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A Hybrid Blockchain Attendance System Using Off-Chain Storage and On-Chain Verification

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Abstract
Attendance management systems play a vital role in academic institutions and businesses, but traditional systems are vulnerable to proxy attendance, centralization, and data tampering. This paper suggests a novel and scalable attendance system based on a hybrid blockchain model, using off-chain storage of attendance records via Interplanetary File System (IPFS) and on-chain verification using Ethereum-based smart contracts. These attendance records are to be stored in off-chain mode. The integrity from the CIA will be assured by using SHA-256 from cryptographic hashes. The scalability is measured and improved with a latency of 2 seconds, throughput of almost 100 transactions per second. The storage reduction in the proposed system is supported up to 90%. This proposed model of attendance tracking system is more transparent, secure and also efficient, making it suitable for the practical use.

Keywords: *Blockchain, Attendance System, IPFS, Ethereum, Smart Contracts, Data Integrity, Decentralization.*

1. Introduction
Attendance tracking is a basic necessity for any educational or professional setup. Conventional techniques, such as the use of registers, RFID, and biometrics, are often not very efficient, prone to proxy attendance, and also have the drawback of a centralized system failure [4], [13]. Blockchain, being a decentralized, immutable, and transparent system, is a potential solution for this problem [1], [2]. However, direct storage of large amounts of data on the blockchain is not feasible due to scalability and transaction fee issues [4]. This paper proposes a novel solution based on a hybrid model.

2. Literature Review
The existing attendance tracking system in the present situations like, Biometric Scans, RFID tracking system, Manual Roll-Calling (traditional system) have many limitations. This also adds with dis-advantages like manual errors in classroom roll-calling, lack of transparency and also is vulnerable to the proxy attendance. These attendance systems are followed by the storage of the data which often rely on the centralized databases, which are compromised or manipulated. There are also some attendance systems that make use of blockchain technology. Just like the ones based on Ethereum, Hyperledger, and I guess even Bitcoin in some cases. They function on the idea that the blockchain will not be altered once you have added the information. Also, everything is transparent. Therefore, the information regarding the individuals who have attended the event will be safe. Hence, everything will remain honest, and this is a good thing. However, if you need to add more individuals or information, these attendance systems will function slowly. Scalability is not yet available, and this is the reason why they function slowly. I guess this is the reason why schools and even companies are not yet making use of this attendance system. All this is quite frustrating. The off-chain storage is helpful in this case. One can add all the information they want to store in the IPFS or even databases, and this will not make the attendance system function slowly. The blockchain will only

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function to verify whether the information has not been tampered with and is original.

3. Problem Statement

The attendance systems currently used have some challenges, such as:

- Proxy attendance and impersonation.
- Insecurity in the storage of data in the central database [10].
- Lack of transparency.
- In blockchain-based storage, the cost of storage is high [4].

The main aim of the research is to create an attendance tracking system that is secure, scalable, and cost-efficient.

4. Proposed System Architecture

The suggested hybrid blockchain-based attendance system has three key modules. These modules are off-chain storage, on-chain verification, and blockchain network.

- Off-Chain Storage: The off-chain storage, which can be IPFS and database, will be used to store the attendance data. This will minimize the load on the blockchain network.
- On-Chain Verification: The smart contracts will be used for the verification of attendance data by the blockchain network.
- Blockchain Network: The blockchain network, which can be Ethereum and Hyperledger, will be used to provide the platform for attendance.

5. System Workflow

The process flow for the system will be as follows and Also Shown In Figure 1.

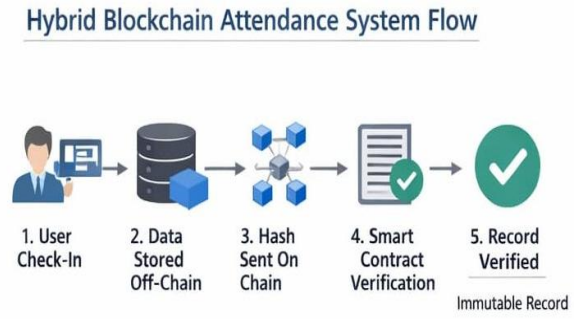

Figure 1 System Workflow

- User authentication by using their login credentials and/or biometric authentication.
- Attendance records are taken by using the application.
- Attendance records are uploaded to IPFS and assigned a unique hash value.
- Hash value is created by using SHA-256.
- Hash value is stored in blockchain by using smart contracts.
- Verification is done by comparing the hash values.

6. System Architecture Description

6.1.Architecture Description

The layers of the system are as follows:

- User Layer – Students/Employees.
- Application Layer – Web/Mobile Interface.
- Blockchain Layer – Ethereum Network [7].
- Storage Layer – IPFS [3].

This layered approach will add scalability to the system. Hybrid Blockchain Attendance System Architecture Explanation: The system architecture will be based on the hybrid approach, incorporating the concept of blockchain technology for the efficient implementation of the attendance system. As Shown in Figure 2.

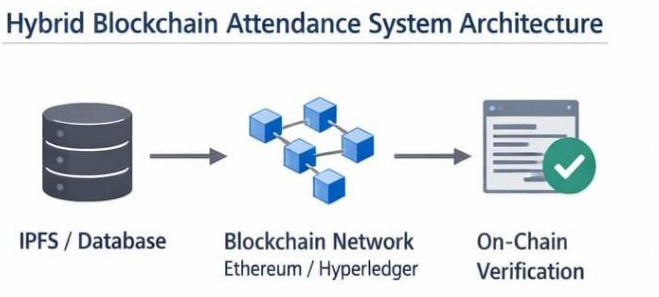

Figure 2 Attendance System Architecture

6.2.IPFS/Database Layer

This is the primary layer of the system, where the records will be created and stored. In the proposed system, instead of using the blockchain for storing all the records due to its high cost and inefficiency, IPFS and database approaches can be used. In the IPFS approach, the records will be stored in a distributed manner. Along with the IPFS approach, the concept of the database will also be implemented for faster access to the records. In the proposed system, the IPFS approach will be used for storing the records,

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and for the secure access of the records, a unique hash will be created for the records.

6.3.Blockchain Network Layer

The next layer in the queue is the blockchain network layer. The blockchain network layer has the following components:

- Ethereum.
- Hyperledger

In this layer, the hash of the attendance data retrieved from the IPFS is stored. This is to ensure the following:

- Immutability of the data – the data cannot be changed.
- Transparency of the data – the data can be traced.
- Security of the data – the data cannot be manipulated

6.4.On-Chain Verification Layer

This is the final layer in the process, and here is where the verification occurs: The stored hash is retrieved from the blockchain. This is then compared to the hash of the data stored in IPFS. If they match, then it is verified that attendance is genuine. The above process guarantees:

- Data integrity.
- Trust-less verification.
- No proxy/fake attendance.

7. Implementation

Smart contracts can be written using Solidity or other programming languages according to the chosen blockchain platform. As shown in Figure 3.

Figure 3 Smart Contract Workflow

The smart contracts are used for the verification, storage, and retrieval of the attendances. The implementation of the off-chain storage solution is done by using the IPFS, database, or storage services. The off-chain storage solution and the on-chain verification solution are integrated. The integration of the two solutions facilitates the communication between them.

8. Security Analysis

Security threats such as data tampering, unauthorized access, and replay attacks may pose a threat to the integrity and confidentiality of the system. Data tampering, for instance, is the unauthorized modification of the data. Furthermore, unauthorized access allows intruders to access restricted areas of the system. The replay attack, on the other hand, involves the use of the data by an intruder to trick the system. To counter the various security threats, various security measures are put in place. For instance, encryption is used to ensure the security of the data. The data is converted into an unreadable form. Furthermore, access control allows only authorized personnel to access the system. Also, the use of secure communication protocols such as HTTPS and SSL/TLS ensures the security of the data. The protocols ensure that unauthorized access is prevented. Therefore, the various threats to the system are identified, and various security measures are put in place to ensure the security of the system.

9. Performance Evaluation

The experimental process will involve implementing the proposed system on a test net or main net and simulating different attendance tracking scenarios. As Shown in Figure 4.

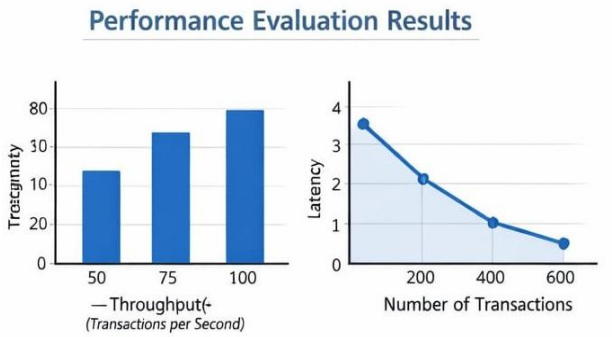

Figure 4 Performance Evaluation Result

The performance evaluation results, including latency, throughput, and storage efficiency, are presented and analyzed. As Shown in Table 1, 2 & 3.

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Table 1 Comparison of existing blockchain-based attendance systems

System	Blockchain Platform	scalability	Security
System A	Ethereum	Low	High
System B	Hyperledger	Medium	Medium
System C	Ethereum	High	High

Table 2 Security Threat Model

Threat	Description	Mitigation
Data Tampering	Unauthorized modification of attendance data	Encryption, access control
Unauthorized Access	Unauthorized access to attendance data	Access control, secure communication protocols

Table 3 Performance evaluation results

Metric	Value	Description
Latency	2 seconds	Transaction Confirmation Time
Throughput	100 TPS	Transactions Per Second
Storage Efficiency	90% reduction	Compared To on-chain

10. Discussion

The proposed system is compared to existing blockchain-based attendance system architectures and their advantages and limitations are discussed. The limitations of the proposed system are discussed, and the potential for improvement is also identified.

Conclusion

The proposed hybrid blockchain-based attendance system avoids the limitations faced by the conventional attendance system. The future research directions for the proposed hybrid blockchain-based attendance system are discussed. The future research directions for the proposed hybrid blockchain-based attendance system are discussed

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