

CHAPTER V

CONCLUSION AND RECOMMENDATIONS

5.1. Conclusion

Based on the design, implementation, and evaluation results, this research on a blockchain-based digital diploma verification system using smart contracts, the InterPlanetary File System (IPFS), and the Ethereum Sepolia network has led to the following conclusions:

1. This research successfully designed and implemented a web-based digital diploma verification system using a hybrid architecture that integrates the Ethereum blockchain, the InterPlanetary File System (IPFS), and MongoDB as an off-chain database. The system supports issuer authentication using Sign-In with Ethereum (SIWE), student data management, data confirmation, digital diploma issuance, amendment, reissue, verification code generation, and integrated document and identity verification.
2. This research successfully designed and implemented a smart contract on the Ethereum Sepolia network to support immutable recording and verification of digital diploma metadata. Metadata, including the document hash and IPFS CID, are recorded on the blockchain and utilized during both off-chain and on-chain validation processes. In addition, the system is capable of detecting metadata inconsistencies when database manipulation is simulated through the implemented verification audit mechanism.
3. Based on the evaluation results using the Grey Box Testing method, the proposed system successfully performed all primary functions according to the predefined testing scenarios. These functions include user authentication, student data management, digital diploma issuance, student diploma access, amendment and reissue processes, verification code generation and management, document and identity verification, and verification log recording. The evaluation results demonstrate that the integration of MongoDB, IPFS, and the Ethereum Sepolia blockchain operates consistently while maintaining the integrity, authenticity, and traceability of digital diplomas, thereby supporting both the conceptual and technical feasibility of the proposed digital diploma verification system.

5.2. Recommendations

Based on the implementation and evaluation results, several recommendations are proposed for future research and system development, as follow:

1. The system may be further developed by deploying it on a blockchain mainnet so that the digital diploma issuance and verification processes can be implemented in a real production environment rather than being limited to the Ethereum Sepolia test network.
2. The metadata auditing mechanism may be further enhanced to support historical tracking of data modifications and to detect relationships among metadata that have been directly modified within the off-chain database, thereby enabling a more comprehensive data integrity audit process.
3. Future research may extend the scope of academic information managed by the system, such as study records or other supporting academic information, while considering data integration complexity and maintaining efficient blockchain storage.