apr 2025- Available at www.ijraset.com

Tokens Ethereum programmers can create tokens to represent any kind of digital asset, track its ownership and execute its functionality according to a set of programming instructions.

Tokens can be music files, contracts, concert tickets or even a patient's medical records. Most recently, <u>Non-FungibleTokens</u> (<u>NFTs</u>)have become all the rage. NFTs are unique blockchain-based tokens that store digital media (like a video, music orart). EachNFT hasthe abilityto verify authenticity, past historyand soleownership ofthepieceofdigital media. NFTshavebecome wildly popularbecausethey offera new waveofdigitalcreatorsthe abilitytobuyandsell theircreations, whilegetting proper creditandafairshare of profits.

Newfound uses for blockchain have broadened the potential of the ledger technology to permeate other sectors like media, government and identity security. Thousands of companies are currently researching and developing products and ecosystems that run entirely on the burgeoning technology.

Blockchain is challenging the current status quo of innovation by letting companies experiment with groundbreaking technology like peer-to-peer energy distribution or decentralized forms for news media. Much like the definition of blockchain, the uses for the ledger system will only evolve as technology evolves.

HowDoesBlockchainWork?

Thenameblockchainishardlyaccidental:Thedigitalledgerisoftendescribedasa "chain"that'smadeup ofindividual"blocks"ofdata. As freshdata isperiodicallyaddedtothenetwork, a new"block" iscreated and attached to the "chain." This involves all nodesupdating their version of the blockchain ledger to be identical.

How these new blocksare created is key to why blockchain is considered highly secure. Amajority of nodes mustverify and confirm the legitimacy of the new data before a new block can be added to the ledger. For a cryptocurrency, they might involve ensuring that new transactions in a block were not fraudulent, or that coins had not be enspent more than once. This is different from a standal one data base or spreadsheet, where one person can make changes without oversight.

"Once there is consensus, the block is added to the chain and the underlying transactions are recorded in the distributed ledger," says C. Neil Gray, partner in the fintech practice areas at Duane Morris LLP. "Blocks are securely linked together, forming as secured igital chain from the beginning of the ledger to the present."

Transactions are typically secured using cryptography, meaning the nodes need to solve complex mathematical equations to process a transaction.

"As a reward for their efforts in validating changes to the shared data, nodes are typically rewarded with new amounts of the blockchain's native currency—e.g., new bitcoin on the bitcoin blockchain," says Sarah Shtylman, fintech and blockchain counsel with Perkins Coie.

B. Public Blockchains vs PrivateBlockchains

Thereare both public and private block chains. In a public block chain, anyone can participate meaning they can read, write or audit the data on the block chain. Notably, it is very difficult to alter transactions logged in a public block chain as no single authority controls the nodes.

A private blockchain, meanwhile, is controlled by an organisation or group. Only it can decide who is invited to the system plusit has the authority to go back and alter the blockchain. This private blockchain processis more similar to an in-house data storage system except spread over multiple nodes to increase security.

HowIsBlockchain Used?

Blockchaintechnologyisusedformanydifferentpurposes, from providing financial services to administering voting systems.

C. Crypto currency

The most common use of blockchain today isas the backbone of cryptocurrencies, like Bitcoin or Ethereum. When peoplebuy, exchange or spend cryptocurrency, thetransactionsarerecorded on a blockchain. The more peopleuse cryptocurrency, the more widespread blockchain couldbecome.

"Becausecryptocurrencies are volatile, they are not yet used much topurchase goods and services. But that is changing as PayPal, Square and other money service businesses make digital asset services broadly available toven dors and retail customers, "notes Patrick Daugherty, senior partner of Foley & Lardner and lead of the firm's block chain task force.



International Journal for Research in Applied Science & Engineering Technology (IJRASET) ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538

Volume 13 Issue IV Apr 2025- Available at www.ijraset.com

1) Banking

Beyond cryptocurrency, blockchain isbeingused to processtransactions in fiat currency, like dollars and euros. This could be faster than sending money through a bank or other financial institution as the transactions can be verified more quickly processed outside of normal business hours.

2) Asset Transfers

Blockchaincanalsobeusedtorecordandtransfertheownership of differentassets. This is currently very popular with digital assets like NFTs, a representation of ownership of digital artand videos.

However, blockchain could also be used to process the ownership of real-life assets, like the deed to real estate and vehicles. The two sides of a party would first use the blockchain to verify that one owns the property and the other has the money to buy; then they could complete and record thesale on the blockchain.

Using this process, they could transfer the property deed without manually submitting paper work to update the local county's government records; it would be instantaneously updated in the block chain.

3) SmartContracts

Another blockchain innovation are self-executing contracts commonly called "smart contracts." These digital contracts are enacted automatically once conditions are met. For instance, a payment for a good might bereleased instantly once the buyerand seller have met all specified parameters for a deal.

``We see great potential in the area of smart contracts-using block chain technology and coded instructions

toautomatelegalcontracts,"saysGray. "Aproperlycodedsmartlegalcontractonadistributedledger can minimize, or preferably eliminate, the need for outside third parties to verify performance."

4) SupplyChainMonitoring

Supply chainsinvolve massiveamountsofinformation, especiallyasgoodsgo fromonepartofthe world totheother. Withtraditionaldatastoragemethods, it can be hard to trace the source of problems, like which vendor poor-quality goods came from. Storing this information on block chain would make easier to go back and monitor the supply chain, such as with IBM's Food Trust, which uses block chain technology to track food from its harvest to its consumption.

5) Voting

Experts are looking into ways to apply block chain to prevent fraudin voting. In theory, block chain voting would allow people to submit votes that couldn't be tampered with as well as would remove the need to have people manually collect and verify paper ballots.

Advantages of Blockchain Higher Accuracy of Transactions

Because a block chain transaction must be verified by multiple nodes, this can reduce error. If one node has the second second

amistake in the data base, the other swould see it's different and catch the error.

In contrast,ina traditional database,ifsomeone makesa mistake, it may be morelikelytogothrough.In addition, everyassetis individuallyidentifiedand tracked on the blockchainledger, so there is no chance of double spending it (likea person overdrawingtheir bank account,thereby spending moneytwice).

No Need for Intermediaries

Using blockchain, two parties in a transaction can confirm and complete something without working through third party. This savestime wellas the cost of paying for an intermediary like a bank.

"Ithastheabilitytobringgreaterefficiencytoalldigitalcommerce,toincreasefinancialempowermentto the unbanked or underbanked populations of the world and to power a new generation of internet applications as a result," says Shtylman. Extra Security

Theoretically, a decentralised network, like blockchain, makes it nearlyimpossible for someone to make fraudulent transactions. To enter in forged transactions, they would need to hack every node and change everyledger.Whilethisisn't necessarilyimpossible,manycryptocurrencyblockchain systemsuseproof-of-stake or proof-of-work transaction verification methods that make it difficult, as well as not in participants' best interests, to add fraudulent transactions. More Efficient Transfers

Since blockchains operate 24/7, people can make more efficient financial and asset transfers, especially internationally. They don't need to wait days for a bank or a government agency to manually confirm everything.



X. DISADVANTAGES OF BLOCKCHAIN

A. LimitonTransactionsperSecond

Given that blockchaindependsonalargemetwork to approve transactions, there's alimit to how quickly it can move. For example, Bitcoin can only process 4.6 transactions per second versus 1,700 per second with Visa. In addition, increasing numbers of transactions can create network speed issues. Until this improves, scalability is a challenge.

B. HighEnergyCosts

Having all the nodes working to verify transactions takes significantly more electricity than a single database or spreadsheet. Not only does this make blockchain-based transactions more expensive, but it also creates a large carbon burden on the environment.

Because of this, some industryleaders are beginning to move away from certain block chain technologies, like Bitcoin: For instance, Elon Musk recently said Tesla would stop accepting Bitcoin partly because he was concerned about the damage to the environment.

C. RiskofAssetLoss

Somedigitalassets are secured using a cryptographickey, like cryptocurrency in a block chain wallet. You need to carefully guard this key.

"If the owner of a digital asset loses the private cryptographic key that gives them access to their asset, currently there is no way to recover it—theasset is gonepermanently," saysGray. Because the system is decentralized, you can't call a central authority, like your bank, toask toregain access.

D. PotentialforIllegalActivity

Blockchain's decentralization adds more privacy and confidentiality, which unfortunately makes it appealingtocriminals. It's harder to trackillicit transactions on block chain than through bank transactions that are tied to a name. How to Investin Block chain

You can't actually invest in blockchain itself, since it's merely a system for storing and processing transactions. However, you caninvest inassets and companies using thistechnology.

"The easiest way is to purchase cryptocurrencies, like Bitcoin, Ethereum and other tokens that run on a blockchain," says Gray.

Another optionistoinvestinblockchaincompaniesusingthistechnology. For example, Santander Bank isexperimentingwithblockchain-basedfinancialproducts, and if you were interested ingaining exposure to block chain technology in your portfolio, you might buyits stock.

For a more diversified approach, you could buy into an exchange-traded fund (ETF) that invests in blockchain assets and companies, like the Amplify Transformational Data Sharing ETF (BLOK), which puts at least 80% of its assets in blockchain companies.

E. The Bottom Line

Despite its promise, blockchain remains something of a niche technology. Gray sees the potential for blockchain being used in more situations but it depends on future government policies. "It remainsto be seen whenandifregulatorsliketheSEC willtakeaction.Onethingisevident—thegoalwillbetoprotect markets and investors," he says.

Shtylmanlikensblockchaintotheearlystagesoftheinternet. "Ittookabout15yearsofhavingtheinternet beforewesawthefirstversionofGoogleand over20 forFacebook.It'shardto predict whereblockchain technology will beinanother10 or15 years, but muchliketheinternet, it will significantly transform the ways wetransact and interact with each other in the future."

Hurdles remain, especially with the transaction limits and energy costs, but for investors who see the potential ofthetechnology, blockchain-basedinvestments may bea bet worthtaking.

enhanceoursocialandeconomicsystems.

AblockchainisbuiltbyrunningsoftwareandlinkingseveralTheBlockchainandtheFutureofTransactionsBlockchaintechnologyistransfor mative, and is expected to have a massive economic impacts imilar to the one the Internet has had in the past few decades.



International Journal for Research in Applied Science & Engineering Technology (IJRASET) ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538 Volume 13 Issue IV Apr 2025- Available at www.ijraset.com

Since blockchaintechnology isatthe heart of Bitcoinand other virtual currencies, it can at the veryleast be expected to power even more consequential mediums of exchange in the future. However, virtual currencies are merely the first use case of blockchain technology.

F. Blockchain Fundamentals

The blockchain is an open and distributed ledger. It uses an append-only data structure, meaning new transactions and data can be added on to a blockchain, but past data cannot be erased. This results in a verifiable and permanent recordof dataand transactionsbetween twoor more parties. This has the potential to increase transparency and accountability, and positively nodestogether. Ablockchain one global entity— there are several blockchains. Imaginea network of connected computers inside a highly secure office, which are connected to each other, but not to the internet. Ablock chain is and banks can build internal blockchains with their own features for various organisational purposes.

Aconsensus mechanismanda reward systemarerequired to maintainthe integrityand functionality of a blockchain.IntheBitcoinblockchain,consensusisachievedby'mining',andtherewardsystemisa protocol awarding aminersome amountof Bitcoin upon successfully mining a block.Mining is undertaken by powerful computers solving complex mathematical puzzles.

Once a transaction verified, and accepted as true by the entire network, miners start working on the next block. Thus, a blockchainkeeps growing (linking each new block to the one before it).



Themainchain(black)consistsofthelongestseriesofblocksfromthegenesisblock(blue)tothecurrent block. Orphan blocks (red) exist outside of the main chain.

ImplicationsforTransactions

Blockchain technology will disrupt the way we write and enforce contracts, execute transactions and maintain records.

Keepingrecords of transactionsis a core function all businesses. These records are meant to track past performance and help with forecasting and planning for the future. Most organizations' records take alot of time and effort to create, and often the creation and storage processes are prone to errors. Currently, transactions can be executed immediately, but settlement can take anywhere from several hours to several days. For example, someone selling stockina corporation as stock exchange can sell immediately, but settlement can take fewdays. Similarly, a deal to purchase house or car can be negotiated and signed quickly, but the registration process (verifying and registering the change in property ownership) often takes days and may involve lawyers and government employees. In each of these examples, each partymaintains its own ledger, and cannot access the ledgers of the other parties involved.

Ontheblockchain, the process of transaction verification and recording is immediate and permanent. The ledger is distributed across several nodes, meaning the data is replicated and stored instantaneously on each node across the system. When a transaction is recorded in the blockchain, details of the transaction such as price, asset, and ownership, are recorded, verified and settled within seconds across all nodes. A verified change registered on any one ledger is also simultaneously registered on all other copies of the ledger. Since each transaction is transparently and permanently recorded across all ledgers, open for anyone to see, there is no need for third-party verification.



ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538 Volume 13 Issue IV Apr 2025- Available at www.ijraset.com

From Virtual Currenciesto Enterprise Use

The block chain underlying Bit coinis currently the large stand best known block chain.

Ethereum is a separate blockchain: while it supports the Ether currency, it also acts as a distributed computingplatformthatfeaturessmartcontractfunctionality. Therefore, despitehaving avirtual currency element, it has many more uses than Bitcoin. For example, companies invarious industries raising funds through ICOs use Ethereum for their projects.

TheHyperledgerProject,bytheLinuxFoundation,aimstobringtogetheranumberofindependentefforts to develop open protocols and standardsin blockchaintechnology for enterpriseuse.

Hyperledgerisaprojectwithseveralopensourceblockchainsandrelatedtoolstosupportthecollaborative development of blockchain — based distributed ledgers.

XI. BENEFITS OF BLOCKCHAIN

Theblockchainisnothingshortofagame-changingtechnologyforanyonewhochoosestouseandmaster it. Let's discuss the benefits of blockchain-

- 1) Transparency Blockchain makes transaction histories more transparent than they ever were. Because it is a type of a distributed ledger, all nodes in the network share a copy of the documentation. The data on a blockchain ledger is easily accessible for everyone to view. If a transaction history changes, everyone in the network can see the change and the updated record. Therefore, all information about currency exchange isavailable to everyone.
- 2) Security–Blockchainisbetterthananyotherrecord-keepingsystemwhenitcomestosecurity,by allstandards.Theshareddocumentationoftransactionscanonlybeupdatedand/or modified with consensus on a blockchain network. Only if everyone or a majority of nodes agree to update a record, the information is edited. Moreover, when a transaction is approved, it is encrypted and connected with the previous transaction.Therefore,noone personor party has the potential to alter a record. Blockchain is decentralized, and so, no one reserves the right to update records by their free will. Any industry that has a critical need to protect sensitive data such as governments, healthcare, financial services, etc., canuse blockchainto enforce stringent security.
- 3) Efficiency With traditional, paperwork processes, completing a transaction is exhausting as it needsthirdpartymediationandispronetohumanerrors.Blockchaincanstreamlineanddiscipline these legacy methods and remove the risk of mistakes, making trading more efficient and faster. Sincethereisonly one ledger, partiesdon't haveto maintain multiple documents, a factthatleads to much less clutter.And, when everyone hasaccessto the sameinformation, establishing trust is easier.Withoutany need forintermediaries, settlementscan be made smooth and effortless,too.
- 4) Traceability–Incomplex supplychains, it is hard to trace products back to their origins. But, with blockchain, the exchanges of goods are recorded, so you get an audit trail to learn where a particular asset came from. You also get to know every stop the product made on its journey & this level of traceability of products can help verify the authenticity and prevent frauds.
- 5) Auditability Another aspect of the point mentioned above isauditability. As each transaction is recorded for its complete lifetime in block chain, there is an audit trail that already exists for your one and check the authenticity of your asset.
- 6) Cost reduction As blockchain eliminates the need for third-parties and middlemen, it saves enormouscostsforbusinesses.Giventhatyoucantrustthetradingpartner, youdon'tneedanyone elsetoestablishtherulesandpoliciesofexchange.Thecostandeffortspentondocumentationand its revisionsare also saved as everyone gets to view a single immutable version of the ledger.

Forlongterm

Block chain technology is still in a nearly, for mative stage, and cryptocurrencies are only its first major use case.

Beyondcryptocurrency, blockchaintechnology will change how we transact, and how we record and verify transactions. This will revolutionize contracts and reduce friction in the exchange of assets. Over the next few decades, block chain technology will percolate through our organizations and institutions, and shape how we transact with one another.

JustastheInternetcontinuestopoweremergenttechnologies, we can expect to see new use cases of blockchain technology acrossall industries.

Advantages of Blockchain Technology

There are many advantage stousing block chain technology compared to other traditional technologies.

• With blockchain, your business process will be better protected with the help of a high level of security



ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538 Volume 13 Issue IV Apr 2025- Available at www.ijraset.com

- Thehackingthreatsagainstyourbusinesswillalsobereducedtoagreaterextent.
- As blockchain offers a decentralised platform, there is no need to pay for centralised entities or intermediaries' services.
- $\bullet \quad Enterprise block chain technology enables or ganisation stouse different levels of accessibility.$
- Organisationscandofastertransactionswiththehelpofblockchain.
- Accountreconciliation can be automated.
- Thetransactionsdonearetransparentandhence, easytotrack. Benefits of Blockchain In Energy Sector

Energydistribution,allocation,andproductionhavealwaysbeenanimportant sector forgovernmentsout there. Withoutproperenergymanagement, itbecomes hardforanygovernment toprovidevaluablegrowth toits economy.Private playersalsoplaya crucialroleand canbenefit fromtheblockchain.Belowarethe benefitsthat the energy sector receives with the use of blockchain.

- Environmental Sustainability: Blockchain helps make the energy sector more environmentally sustainable. Ithelpsovercomelegacyenergy sectorefficiency is sustainable work where it is possible to produce, store, and distribute energy more efficiently.
- Reduced Costs: The costs associated are reduced when it comes to infrastructure and operational aspects of the energy sector.
- ImprovedTransparency:Theuseofadistributedledgersimprovestransparency.

Benefits of Block chain In Real Estate

Thereal estatesector's condition has not been so good for the past few years. That's partly because of the ever-increasing price and how frustrating it has become to buy a property. Block chain has brought a new fresh outlook on how the real estate sector operates. The benefits of block chain in real estate include the following -

- Tokenization: With blockchain, it will become possible to tokenize actions. This means that properties can be rented outfor a certain periodusing pre-defined code. Tokensalso makeit possible to add any business logic, including the ability to protect against fraud.
- Proper Tenant and Investor Identity: Digital identities can help both investor and tenant to create digital identities that are easy to verify and work with. The KYC/AML procedures will become more streamlined with the use of proper identity management. Lastly, documentation becomes easier and more shareable.
- Property Sale: Property sales can be automated with smart contracts. It enables legal agreements that are traceable and executable if a certain condition is met.
- Real-TimeAccounting:Withblockchain,itispossibletodoreal-timeaccounting Benefits of Blockchain In Trade Finance
- Trade finance benefited immensely from the blockchain. It required some form of reform to solve the problems it is currently facing. The benefits of blockchain in trade financeinclude following.
- DataIntegrity: Withblockchain, the tradefinances ector improves when it comes to data integrity, authenticity, and proper asset provenance.
- StreamlinedProcess:Automationalso becamea normduetoblockchaindAppandsmart contract capabilities.Itimprovedoverallprocessefficiency,includingtheabilitytodoreal-timesettlement. The processalso became error free dueto the non-involvement of intermediaries.
- Programmable: With blockchain, organizations can now code multiple aspects of the business, including data privacy, governance, identity management, and so on.
- Market Reactivity: Using digital security also means that trade finance organizations can make changes when the need arises. In simple words, it offers customization.
- Cost Reduction: Using an automated network means cost reduction, including transactional, operational, and infrastructural.

International Journal for Research in Applied Science & Engineering Technology (IJRASET) ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538 Volume 13 Issue IV Apr 2025- Available at www.ijraset.com



Capacities of block chain technology for health caredomain.

The Blockchain makes the entire prescription process transparent, from manufacturing pharmacy to shelves. Congestion, freight direction, and speed may all be tracked using IoT and Block chain. It offers the chancet oschedule acquisition and speed may all be tracked using IoT and Block chain. It offers the chancet oschedule acquisition and speed may all be tracked using IoT and Block chain. It offers the chancet oschedule acquisition and speed may all be tracked using IoT and Block chain. It offers the chancet oschedule acquisition and speed may all be tracked using IoT and Block chain. It offers the chancet oschedule acquisition and speed may all be tracked using IoT and Block chain. It offers the chancet oschedule acquisition and speed may all be tracked using IoT and Block chain. It offers the chancet oschedule acquisition and speed may all be tracked using IoT and Block chain. It offers the chancet oschedule acquisition acqusefficientlytoprevent disruptions and short ages inclinics, pharmacies, and other medical facilities with a given medication. The deployment of digital frameworks built Blockchain wouldhelpensurethatthelogisticsdataavoid on uncontrolledadjustments.Itincreasestrustandpreventsthe illicit handling of records, payments, and medication themselves by various people interested in purchasing drugs. The technology can effectively improve the condition of patients while at a competitive cost retaining the funds. It eliminates all obstacles and barriers in multi-level authentication . Because Blockchain can preserve an incorruptible, decentralised, and transparent log of all patient data, it is ripe for security applications. Furthermore, while Blockchain is visible, it is also private, hiding any individual's identity behind complicated and securealgorithmsthat can preserve the sensitivity of medical data. Thanks to the technology's decentralised structure, patients, doctors, and healthcare providers can all share the same information swiftly and safely.





ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538 Volume 13 Issue IV Apr 2025- Available at www.ijraset.com

XII. BACKGROUND OF THE STUDY

Apatientmovingfromonestatetoanother, or visiting multiplespecialists. Currently, their medical records are often fragmented across different healthcare providers using incompatible systems. This leads to delays, potential errors, and repeated tests. Block chain's ability to create a shared, immutable ledger could enable seamless and secure data exchange, ensuring a complete patient history is accessible when needed.

 During disaster relief efforts, where temporary medical facilities are set up, accessing patient records quicklyiscrucial.Blockchaincouldprovideasecureanddecentralizedwaytosharecriticalhealth information, even in environments with limited infrastructure.

ResearchPaperStudyInsights:

- 2) "Blockchain for Health Data and Beyond: CurrentApplications, Challenges, and Future Trends" (Yaga et al., 2019):
- This paper highlights the potential of blockchain to address the challenges of data interoperability, security, and patientcentricityin healthcare. It emphasizes the need for a decentralized and secure platform to managepatient health records, citing the limitations of existing centralized systems.
- The paper addresses the security concerns surrounding the current health record systems, and points to the cryptographic nature of block chain as a strong solution to this problem.
- 3) "AReviewontheApplicationofBlockchaininHealthcare"(Ekblawetal.,2016):
- This study explores the use of block chain for managing electronic health records (EHRs), emphasizing the need for secure and auditable data sharing among health care providers.
- It points out that blockchain could help solve the problem of data ownership, by allowing patients to control who has access to their data.

Main AIM:

The main aim of developing a blockchain-based patient health record system is to create a secure, interoperable, and patient-centric platform that revolutionizes health caredatamanagement. This involves:

- Enhancing Data Security and Privacy: Utilizing blockchain's cryptographic features to protect sensitive patient information from unauthorized access and tampering.
- Improving Interoperability: Enabling seamless and secure data exchange between disparate healthcare providers and systems, eliminating data silos and fragmentation.
- Empowering Patients: Givingindividuals greater control over their healthrecords, allowingthem to manageaccess permissions and share their data withouthorized parties.
- Ensuring Data Integrity and Immutability: Leveraging blockchain's immutableledger to maintain the accuracy and reliability of patient healthrecords, reducing the risk of errors and fraud.
- Streamlining Healthcare Processes: Optimizing workflows and reducing administrative burdens through efficient data sharing and secure transactions.
- FacilitatingResearch andDataAnalytics:Providingasecureand auditableplatformfor researchers to access and analyze anonymized patient data, advancing medical knowledge and improving public health.

Theadvantagesoftheproposedsystem:

- A blockchain-based patient health record system offers several key advantages over traditional, centralized systems:
- EnhancedSecurity:
- Blockchain'scryptographicfeatures and decentralized nature make it significantly more resistant to hacking and data breaches.
- > Dataisdistributedacrossmultiple nodes, making it difficult for a single point of failure to compromise the entire system.
- ImprovedInteroperability:
- Blockchaincanfacilitateseamlessandsecuredataexchangebetweendifferent healthcare providers andsystems, regardless of their underlying technology.
- > Thiseliminatesdatasilosandpromotesamoreholisticviewofpatienthealth.



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- PatientEmpowerment:
- Patientsgaingreatercontrolovertheirhealthrecords, allowingthemtomanage access permissions and share their data with authorized parties.
- > Thisfosterspatientengagementandpromotesshareddecision-making.
- DataIntegrityandImmutability:
- > Blockchain'simmutableledgerensuresthathealthrecordsareaccurateandtamper-proof.
- \blacktriangleright This reduces the risk of errors and fraud, enhancing the reliability of patient data.
- IncreasedTransparencyandAuditability:
- > Alltransactionsanddatachangesarerecordedontheblockchain, creating atransparent and auditable trail.
- > Thisenhancesaccountabilityandfacilitatesregulatorycompliance.
- ReducedAdministrativeCosts:
- Automated datasharing and secure transactions canstreamline administrative processes, reducing paperwork and operational costs.
- FacilitationofResearch:
- > Secureandanonymizeddatasharingcanfacilitatemedicalresearch.
- \succ This can lead to advance ment sin medical technology and treatments.
- MitigationofMedicalIdentityTheft:
- > The useofcryptography and permissioned accesscansignificantlydecrease theriskof medical identity theft.

Requirementsoftheproject SoftwareRequirements: IDE:VisualstudioCode,Atomorsublimetext Browser : chrome HardwareRequirements: RAM: 4GB min ROM:256GBmin Programming: FrontEnd:HTML&CSS Back End : Python

Process/Implementation:

- WewillWriteBlockchainCode
- > Willuselibrarieslikeimporthashlib,random,SHA256,datetime.
- InstallFlaskandotherdependencies
- > Thenwewillcreateflaskapplication(app.py)and willcreateanewfilenamedapp.pyintheproject folder.

Followingcode:

fromflaskimportFlask,render_template,request from hashlib import sha256 fromdatetimeimportdatetime import random app=Flask(name) #listtostoreblockchain blockchain = [] #Patientrecordclass classPatientRecord: definit(self,name,uid,age,medical_history): self.timestamp = datetime.now() self.name=name self.age = age self.uid = uid self.medical_history = medical_historyself.previous_hash = None self.hash=self.calculate_hash()

defcalculate_hash(self): hash_data = str(self.timestamp) + self.name + str(self.uid) + str(self.age) + self.medical_historyreturn sha256(hash_data.encode()).hexdigest()

def calculate_previous_hash(self): if len(blockchain) > 0:



previous_record=blockchain[-1] returnprevious_record.hash else: returnNone

to add new record to blockchain @app.route('/add_record', methods=['POST']) def add_record():
name = request.form['name'] age = request.form['age']
medical_history = request.form['medical_history'] uid = request.form['uid']

Createanewpatientrecord
record=PatientRecord(name,uid,age,medical_history)

Adding the patient record to the blockchain record.previous_hash = record.calculate_previous_hash() blockchain.append(record)

```
returnf'Recordaddedtoblockchainsuccessfully.YourUserID-{uid}'
```

getting patient record from blockchain @app.route('/get_record', methods=['GET']) def get_record(): uid = request.args.get('uid') for block in blockchain: ifthere wide

ifblock.uid==uid:

return render_template('record.html', record=block) return 'Record not found.'

#displayingwholeblockchain

```
@app.route('/view_blockchain', methods=['GET']) def view_blockchain():
returnrender_template('blockchain.html',blockchain=blockchain)
```

@app.route('/get_patient_history', methods=['GET']) def get_patient_history():
 pass
 @app.route('/get_history', methods=['GET']) def get_history():
 uid = request.args.get('uid') history = list()
forblockinblockchain: if block.uid == uid:
 history.append(block) else:
 continue
 iflen(history)>=1:
 return render_template('patient_records.html', all_records=history)else:
 return'Recordnotfound.'

```
#returninglandingpage @app.route('/')
defindex():
returnrender_template('index.html')
ifname_____=='main':
```

app.run(debug=True)

.Create HTML Templates Create a templates folder: Createafoldernamedtemplatesinyourprojectfolder. Create index.html: <!DOCTYPEhtml> <html>



<head> <title>PatientManagementSystem</title> <style>body{ background-color: #ac8e8e; font-family: Arial, sans-serif; }

h1{ text-align:center; margin-top:50px; }

form{
margin:0auto;
width:50%;
background-color: rgb(124, 174, 45); padding: 20px;
border-radius:10px;
box-shadow:0px0px20pxrgba(87,52,201,0.2);
}

```
label{
```

font-weight:bold;

```
}
```

```
input[type=text], input[type=number], textarea{ width: 100%;
padding:10px;
border:1pxsolid#713030; border-radius: 4px;
box-sizing: border-box; margin-top: 5px; margin-bottom: 10px; resize: vertical;
}
```

```
input[type=submit] { background-color: #7e6f33; color: white;
padding:10px20px; border: none;
border-radius:4px; cursor: pointer;
}
```

```
input[type=submit]:hover{ background-color: #7b293d;
}
```

input[type=submit]:focus{ outline: none; } </style> </head> <body> <h1>Patienthealthrecordusingblockchain</h1> <center> </center> </center> <formmethod="POST"action="/add_record">

```
<labelfor="name">Name:</label>
```



ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538 Volume 13 Issue IV Apr 2025- Available at www.ijraset.com

```
<inputtype="text"id="name"name="name"><br>
 <labelfor=''age''>Age:</label>
 <inputtype="number"id="age"name="age"><br>
 <labelfor="medical_history">MedicalHistory:</label>
 <textareaid="medical_history"name="medical_history"></textarea><br>
 <labelfor="uid">USERIDENTITY:</label>
 <inputtype="number"id="uid"name="uid"><br>
 <inputtype=''submit''value=''AddRecord''>
 </form>
 <br><br>>
 <formmethod="GET"action="/get_history">
 <labelfor="name">USERIDENTITY:</label>
 <inputtype="text"id="uid"name="uid"><br>
 <inputtype="submit"value="GetRecord">
 </form>
 <br><br>>
 <formmethod="GET"action="/view_blockchain">
 <inputtype="submit"value="ViewallBlockchain">
 </form>
 </body>
 </html>
 1) Createrecord.html
 <!DOCTYPEhtml>
 <html>
 <head>
 <title>PatientRecord</title>
 </head>
 <body>
 <h1>PatientRecord</h1>
 Name: { { record.name } }
 Age:{{record.age}}
 MedicalHistory:{{record.medical_history}}
 Timestamp: { {record.timestamp } }
 Hash:{{record.hash}}
 PreviousHash:{{record.previous_hash}}
 </body>
 </html>
 2) Createblockchain.html
 <!DOCTYPEhtml>
 <html>
 <head>
 <title>BlockchainViewer</title>
<style>body{
 font-family: Arial, sans-serif; background-color: #b8b66a;
 }
 h1{
```

text-align:center; font-size: 36px; margin-top:50px;



table {margin:auto; border-collapse: collapse; width: 80%; margin-top: 50px; margin-bottom: 50px; } th{ background-color: #6e5391; color: white; padding: 10px; text-align:center; font-weight:normal; } td{ padding: 10px; text-align:center; border-bottom:1pxsolid#ddd; } tr:nth-child(even) { background-color: #5f9e7a; } tr:hover{ background-color:#a6ab5d; } </style> </head> <body> <h1>BlockchainViewer</h1> Timestamp Name Age UID MedicalHistory Hash PreviousHash {%forblockinblockchain%} {{block.timestamp}} {{block.name}} {{block.age}} ${\{block.uid\}}$ {{block.medical_history}} {{block.hash}} {{block.previous_hash}}



</body> </html> 3) Createpatient_records.html <!DOCTYPEhtml> <html> <head> <metacharset="utf-8"> <title>PatientManagementSystemusingBlockchain</title> <style>body{ font-family: Arial, sans-serif; background-color: #509b5b; margin: 0; padding:0; } h1{ color: #837eb4; text-align:center; margin: 1rem 0; } table{ border-collapse: collapse; width: 100%; max-width:800px; margin: 0 auto; background-color:#adb583; box-shadow:0px0px10pxrgba(0,0,0,0.1); } th, td{ text-align: left; padding:0.5rem; } th{ background-color: #333; color: #fff; font-weight:bold; } tr:nth-child(even) { background-color: #a3b285; } tr:hover{ background-color:#acb078; } p{ text-align:center; margin: 1rem 0; } </style> </head> <body> <h1>RecordsforPatient:{{all_records[0].name}}</h1> {%ifall_records%} Index Name Age MedicalHistory Timestamp



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Hash {%forblockinall_records%} ${loop.index}$ {{block.name}} {{block.age}} {{block.medical_history}} {{block.timestamp}} {{block.hash}} {%endfor%} {%else%} Norecordsfoundforthispatient. {%endif%} </body> </html>RuntheApplication IntheVSCodeterminal,run:pythonapp.py 4)

- 5) Openyourwebbrowser Explanation:
- TheFlaskapphandlesroutinganddataprocessing.
- ThePatientRecordclassrepresentsablockintheblockchain.
- Thecalculate_hashmethodgeneratesaSHA256hashforeachrecord.
- Thecalculate_previous_hashmethodlinksblockstogether.
- TheHTMLtemplatesprovidetheuserinterface.
- Thegethistoryfunctionallowstheusertoviewalltheblocksassociated with a single UID.

Output :MainPage:

Patient health record using blockchain
Name:
Age:
Medical History:
USERIDENTITY:
Add Record
USERIDENTITY:
Get Record
View all Blockchain



Blockchain Viewer							
Timestamp	Name	Age	UID	Medical History	Hash	Previous Hash	
2025-04-05 12:51:58.230028	NANDITA	30	78231	PCOD	94b7d76917cdbd51af63c640a3b70c881763fca7b29f406cc8b56702ab567391	None	
2025-04-05 12:53:33.546315	DIKSHA	29	89632	COUGH AND RUNNING NOSE	c3b18ec81fa23bbe4e0ca2f903c6b00149cd3eb41ecd72b576d284c08de10378	94b7d76917cdbd51af63c640a3b70c881763fca7b29f406cc8b56702ab567391	
2025-04-05 12:57:02.109226	ANJALI	28	47283	BACK Pain and Gas	024d9487b6c33f44759cc28ecc86d6970031be109d801260b8223d4f8b1fb319	c3b18ec81fa23bbe4e0ca2f903c6b00149cd3eb41ecd72b576d284c08de10378	
2025-04-05 13:01:35.288356	SUSHMITA SINGH	28	21345	HIGH BP	d5851c706091187c452d0c6526754f15af9325360db4a6df3bfb7d12a96dde95	024d9487b6c33f44759cc28ecc86d6970031be109d801260b8223d4f8b1fb319	

GOOGLEFORMRESPONSESCHARTS:







International Journal for Research in Applied Science & Engineering Technology (IJRASET) ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538 Volume 13 Issue IV Apr 2025- Available at www.ijraset.com



XIII. CONCLUSION

The purpose of these literature reviews was to collect information on how an information system helped themanagement of PatientHealthRecords.Basedonthereviews, it was found out that web-based Patient Health Records systems provide convenience, efficiency and security to the system users and hospitals compared to the manual systems.

Mainwork isthatI've createdallthearchitecture for blockchain, from setofstatetransitionrulestoa method for creating blocks, mechanisms for checking the validity of transactions. blocks. and the full to chain. This is an ewand unique way to develop a system for securing health data. Third Parties, Attacks or any system will take a lot of time to crack this system. We can say it is tough to break the hash and information will be stored with security. It will help the whole human for medical health records Data through blockchain technology.

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