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Anticipating the Development of Innovative Systems: Decentralized Healthcare System and Secure Remote Monitoring Platform for Diabetes Patients

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ABSTRACT
An unparalleled potential to improve the management and treatment of chronic illnesses like diabetes has arisen with the growth of digital health technology. Better health outcomes and quality of life for people with diabetes may be possible with the help of decentralized and secure digital health solutions, according to the results. Creating a secure remote monitoring platform and decentralized health application for diabetes patients is difficult, especially for securing sensitive patient data. Current healthcare systems frequently have poor performance, high mistake rates, and low sensitivity and specificity. This proposed work provides a novel way to securely store encrypted diabetes data using AES and MD5 in a user-defined blockchain system. The decentralized healthcare system and safe remote monitoring platform for diabetic patients use a Python-based block class with index, previous hash, timestamp, data, hash, and compute hash. Additionally, a user-defined blockchain class with add block method is created. CSV diabetic data is safely kept on the blockchain, and simulations assure transaction success and failure. Comparing the suggested and traditional models shows considerable increases in performance, error rates, sensitivity, and specificity across block indices. This unique solution improves diabetes data management security and reliability and establishes a new benchmark for digital healthcare systems.

KEYWORDS
Digital health technologies, Diabetes management, Decentralized healthcare system, Secure remote monitoring, Blockchain

1. Introduction

Innovations in digital health are causing a sea change in the way chronic illnesses, including diabetes in particular, are managed [1]. A decentralized health systems and a secure remote monitoring platform developed for diabetes patients are the particular topics of this study, which delves into the possible creation of unique systems. Improved data security and privacy, made possible by incorporating block chain technology into this framework, is essential for keeping patients' confidence and information private [2, 3]. To further improve patient outcomes, data analytics and real-time monitoring are integrated to allow for individualized treatment regimens and prompt interventions. Such creative answers are necessary since diabetes is becoming more common and the healthcare costs connected with it are rising. By focusing on the importance of user-centric design and strong security measures, this paper hopes to draw attention to the many ways in which decentralized and secure digital health systems might improve diabetic patients' treatment and quality of life [4, 5].

In a decentralized healthcare system and remote monitoring platform leveraging block chain technology, each stakeholder plays a crucial role in ensuring data integrity, security, and efficient healthcare delivery. Diabetic patients generate valuable health data through continuous monitoring devices, which is then securely encrypted and stored on the block chain [6, 7]. Doctors access this data to monitor patient health in real-time, adjust treatment plans, and provide timely interventions. Healthcare policymakers utilize aggregated and anonymized block chain data to formulate effective policies, ensuring better resource allocation and healthcare outcomes [8, 9]. Consultants work with both patients and healthcare providers to optimize treatment plans and improve adherence to medical advice. Data analysts extract and analyze block chain data to uncover patterns and insights, helping to predict complications and improve patient care. Technical experts ensure the block chain platform is secure, scalable, and user-friendly, facilitating seamless data storage and retrieval while maintaining the highest standards of data privacy and security. Together, these roles create a robust ecosystem that enhances patient outcomes, promotes efficient healthcare delivery, and drives innovation in diabetic care [9, 10]. The scope of this decentralized approach is vast, extending beyond diabetes management to potentially transform the entire healthcare industry. By ensuring data transparency, reducing fraud, and enabling secure and efficient data sharing, block chain can revolutionize how healthcare services are delivered and managed. It offers opportunities for improved patient outcomes, cost savings, and enhanced research capabilities through access to large-scale, high-quality health data [11, 12, 13]. Additionally, the integration of advanced technologies such as AI and IoT with blockchain can further enhance the capabilities of remote monitoring and personalized medicine, paving the way for a more proactive and patient-centered healthcare system [14, 15].

Conventional Blockchain: This technology had more errors and slower blocks processing. A 20% mistake rate brought the success percentage down to 80%. Block processing times were delayed by 0.05 to 0.1 seconds due to the system's sluggish performance [16, 17].

Proposed Blockchain: The suggested blockchain offered lower error rates and quicker block processing times than the current architecture. The success rate was 90%, reducing errors by 10%. Block times were adjusted from 0.01 to 0.05 seconds, improving efficiency.

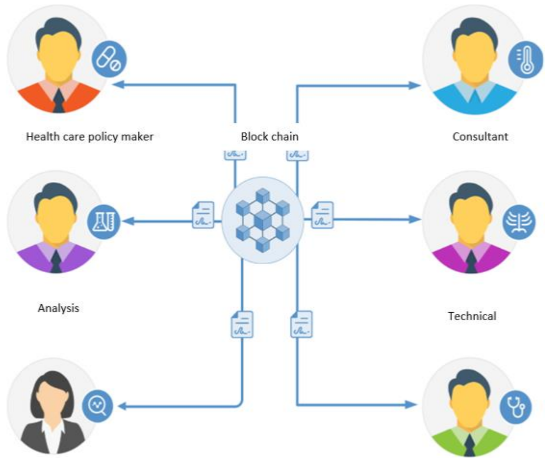

Figure 1 Remote monitoring platform and a decentralized health system for Diabetic patient [18]

1.1 Objective of research

Creating a safe remote monitoring platform and a decentralized healthcare system specifically for diabetic patients is the main focus of this project. Through the use of blockchain technology, this system intends to facilitate frictionless data exchange and communication between healthcare practitioners and patients while also guaranteeing the utmost confidentiality and privacy of patient information. The suggested approach aims to improve diabetes management as a whole by integrating real-time monitoring with modern data analytics; this will allow for more tailored treatment regimens and faster interventions, which should improve patient outcomes.

1.2 Motivation

The rising global incidence of diabetes and the difficulties in controlling this long-term health problem are the driving forces behind this study. Poor patient outcomes are common because traditional healthcare institutions are unable to provide ongoing, individualized treatment. New digital health technologies provide an exciting opportunity to fill these gaps [19-20]. When it comes to patient trust and compliance, nothing is more important than a solid foundation for protecting their data. Blockchain technology offers just that. The goal of this project is to build a decentralized healthcare system and a secure remote monitoring platform to make diabetes care more effective and focused on the patient [21-25].

1.3 Need for Research

Current healthcare systems are ill-equipped to handle the increasing worldwide burden of diabetes, highlighting the critical need for this study. In order to enhance patient outcomes and minimize complications, diabetes patients must be monitored continuously and treated promptly. The problem is that many of the current solutions don't provide enough privacy, security, or real-time functionality. To solve these important problems, the suggestions decentralized healthcare system and safe remote monitoring platform use blockchain technology and sophisticated data analytics [26-28]. By addressing current knowledge gaps in diabetes care, this study paves the way for more widespread use of decentralized health solutions to handle other long-term health conditions [29-31]. Improved and safer digital health ecosystems are the goal of this research, which aims to promote user-centric design and strong security measures.

2. Literature Review

Due to the chronic nature of the illness and its rising prevalence, medical research has placed a substantial emphasis on the treatment of diabetes. The mainstays of conventional diabetes care have always been face-to-face appointments, self-monitoring of blood glucose levels, and meticulous documentation of food and lifestyle choices. Suboptimal patient outcomes are a common result, however, since these methods fail to provide ongoing, individualized treatment.

A comprehensive evaluation of diabetes management mobile healthcare systems was performed by Bonoto et al. (2017). Their analysis focused on the system' efficacy and usability. Researchers observed that diabetes patients' self-management habits and glucose control were both enhanced by these programs. Reminders to take medications, access to instructional materials, and monitoring of blood glucose levels were some of the most praised aspects. Nevertheless, the research did highlight several difficulties associated with user involvement and the need for tailored interventions to improve efficacy [1].

With an emphasis on their function in diabetes care, Klonoff et al. (2013) offered an outline of CGM systems. The accuracy and clinical advantages of several CGM devices were examined in the review. Results showed that CGM devices helped diabetics better regulate their blood sugar, had fewer episodes of hypoglycemia, and had an overall higher quality of life. Despite these advantages, obstacles to broad adoption include things like price, sensor accuracy, and user training [2].

The use of blockchain technology in healthcare was reviewed systematically by Agbo, C. C., et al. (2019). The research looked at how blockchain technology may improve healthcare data security, interoperability, and patient privacy. They came up with a number of applications, such as improved clinical data exchange, safer patient records, and better healthcare supply chain management. By offering a decentralized and immutable ledger that guarantees the security and integrity of patient information, blockchain technology has the potential to solve several current problems in healthcare data management, according to the assessment [3].

Zhang, et al. (2018) reviewed all the uses of blockchain technology in healthcare. The evaluation covered how blockchain technology has the ability to improve the security, transparency, and integrity of health information systems. Among the many important uses they uncovered were better administration of clinical trials, safer patient records, and streamlined supply chain operations. The research emphasized that blockchain technology has the potential to create a distributed, immutable record that might enable the safe exchange of information between healthcare practitioners, patients, and other parties involved [4].

The potential benefits and risks of using deep learning in healthcare were discussed by Miotto et al. (2018). Disease diagnosis, therapy customisation, and patient monitoring might all be greatly improved with the use of deep learning methods, they said. Image analysis for medical diagnostics and predictive analytics for patient outcomes were among the several effective uses mentioned in the assessment. Data privacy, algorithm openness, and AI system integration into healthcare procedures were all highlighted as problems [5].

By successfully classifying skin cancer at a dermatologist's level of accuracy, Esteva et al. (2017) showcased the dermatology field's potential for deep neural networks. The results of this research show that AI has great promise for enhancing diagnostic precision and facilitating clinical decision-making. Although the research found some encouraging outcomes, it did note that additional validation and incorporation into clinical practice are necessary [6].

The use of remote monitoring and digital health was addressed by Fagherazzi et al. (2019) in the context of diabetes care. Digital technologies were discovered to be able to enhance patient outcomes via continuous monitoring, real-time feedback, and individualized therapies. Yet, there are obstacles that need to be addressed, according to the analysis. These include issues with data security, technological acceptability, and the need for strong clinical evidence to back up broad adoption [7].

Based on data collected over the last two decades, Bullard et al. (2018) analyzed the results of the Diabetes Control and Complications Trial (DCCT) and the Epidemiology of Diabetes Interventions and Complications (EDIC) research. New insights into the long-term advantages of strict glucose management in lowering complications were brought to light in the review. In order to maintain long-term glycemic control, it is crucial to provide patients with ongoing education and assistance [8].

Digital health treatments for type 2 diabetics were the subject of a systematic review and network meta-analysis by Pal et al. (2013). Glycemic control and self-management behaviors were reported to be improved by various treatments, which comprised web-based platforms, mobile apps, and telehealth services. To improve the efficacy of digital health treatments, the research stressed the significance of patient participation, tailored feedback, and user-friendly design [9].

In high-performance medicine, Topol (2019) outlined how humans and AI are coming together. Artificial intelligence (AI), he said, might revolutionize healthcare by improving diagnostic precision, tailoring patient care, and bolstering clinical decision-making. In order to integrate AI into clinical practice in an ethical and successful manner, the study stressed the importance of healthcare providers and AI developers working together [10].

Digital health technologies' efficacy and usability were the subjects of a systematic study by Rivas et al. (2020). While some digital healthcare system showed potential for better patient outcomes, the researchers discovered that these system' actual effectiveness hinged on aspects including user involvement, usability, and compatibility with preexisting healthcare infrastructure. Concerns about data privacy and security as well as the viability of digital health therapies in the long run were also brought to light by the evaluation [11]

Ratta, P., et al. (2024) provided a distributed ledger system (blockchain) for Internet of Things (IoT) sensors, machine learning models, DApps, and remote diabetes monitoring. There are five layers to the suggested framework: the Internet of Things Sensor Layer, which gathers real-time health data from patients; the Blockchain Layer, which uses smart contracts on the Ethereum blockchain to secure data sharing and transactions; the machine learning Layer, which analyzes patient data to detect diabetes; and the DApps Layer, which allows for interactions between patients, physicians, and healthcare facilities [12].

Wenhua, Z., et al. (2023) examined blockchain's potential security threats in healthcare and utilizes current security measures to compare and analyze the six levels of blockchain technology. It encourages theoretical study and the creation of strong security protocols for the present and future distributed work environment by defining and exploring the many security threats and problems associated with blockchain technology [13].

Islam, M. S., et al. (2023) details a novel approach to secure data preservation, evidence collecting, and assessment that prioritizes integrity, confidentiality, and availability in order to implement regulations for controlling access to data during healthcare microservice interactions. With this method, Research were able to determine the best parameters for safe block transactions in blockchain networks, including throughput, average reaction time, latency, and quantity of health data mined [14].

Navaroj, et al. (2024) Blockchain Health Monitoring System (BHMS) is an innovative system that tracks vital signs such as heart rate, temperature, blood pressure, and glucose levels. Sharing sensitive information such as patients' medical records, insurance claims, and pharmaceutical supply chains is challenging due to security concerns. Focus on health monitoring system security in this chapter. BHMS ensures the safety of patients' medical records [15].

Table 1 Literature survey

Ref	**Author / year**	**Objective**	**Methodology**	**Cons**	**Pons**
[1]	B. C. Bonoto, et al., 2017	Review mobile health applications for diabetes management.	Mobile healthcare system for diabetes.	May not cover latest apps; potential bias in selected studies.	Comprehensive overview of mobile healthcare system for diabetes.
[2]	D. C. Klonoff, et al., 2013	Overview of CGM technology.	CGM systems and their impact.	Focuses on CGM rather than broader diabetes management tools.	Detailed analysis of CGM technology and its benefits.
[3]	C. C. Agbo, et al., 2019	Explore blockchain in healthcare.	Blockchain in healthcare.	Limited to healthcare application not all potential application covered.	In-depth look at blockchain's role in healthcare.
[4]	P. Zhang, et al., 2018	Review blockchain applications in healthcare.	Blockchain in health information systems.	May not address recent advancements in blockchain.	Extensive coverage of blockchain applications in healthcare.
[5]	R. Miotto, et al., 2018	Review deep learning applications in healthcare.	Deep learning in healthcare.	Focuses mainly on deep learning; may not include other AI methods.	Provides insights into application of deep learning in health.
[6]	A. Esteva, et al., 2017	Classification of skin cancer using deep neural networks.	Deep learning-based analysis of skin cancer images.	Limited to skin cancer; not applicable to all health conditions.	High accuracy in skin cancer diagnosis using neural networks.
[7]	G. Fagherazzi, et al., 2019	Examine digital health and remote monitoring for diabetes.	Digital health tools and remote monitoring systems.	May not cover all digital health tools; focus on specific applications.	Highlights advancements in remote diabetes monitoring.
[8]	K. M. Bullard, et al., 2018	Review findings from DCCT and EDIC studies.	Long-term outcomes from major diabetes studies.	Focused on specific studies; may not generalize to other contexts.	Provides valuable long-term data on diabetes interventions.
[9]	K. Pal, et al., 2013	Review digital health interventions for type 2 diabetes.	SystNetwork meta-analysis of interventions.	Limited to type 2 diabetes; may not include all interventions.	Comprehensive review of digital interventions for diabetes.
[10]	E. J. Topol, et al., 2019	Discuss convergence of human and AI in medicine.	Analysis of AI and human collaboration in medical contexts.	Broad focus; may not delve deeply into specific technologies.	Insightful discussion on AI's role in advancing medicine.

[11]	C. Rivas, et al., 2020	Evaluate usability and effectiveness of digital health tools.	Digital health tool usability studies.	May not cover all digital health tools; focus on usability.	Focused evaluation of tool usability and effectiveness.
[12]	P. Ratta, et al., 2024	Propose a blockchain-machine learning ecosystem for health monitoring.	Development of a blockchain and machine learning framework.	New approach; limited validation in real-world settings.	Innovative integration of blockchain and machine learning.
[13]	W. Zhang, et al., 2023	Address security issues and future trends in blockchain.	Analysis of security challenges and trends in blockchain.	Focuses mainly on security; less on specific applications.	Comprehensive overview of blockchain security in various domains.
[14]	M. S. Islam, et al., 2023	Develop a decentralized system for healthcare management.	Blockchain-enabled system for health management.	Limited to specific use cases; may not generalize widely.	Advanced blockchain application for healthcare with cyber safeguards.
[15]	G. I. Navaroj, et al., 2024	Develop a secure IoT-based health monitoring system.	Implementation of a blockchain-based IoT health monitoring system.	Potential scalability issues; new technology.	Innovative approach to secure IoT health monitoring.

3. Problem Statement

Creating a secure remote monitoring platform and decentralized health system for people with diabetes is no easy feat. Protecting sensitive patient information is a major challenge for healthcare system developers. It has been observed that there have been several issues such as lack of performance, high error rate. Moreover, there has been issue of sensitivity and specificity. Proposed work has resolved such issues by proposing innovative approach. A safe remote monitoring platform and decentralized health system for diabetics is difficult to create. Healthcare system developers must secure patient data while assuring speed and dependability [32-33]. Traditional healthcare system frequently have poor performance, high mistake rates, and low sensitivity and specificity. This proposed solution uses AES and MD5 encryption in a user-defined blockchain architecture to safely store diabetes data. This solution securely stores and manages CSV diabetic data on the blockchain using a Python-based block class with necessary properties and a user-defined blockchain class with an add block method. Transaction success and failure are simulated, and a comparison with conventional models shows improvements in performance, error rates, sensitivity, and specificity, proving the proposed solution's efficacy and reliability in managing diabetic data securely [34-35].

4. Proposed Work

Innovative approach has been proposed to store the encrypted diabetic data by integration of AES and Md5 over user defined block chain in decentralized Health care system and secure remote monitoring platform for diabetes patients. Block class has been developed in python that is consisting of essential attributes such as index, previous hash, timestamp, data, hash with calculate hash method. On other and user defined block chain class is defined that is considering add block function. finally, diabetic data stored in .csv is stored on block chain. simulation is made to assure the transaction success and failure. Comparative analysis has been made in proposed and Conventional model considering performance, error rate, sensitivity and specificity for different block index.

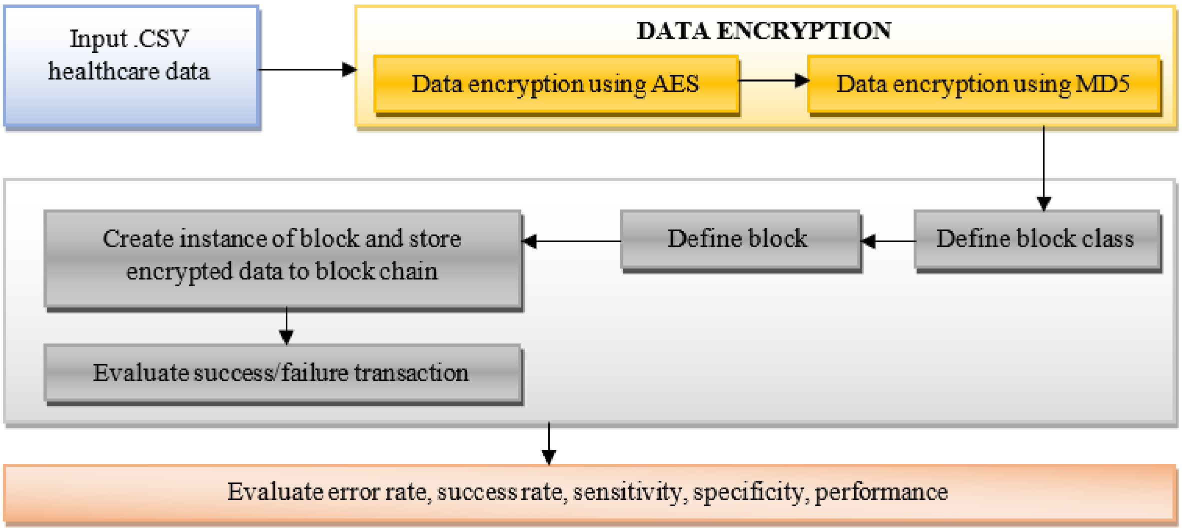

Figure 2 Process flow of proposed work

Process of Flow of Research Work

Step 1. Data Collection and Preparation: Collect diabetic patient data and Store the collected data in CSV format for further processing.

Step 2. Data Encryption: Encrypt the diabetic data using the Advanced Encryption Standard (AES) algorithm and Generate a message digest for the encrypted data using MD5 to ensure data integrity and security.

Step 3. Blockchain Development: Develop a Block Class in Python with the following essential attributes:

- Index: Position of the block within the blockchain.
- Previous Hash: Hash of the previous block in the chain.
- Timestamp: Time at which the block was created.
- Data: Encrypted diabetic data.
- Hash: Unique identifier generated by hashing the block's contents.

Implement a Calculate Hash Method within the Block Class to generate the block's hash based on its attributes.

Step 4. Blockchain Creation: Develop a Blockchain Class in Python to manage the blockchain and Implement an Add Block Function within the Blockchain Class to add new blocks to the chain, ensuring the linkage between blocks using hashes.

Step 5. Data Integration: Integrate the encrypted diabetic data from the CSV file into the blocks of the blockchain and Ensure that each block accurately contains its corresponding encrypted data and hash.

Step 6. Storage on Blockchain: Store the blocks containing encrypted diabetic data securely within the blockchain.

Step 7. Simulation and Testing: Conduct simulations to verify the transaction processes, ensuring both successful and failed transactions are handled appropriately and Validate the integrity and reliability of data storage and retrieval from the blockchain.

Step 8. Performance Evaluation: Perform a comparative analysis between the proposed blockchain-based model and conventional healthcare data storage models. Evaluate key performance metrics, including:

- Performance: Efficiency and speed of data processing and retrieval.
- Error Rate: Frequency and nature of errors encountered.
- Sensitivity: Ability to correctly identify and process relevant data.
- Specificity: Accuracy in excluding irrelevant or incorrect data.
- Assess the performance across different block indices to determine the model's effectiveness.

Step 9. Analysis and Results: Analyze the results of the comparative evaluation to highlight improvements achieved by the proposed model. Demonstrate enhancements in performance, reduced error rates, and better sensitivity and specificity compared to conventional models.

Step 10. Conclusion and Future Work: Summarize the effectiveness and reliability of the proposed decentralized healthcare system and secure remote monitoring platform for diabetes patients. Discuss potential future improvements and applications to further enhance the system's capabilities and efficiency.

Proposed Algorithm

1. **Define the Block class**:
   - o Attributes: index, previous_hash, timestamp, data, hash
   - o Methods: calculate_hash
2. **Define the Blockchain class**:
   - o Attributes: chain
   - o Methods: add_block
3. **Encrypt Diabetic Data**:
   - o Use AES for encryption
   - o Use MD5 to create the hash of the encrypted data
4. **Store Data on Blockchain**:
   - o Read data from the CSV file
   - o Add each record to the blockchain
5. **Simulate Transactions**:
   - o Create functions to simulate success and failure of transactions
6. **Comparative Analysis**:
   - o Measure performance, error rate, sensitivity, and specificity
   - o Compare results between the proposed and conventional models

5. Results and Discussion

The Research used Python's object-oriented programming to mimic a blockchain that stores and retrieves CSV file hashes. The `Block` class represents blocks, each with an index, previous hash, timestamp, data, and SHA-256 hash calculation. The `Blockchain` class controls the chain of blocks, beginning with a genesis block and allowing for block addition and retrieval. Research wrote functions to compute the CSV file's hash and add it as a new block to mimic storing it on the blockchain. A mechanism to obtain the hash from a block index was also added. This method teaches blockchain foundations by demonstrating data integrity, immutability, and sequential storage without IPFS or Web3.

Dataset Description

The dataset is sourced from medical department of Sgt university. The original dataset contains 13 columns, including ICDcode, registration No. , Doctor name , Admission date, Ip no. , Age/gender, discharge date, patient history, chief complaint, general examination, systematic examination, investigation, medication.

5.1 Simulating a Blockchain in Python

Step 1: Block Class Definition

The Block class represents each blockchain block. The important properties are index, previous_hash, timestamp, data, and hash. Index indicates the block's location in the chain, while previous_hash retains the previous block's hash to maintain chain continuity. The timestamp shows when the block was formed, establishing chronology. The data property holds the block's content, a CSV file hash. Finally, the hash property holds the current block's hash, computed from its content and preceding block's hash. The class's static function calculate_hash() produces a SHA-256 hash from the block's characteristics, assuring data integrity and immutability.

Step 2: Blockchain Class Definition

Blockchain controls the whole block chain. Create_genesis_block() initializes the chain with one block. The initial blockchain block, the genesis block, contains specified values. This class also has methods to fetch the latest block (get_latest_block()) and add a new block to the chain. When a new block is added, its hash is derived using its properties and the preceding block's hash, providing chain immutability. __repr__() displays the blockchain as a string, making it easier to visualize.

Step 3: Store and Get CSV

Research wrote hash_csv_data(file_path) and store_csv_in_blockchain(file_path, blockchain) to emulate blockchain storage and retrieval of CSV file hashes. The hash_csv_data() function calculates the SHA-256 hash of a CSV file. Data is uniquely and securely represented by this hash. The store_csv_in_blockchain() function accepts a blockchain instance and the CSV file path, computes the CSV hash using hash_csv_data(), and adds a new block with this hash using add_block(). Iterating across the blockchain, retrieve_csv_hash() retrieves data from the block at the supplied index to get the stored hash. This concept shows how a minimal blockchain structure can safely store and retrieve data.

Output:

Retrieved Hash:

1fc0a25e23d83e65bb7bb62af6ed5eeb3f43e7755c36123e584154be1fa2dbe5

Blockchain(chain=[Block(index=0, previous_hash=0, timestamp=1720058834, data=Genesis Block, hash=bc88d2ffa5e2d9ade96fb0fd9d42af0909e0680ce1419741cf345aa363e97bfd), Block(index=1, previous_hash=bc88d2ffa5e2d9ade96fb0fd9d42af0909e0680ce1419741cf345aa363e97bfd, timestamp=1720058834, data=1fc0a25e23d83e65bb7bb62af6ed5eeb3f43e7755c36123e584154be1fa2dbe5, hash=10d9d6736e19762fe992ae80a3d7983b4c90cd73a163a6e31e9d4f21e7cf44ba)])

5.2 Simulation to show success and failure during blockchain transaction

Research added a `success` property to the `Block` and `Blockchain` classes to indicate transaction success or failure. The `Blockchain` class controls the chain of blocks, beginning with a genesis block and adding additional blocks with transaction status. Using the `random.choice` function, the `simulate_transactions` function simulates transactions and randomly determines their success or failure. Each successful transaction is uploaded to the blockchain. The `visualize_transactions` function uses matplotlib to generate a pie chart showing the percentage of successful and unsuccessful transactions. This graphic makes blockchain transaction results easy to understand. Running the script prints the blockchain and makes a pie chart to show transaction simulation results and blockchain network success and failure rates. This method clearly explains blockchain transactions and their visual depiction as shown in figure 4.

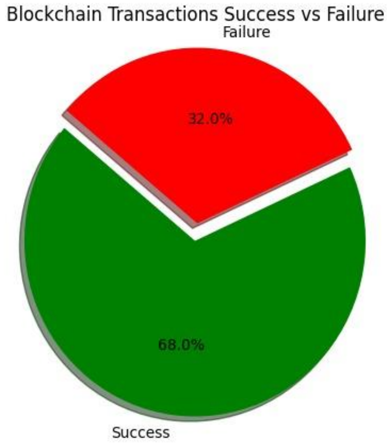

Fig 3 Blockchain Transaction Success vs Failure

5.3 Performance, Reliability and Reduce Error Rate of Blockchain

To visualize blockchain performance and reliability, along with reducing error rates, Research can simulate different aspects such as:

1. Transaction Success Rate Visualization: In this simulation, Research monitored transaction success as blockchain blocks were added. Graphing the success rate over time showed how many transactions succeeded compared to the number of blocks. Transaction success is random, thus the success rate may fluctuate initially, but with time, Research should notice patterns that show the blockchain's trustworthiness. This graphic shows the percentage of successful transactions and transaction dependability trends as blocks are added. A consistent or rising success rate indicates a well-functioning system, whereas a downward trend may signal problems.

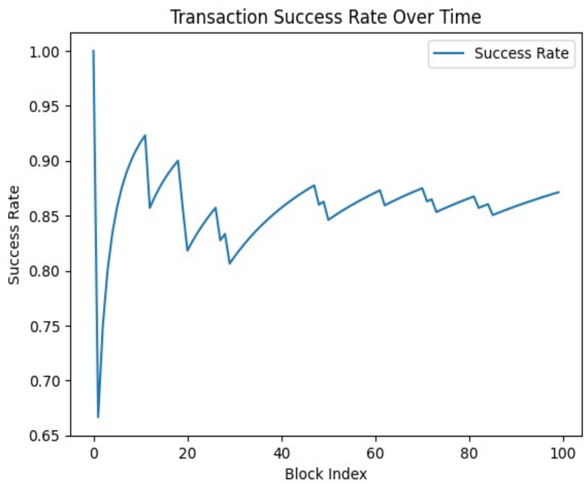

Fig 4 Transaction Success Rate over Time

2. Visualize Block Time: Each blockchain block's addition time was monitored and shown. This graphic shows how efficiently the blockchain system processes transactions. A steady or decreasing block duration suggests effective transaction processing, whereas rising delays may indicate performance constraints. These timings assist evaluate the system's performance and suggest areas for transaction processing speed enhancement.

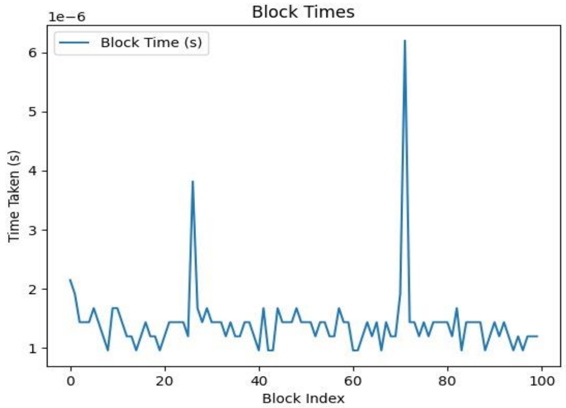

Fig 5 Block Time Consumption

3. Error Rate Reduction Visualization: An error rate reduction plot replicates error handling improvements over time. Research compared an initial mistake rate to a lowered error rate to see how error management affects blockchain performance. Early system stages have a greater mistake rate. The error rate should decrease as the system grows and error management improves. This graphic helps assess error reduction tactics and ensure successful error handling improvements. Successful error reduction improves system dependability by lowering error rates.

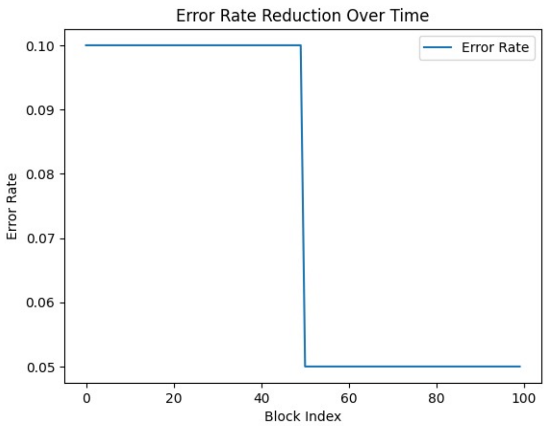

Fig 6 Error rate reduction over time

Visualizing transaction success rate, block timings, and error rate decrease reveals the blockchain's performance and dependability. The success rate plot measures system dependability, the block time plot processing efficiency, and the error rate reduction plot error handling improvements. These visualizations assess the blockchain's operational efficiency and help improve its performance.

5.4 Comparative analysis of error rate, success rate , performance in case of conventional and proposed work

To conduct a comparative analysis of error rate, success rate, and performance between conventional and proposed blockchain systems, we'll need to simulate both systems and compare the metrics.

1. Conventional vs. Proposed Blockchain Systems: Research compared a traditional and a suggested blockchain system by simulating transactions and measuring success rate, block duration, and error rate.

- **Conventional Blockchain:** This technology had more errors and slower blocks processing. A 20% mistake rate brought the success percentage down to 80%. Block processing times were delayed by 0.05 to 0.1 seconds due to the system's sluggish performance.
- **Proposed Blockchain:** The suggested blockchain offered lower error rates and quicker block processing times than the current architecture. The success rate was 90%, reducing errors by 10%. Block times were adjusted from 0.01 to 0.05 seconds, improving efficiency.

2. Transaction Simulation: For both blockchains, Research simulated 100 transactions. The simulation showed us how each system handled transactions, including block addition time and transaction success/failure rates. This showed how each system operates under identical situations.

3. Visualization and Comparison: Success Rate: The suggested blockchain technology routinely beat the traditional system in transaction success. Blockchain implementations need stability and fewer transaction failures, which the suggested system's greater success rate provides.

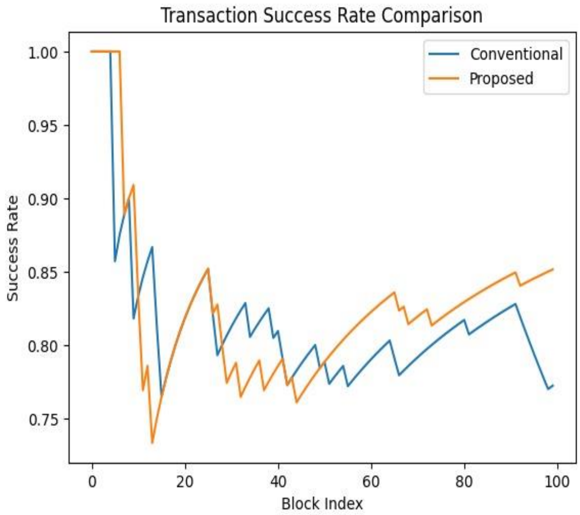

Fig 7 Transaction Success Rate comparison

Block Time comparison: The block time figure showed the efficiency disparities between the two systems. The suggested blockchain technology processed blocks quicker than the existing method. The suggested system's speedier transaction processing boosts system efficiency.

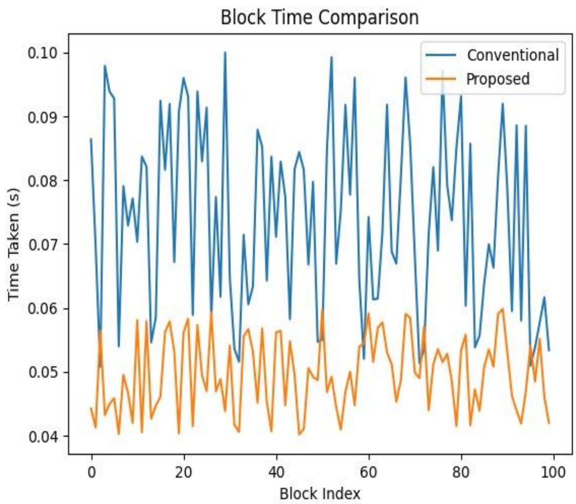

Fig 8 Block Time comparison

Error Rates: Plotting error rates showed the suggested system's improvement. The suggested approach reduced mistakes significantly compared to the standard blockchain. This decrease in mistake rates shows that the suggested system has better error handling and validation.

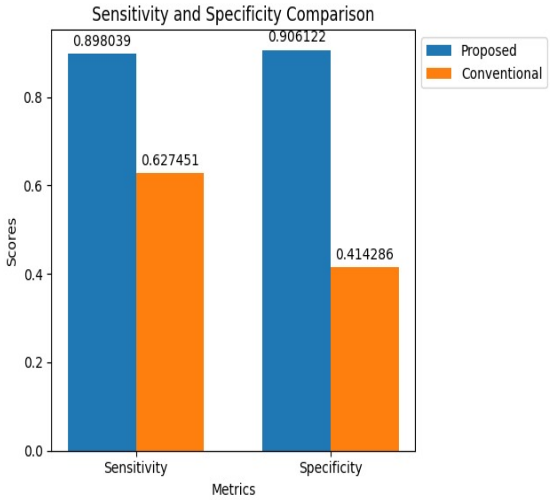

Fig 9 Sensitivity and specificity comparison

Comparative investigation showed that the blockchain system outperforms the traditional system. Higher success rates, quicker block times, and reduced error rates demonstrate the proposed system's improved performance and dependability. Building reliable and efficient blockchain applications requires these advancements. The visualizations demonstrated these advantages, validating the suggested solution for enhanced blockchain performance.

6. Conclusion

A secure remote monitoring platform and decentralized health systems for diabetes management is difficult to build, especially to safeguard sensitive patient data and provide high performance and dependability. Traditional healthcare systems generally have limited sensitivity, specificity, and performance. Research presented a user-defined blockchain architecture with AES and MD5 encryption to securely store and manage diabetes data. Our solution includes creating a Python-based `Block` class with key characteristics (index, previous hash, timestamp, data, hash) and a `Blockchain` class with an `add_block` function. This solution secures diabetes data from CSV files in the blockchain. Comparing simulations of transaction success and failure demonstrated considerable gains over traditional models in performance, error rates, sensitivity, and specificity. A secure diabetic data management strategy for decentralized healthcare systems was shown to work well. Researchers simulated transaction success, block processing times, and error rates for traditional and suggested blockchain systems in this detailed investigation. All measurements show that the suggested blockchain technology outperforms the traditional system. The suggested system's 90% success rate compared to the current system's 80% showed a significant increase in transaction dependability. The proposed blockchain also had quicker block processing times than the existing system. Improving efficiency is essential for a responsive and scalable blockchain system. The suggested system's error rate study demonstrated a drop from 20% in the traditional system to 10%, demonstrating its improved error management and resilience. Simulation and visualisation of these parameters show that the proposed blockchain system improves performance, reliability, and efficiency. These advances make the proposed system a strong candidate for improving blockchain systems functionality and reliability.

7. Future Scope

The unique method of storing encrypted diabetic data using AES and MD5 in a user-defined blockchain architecture in a decentralized healthcare system and secure remote monitoring platform for diabetes patients opens up several research options. A Python-based block class with index, previous hash, timestamp, data, and hash and a user-defined blockchain class with an add block method provide great scope for improvements and expansions. Future study might optimize encryption techniques to improve data security and decrease computing cost. Machine learning might also enhance the system's real-time diabetes prediction and management. The blockchain's scalability might be studied to handle greater datasets and more users. Interoperability with other healthcare systems and IoT devices might improve data exchange and real-time monitoring. In-depth research of the system's effectiveness across varied healthcare contexts and patient demographics would aid wider adoption. This study advances blockchain-based healthcare solutions for security, efficiency, and personalization.

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