**Blockchain Medical Record Tracker**

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**Abstract**

This project implements a basic blockchain system to securely record medical patient visits using Python and Jupyter Notebook. Inspired by research conducted during the term paper for CSCI 5858, the project demonstrates how blockchain technology can enhance healthcare data integrity, transparency, and security. Each patient visit is stored as a block in a blockchain, cryptographically linked through SHA-256 hashing. The project reinforces key concepts learned throughout the course, including blockchain structure, decentralized storage, and transaction verification.

**1. Introduction**

The rise of blockchain technology has transformed digital recordkeeping by introducing decentralized, tamper-resistant data management systems. In healthcare, maintaining secure and accurate patient records is critically important, yet increasingly challenging. Hospitals and healthcare systems operate 24 hours a day, 365 days a year, constantly generating and accessing sensitive patient information. This nonstop operation, combined with traditional reliance on centralized databases, makes healthcare institutions attractive targets for cyberattacks, ransomware, and unauthorized data breaches.

Traditional centralized medical record systems are vulnerable because a single point of failure can expose large volumes of sensitive information. Unauthorized changes to medical records can have life-threatening consequences for patients. Furthermore, regulatory frameworks such as HIPAA and GDPR demand strict control over patient data security and integrity.

Blockchain technology offers a promising solution through its core properties of decentralization, immutability, and cryptographic security. By distributing recordkeeping across a chain of linked, verifiable blocks, blockchain significantly reduces the risk of centralized breaches and data manipulation. Immutable ledgers can protect patient data even under high-load conditions where human error or technical faults are more likely.

This project, Blockchain Medical Record Tracker, was conceptualized following research completed in the term paper assignment for CSCI 5858. It applies fundamental blockchain mechanics to simulate secure, transparent, and tamper-resistant medical record storage. The project was developed individually, following the academic integrity guidelines outlined in the course syllabus, and demonstrates how foundational blockchain concepts can address critical challenges in modern healthcare environments.

**2. System Design**

The Blockchain Medical Record Tracker project simulates a simplified healthcare record management system using fundamental blockchain concepts and Python’s object-oriented programming features. The goal is to demonstrate how blockchain principles can be applied to securely store and link patient medical visits, ensuring data integrity and transparency.

**2.1 Block Class**

Each block in the chain includes:

* **Index**: The block’s position in the blockchain.
* **Timestamp**: The date and time when the block were created.
* **Data**: Patient visit information (e.g., name, visit reason, and visit date).
* **Previous Hash**: The cryptographic hash of the previous block in the chain, ensuring chronological linkage.
* **Current Hash**: The block’s own hash generated using the SHA-256 hashing algorithm from Python’s hashlib library.

The calculate\_hash() method concatenates these fields and computes a secure hash to uniquely identify the block. This cryptographic linking of blocks prevents unauthorized changes; if any block is altered, its hash will no longer match, immediately breaking the chain’s validity.

**2.2 Blockchain Class**

The Blockchain class maintains the chain of blocks:

* It initializes with a genesis block, serving as the foundational first record.
* New patients visit records are added as new blocks, automatically capturing their timestamp and previous block hash.
* The add\_block() method adds blocks sequentially while maintaining proper linkage.
* The is\_chain\_valid() method verifies the entire chain by re-computing hashes and checking consistency from the genesis block to the latest block.

This simple but critical validation mimics how real-world blockchains ensure historical transaction integrity.

**2.3 How This Design Reflects Real Blockchain Concepts**

This design demonstrates multiple core blockchain principles studied in CSCI 5858:

* **Blockchain Structure**: Every new record is chained to previous records through hashes, creating an immutable ledger.
* **Immutability Through Hashing**: SHA-256 ensures that even minor changes to data would result in a drastically different hash, immediately flagging tampering attempts.
* **Data Integrity and Transparency**: The system enables consistent auditing of patient visit history.
* **Chronological Recordkeeping**: Each patient visit is timestamped and linked sequentially, reflecting real-world blockchain transaction history.

While the system omits complex features such as distributed networking, consensus algorithms, mining processes, or smart contracts (which were discussed during later course topics such as Ethereum and DeFi), it captures the essential mechanics of blockchain technology: decentralization, immutability, and security.

This coding exercise aligns with the course’s learning outcomes, especially in mastering blockchain data structures, understanding transaction validation, and applying cryptographic principles in practical systems.

**3. Results**

Upon execution in Jupyter Notebook, the Blockchain Medical Record Tracker successfully simulated a secure, sequential record-keeping system for patient medical visits. The system produced the following key outcomes:

* A blockchain was successfully initialized with a genesis block, setting the foundation for future record additions.
* Three patient visit records were added sequentially, each automatically timestamped and cryptographically linked to the previous block through SHA-256 hashing.
* Each block accurately contained patient information, ensuring a clear chronological transaction history.
* The blockchain’s integrity was validated through a consistency check function, which verified that no data tampering occurred across the entire chain.
* The project demonstrated that even a simplified blockchain model could achieve core objectives of data security, transparency, and immutability.

The project emphasized practical application of blockchain mechanics in healthcare, showing how real-world medical institutions could potentially deploy blockchain-based systems to enhance patient record management. While the prototype operates in a single-system environment without distributed consensus or mining, it establishes a conceptual starting point for more complex, production-grade blockchain healthcare solutions.

The project code remains lightweight and easily modifiable, offering a foundational framework for students and developers seeking to deepen their exploration of blockchain's potential across industries.

**4. Conclusion**

Through the development of the Blockchain Medical Record Tracker, key learning outcomes from CSCI 5858: Blockchain and Cryptocurrency Technologies were successfully reinforced and applied in practice. The project provided hands-on experience with core blockchain concepts, such as:

* Ensuring data integrity through cryptographic hashing,
* Structuring sequentially linked transactions into an immutable ledger,
* Demonstrating decentralized trust without reliance on centralized servers.

Decentralization plays a critical role in improving healthcare record security. Traditional centralized medical record systems are vulnerable to attacks such as SQL injection, unauthorized access, and data breaches especially in high-traffic hospital environments operating 24/7/365. By decentralizing record storage into independently verifiable blocks, blockchain greatly reduces the risk of large-scale system failures and cyberattacks, ensuring that patient data remain secure and private even under intense operational demands.

This project illustrates how blockchain principles particularly immutability, transparency, and verifiable history can be leveraged to improve healthcare recordkeeping. By simulating a simplified medical record system, it becomes clear that blockchain technology holds significant promise in addressing the growing challenges of data security, accessibility, and interoperability within the healthcare sector.

Although limited in scope, this project represents a crucial starting point for applying blockchain technology to real-world problems. Future expansions could include implementing encryption layers for sensitive patient data, developing access control mechanisms (such as multi-authority permissions), integrating external data storage (IPFS or cloud hybrid systems), or simulating smart contract-based record management on blockchain platforms like Ethereum.

The project was developed individually, adhering to the academic integrity guidelines outlined in the course syllabus. The decision to use Jupyter Notebook was driven by its simplicity, flexibility, and ability to rapidly prototype blockchain concepts in a clean, interactive environment. Although the program itself is simple, it successfully captures the foundational mechanics of blockchain: decentralized structure, cryptographic integrity, and data validation. By independently building this working blockchain simulation, the project strengthened both theoretical understanding and practical coding skills essential for further exploration into blockchain applications across industries beyond cryptocurrencies.

**References**

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