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Implementation of Blockchain for Integrated Civil Service Statistical Data (Case Study: Civil Service and Human Resource Development Agency of Madiun Regency, East Java Province)

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ABSTRACT

Digital transformation in personnel data management requires a transparent, secure, and integrated system to support data-driven decision-making and enhance accountability in civil service operations. An integrated information system and reliable personnel statistical data are essential to assist decision-makers in analyzing staffing needs and formulating more accurate and efficient data-based policies. This is also in line with the principles of good governance through improved transparency and accountability. The Personnel and Human Resource Development Agency (BKPSDM) of Madiun Regency, East Java, requires a technology capable of managing personnel information effectively while ensuring security, transparency, and data integrity through a decentralized mechanism. Blockchain, as a distributed ledger technology, offers an innovative solution for maintaining data authenticity and increasing public trust by recording permanent, encrypted, and validated transactions within a decentralized network. Despite its potential to support real-time audit trails and interactive data visualization, the implementation of blockchain in the management of personnel statistical data remains limited. This study aims to design and implement an integrated personnel information system framework that combines a relational database with smart contracts on the Ethereum network. Statistical data is retrieved from the database, hashed using the SHA-256 cryptographic algorithm, and the resulting hash is stored in a smart contract as proof of authenticity and to prevent data tampering. The research method follows a software engineering approach, including system architecture design, data processing, cryptographic hashing, smart contract deployment, and real-time validation through hash comparison. Data is then presented using web-based interactive visualizations to support efficient analysis. The implemented framework successfully improved transparency, accountability, and trust in personnel statistical data, thereby supporting more accurate and efficient strategic decision-making within the local government environment. Evaluation results show that the integration of blockchain technology in this system provides an immutable audit trail and enables independent data verification without relying on third parties, ultimately reinforcing good governance practices.

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1. INTRODUCTION

Digital transformation in the government sector has become an urgent necessity to improve the quality of public services, including personnel data management. Personnel data not only serves as an administrative archive but also provides a critical foundation for strategic decision-making that impacts the development of human resources within the civil service. Therefore, personnel information systems are required to deliver accurate, up-to-date, and easily accessible data to support data-driven policymaking [1].

The need for transparent, secure, and integrated systems has become increasingly urgent, in line with rising demands for accountability and the implementation of good governance principles [2]. The interactive presentation of personnel statistical data through accurate visualizations is crucial for assisting agency leaders in analyzing staffing needs, planning career paths, and objectively evaluating performance [3]. Moreover, integrated personnel information systems play a vital role in minimizing the risk of data manipulation that could be detrimental to both the institution and its employees [4].

Recent studies have highlighted the potential of integrating public blockchains, such as Ethereum, with traditional databases to ensure data integrity, transparency, and auditability. Several works have proposed hybrid architectures where data hashes are recorded on the blockchain while large datasets remain stored in SQL databases [5], [6]. Other research has demonstrated mechanisms for storing data hashes from databases or cloud services on the blockchain as proof of data authenticity [7], [8]. In domains such as supply chain and the Internet of Things, physical devices have been integrated with smart contracts on Ethereum to verify the status of goods and sensors [9], [10]. In healthcare, a number of studies have proposed frameworks enabling patients to share data while preserving privacy, recording data access on the blockchain, and storing medical records in hospital databases [11], [12]. Furthermore, technical challenges such as scalability, privacy, and interoperability have been discussed in the context of blockchain-database integration [13], [14]. Collectively, these studies suggest that combining relational databases with smart contracts on Ethereum can offer innovative solutions for data auditing, provenance tracking, and access rights automation, though further research is needed to address legacy system compatibility and performance constraints.

This study focuses on Madiun Regency, located in East Java, Indonesia, which has demonstrated strong commitment to improving public service quality through digital transformation. However, the region continues to face challenges in ensuring the integrity, traceability, and accountability of personnel statistical data, which is currently managed using conventional databases prone to manipulation and lacking verification mechanisms. In addition, the diversity of data sources, frequent updates, and the absence of standardized audit trails present significant barriers to accurate and timely analysis, particularly for leadership-level decision-making.

The main objective of this study is to design and implement a blockchain-integrated framework for managing personnel statistical data by combining a relational database with smart contracts on the Ethereum platform. The framework aims to enhance data integrity, ensure traceability through cryptographic hashing, and provide transparent, verifiable audit trails without disrupting existing data workflows. Ultimately, the proposed system seeks to strengthen governance, reduce the risk of data fraud, and support strategic decision-making with reliable, real-time personnel insights.

This research proposes a framework for integrating relational databases with smart contracts on the Ethereum network by recording hashes of statistical data in the smart contract as proof of authenticity. The implementation process includes data retrieval, hash generation and storage in the smart contract, and visualization of results through interactive graphical dashboards.

The main contributions of this paper include:

- the design of an integrated system architecture combining relational databases and blockchain for personnel data,
- the development of a data authenticity verification mechanism through smart contracts,
- the provision of interactive visualizations of personnel statistical data to support data-driven decision-making with higher levels of transparency and accuracy.

2. METHOD

The research methodology was systematically designed to support the implementation of blockchain in the management of personnel statistical data, referencing prior studies on the integration of blockchain and relational databases. The research stages include a literature review, system architecture design, smart contract development, integration of the relational database with smart contracts on the Ethereum network, development of an interactive visualization module, and comprehensive system testing. Each stage is structured and described as follows:

2.1. Literature Review

The literature review stage was conducted to identify and analyze previous research relevant to the application of blockchain technology in personnel information systems, particularly those integrating relational databases with smart contracts. This study encompassed a review of scientific articles, white papers, and technical standards related to Ethereum blockchain architecture, smart contract mechanisms, and methods for visualizing personnel statistical data. The literature analysis aimed to gain a comprehensive understanding of the challenges, opportunities, and best practices in implementing blockchain technology to support transparency, integrity, and accountability of data within government environments. The results of the literature review were used as the foundation for designing the system architecture and determining the technical specifications for the development of modules in this research.

2.2. System Architecture Design

The system architecture design focuses on integrating blockchain technology with a relational database to support secure, transparent, and reliable management of personnel statistical data. The architecture consists of four main components that interact with each other, as illustrated in **Figure 1**, which provides a comprehensive overview of the data flow and system integration.

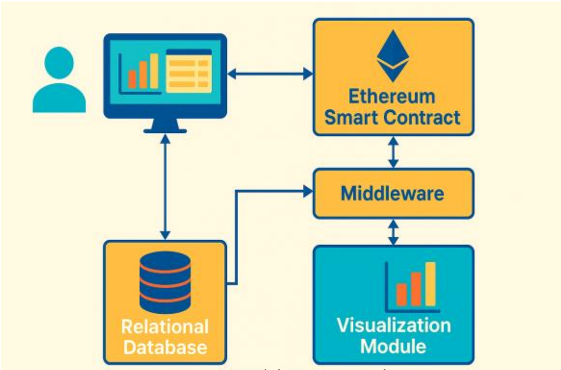

Figure 1. Architecture Diagram

First, the Relational Database (using MariaDB or MySQL) serves as the primary storage for all personnel data, providing efficient support for CRUD (Create, Read, Update, Delete) operations. Second, the Ethereum Smart Contract is used to record the hash of personnel statistical data as proof of authenticity, ensuring data integrity. Third, the Middleware is a software module that acts as an intermediary between the relational database and the Ethereum smart contract. The middleware is responsible for retrieving data hashes from the database, sending them to the blockchain, and performing data verification to detect potential changes or manipulation. Fourth, the Visualization Module displays personnel data interactively in the form of charts, tables, or diagrams through a web-based interface, enabling users to analyze personnel data in depth.

The system interaction flow begins with the user accessing the web application and requesting data through the visualization module. The visualization module retrieves data from the relational database, then the middleware processes and sends the data hash to the Ethereum smart contract for recording and verification. The verified data is subsequently presented back to the user via the visualization module. All interactions among these components are clearly documented in the architecture diagram, providing a comprehensive overview of the data flow and system integration.

2.3. Personnel Data Collection

Personnel data collection was conducted as the initial stage of this research to provide a valid, accurate, and representative database that supports the design, development, and testing processes of the integrated blockchain-based personnel data management system. The collected data included essential information on employees within the Personnel and Human Resource Development Agency (BKPSDM) of the Government of Madiun Regency, such as employee identification, positions, organizational units, rank history, and other statistical data necessary for comprehensive personnel analysis. Data sources were obtained from digital archives, official documents, and existing personnel information systems implemented at the BKPSDM of Madiun Regency, with each collected data item verified for legality and authenticity.

The data collection process was carried out in adherence to security standards and personal data protection, applying multi-layered validation procedures to minimize the risk of recording errors. The personnel data collected were then processed into a structured format and imported into the relational database, which served as the foundation for the design, development, and testing stages of the proposed system.

To support data analysis and the presentation of personnel information in a more informative manner, a statistical data visualization module was designed based on various relevant data categories. The visualization design is structured and presented in **Table 1**, which provides a detailed overview of the data types and corresponding visualization methods used to enhance interpretation and support decision-making.

Table 1. Design of Civil Service Statistical Data Visualization

No	Data Category	Type of Visualization	Visualization Objective
1	Distribution of employees per unit	Horizontal bar chart	To display the number of employees in each unit comparatively.

2	Employee composition by position	Pie chart	To show the proportion of employees in each position.
3	Employee composition by rank/grade	Pie chart	To show the proportion of employees in each rank or grade.
4	Employee age distribution	Histogram	To map the age distribution of employees to support demographic analysis.
5	Employee composition by religion	Vertical bar chart	To visualize the distribution of employees based on religion.
6	Employee composition by gender	Vertical bar chart	To visualize the distribution of employees based on gender.

2.4. Statistical Data Processing

Statistical data processing is carried out to convert the collected personnel data into structured aggregate information ready to be recorded on the blockchain. This stage includes data aggregation, transformation, compilation of aggregate data, and preparation for recording into the Ethereum smart contract. This process is essential to ensure that personnel data can be presented in a concise and uniform format while maintaining data integrity within the blockchain-based system. A detailed design of the personnel statistical data processing stages is presented in **Table 2**, which illustrates the workflow from data acquisition to preparation for blockchain recording.

Table 2. Personnel Statistical Data Processing Stages

No	Stage	Description
1	Data Aggregation	Grouping personnel data based on specific categories (e.g., organizational unit, rank, etc.).
2	Data Transformation	Converting data formats to ensure uniformity and compatibility with the visualization and blockchain modules.
3	Aggregate Data Compilation	Compiling the aggregated results into structured statistical tables.
4	Data Validation	Checking the consistency and accuracy of the aggregate data before recording it on the blockchain.
5	Data Preparation for Blockchain	Preparing the aggregate data hash to be recorded in the smart contract on the Ethereum network.

2.5. Smart Contract Development

The smart contract development process began with a requirements analysis to define the structure of data to be recorded, access permissions, and integration with the relational database. Based on this, the contract was designed with appropriate variables, functions, and access modifiers to ensure secure interactions. Implementation was carried out in Solidity, followed by middleware integration to enable hash generation from aggregated personnel records and store them on the blockchain. Compilation and unit testing ensured logical correctness and system stability. The contract was then deployed on a private Ethereum network, with end-to-end validation confirming workflow reliability—from data retrieval and hashing to secure presentation in the visualization module. Table 3 summarizes each development stage, encompassing design, coding, testing, deployment, and integration phases that collectively ensure data authenticity and auditability.

Table 3. Specific Stages of Smart Contract Development

Stage	Description
Requirements Analysis	Define the data to be recorded, access rights, and integration needs.
Structure Design	Design variables, functions, and access controls for the smart contract.
Coding	Implement the smart contract design using the Solidity programming language.
Middleware Integration	Develop a middleware module to connect the relational database and the smart contract.
Compilation & Initial Testing	Test basic functions on the private network to detect initial errors.
Comprehensive Testing	Ensure correct function execution, maintained authorization, and accurate data recording.
Deployment	Deploy the smart contract to the private Ethereum network.
End-to-End Validation	Evaluate the entire system workflow from the database to the visualization module.

Table 3 outlines the key stages of smart contract development within the integrated personnel data system, ensuring functional reliability, data integrity, and support for digital audit trails to enhance transparency and accountability.

2.6. Database and Smart Contract Integration

The integration of the relational database with the smart contract is a key stage in bridging the storage of personnel data in the relational database with blockchain-based audit trails. This integration enables automatic data synchronization and supports real-time verification of data authenticity.

A middleware module was developed as an intermediary component with two main functions:

- Retrieving aggregated personnel data from the relational database, generating data hashes, and sending these hashes to the smart contract on the private Ethereum network for recording.
- Receiving the recording results or verification status from the smart contract, then updating the data integrity status in the relational database.

Communication between the middleware and the smart contract uses a secure protocol-based Application Programming Interface (API), supported by encryption mechanisms to protect data during transmission. This approach ensures that personnel data stored in the relational database remains private, while its authenticity can be proven through hash records on the blockchain.

Comprehensive integration testing was conducted to ensure that the synchronization flow operated without errors, hash data was recorded consistently, and the integrity status in the database was updated in a timely manner. The results demonstrate that the system is capable of supporting the transparency and accountability required for personnel data management, in line with audit standards in government institutions. The structure and integration mechanism between the database and smart contract underlying this testing are illustrated in **Figure 2**.

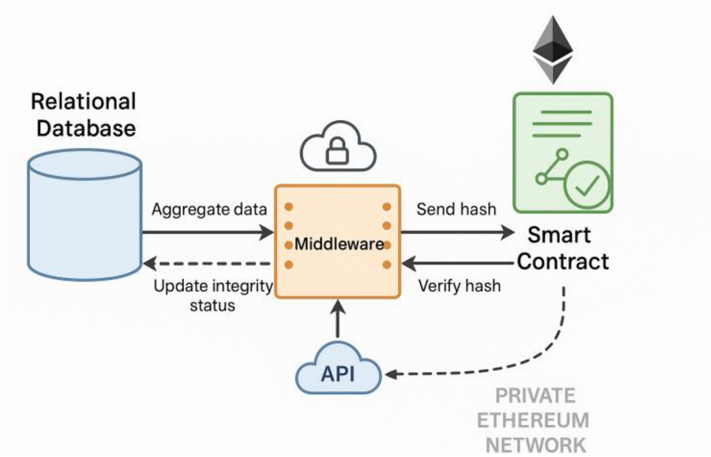

Figure 2. Database and Smart Contract Integration Diagram

2.7. Data Visualization Module Development

The development of the data visualization module aims to present personnel statistical data in an interactive, informative, and user-friendly manner through a web-based interface. This module is designed by integrating personnel data stored in the relational database with authenticity verification results recorded in the smart contract on a private Ethereum network. As a result, every piece of data displayed in the visualization module is guaranteed to be authentic, thereby supporting information transparency for end users. The structure and workflow of this visualization module are illustrated in **Figure 3**.

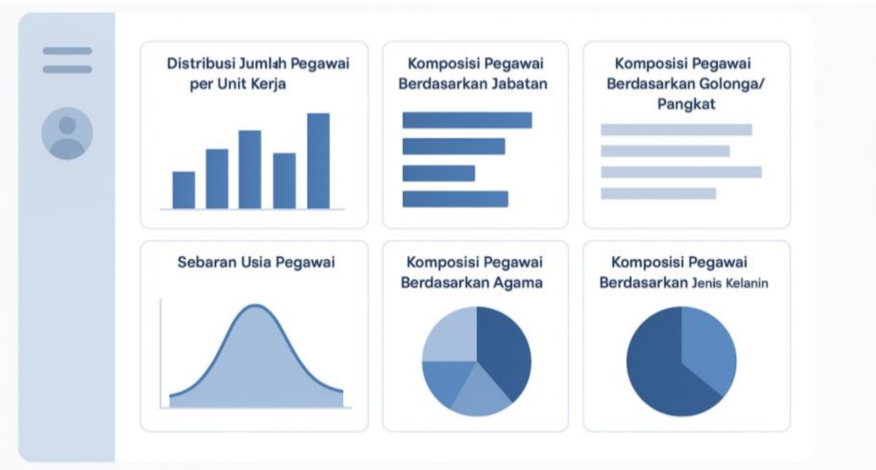

Figure 3. Data Visualization Module

This module displays various forms of visualizations, including bar charts, line charts, pie charts, and interactive tables, designed to support in-depth personnel data analysis. The information presented in the module includes the distribution of employees by organizational unit, employee composition by position, composition by rank or grade, employee age distribution, composition by religion, and composition by gender. The visualization module is equipped with interactive features that allow users to customize the data display according to their analytical needs. The presence of this module is expected to provide a comprehensive overview of the personnel data conditions, supporting transparent, accurate, and accountable monitoring, analysis, and data-driven decision-making.

2.8. System Testing

System testing was carried out to ensure that the integration between the relational database and the smart contract on the private Ethereum network functioned as designed. Functional testing aimed to evaluate the consistency between the hash values recorded in the smart contract and the generated aggregate data, the stability of the middleware in synchronizing data, and the accuracy of the data visualization module. Performance testing focused on measuring the average response time for data retrieval, hash submission, and visualization rendering, in order to ensure that the system supports real-time access, detects potential data manipulation, and provides a verifiable audit trail. The testing results demonstrated that the system successfully maintains the integrity and authenticity of personnel data with responsive and reliable performance. A detailed overview of the testing stages and parameters is presented in **Table 4**.

Table 4. System Testing Results of Database Integration with Smart Contract on Private Ethereum Network

No	Tested Aspect	Test Results	Scientific Conclusion
1	Hash Consistency	Hashes in the smart contract are identical to those in the database	Data authenticity is preserved, supporting the audit trail.
2	Middleware Stability	No synchronization failures occurred	Middleware operates stably, supporting data synchronization.
3	Visualization Accuracy	Visualization data is consistent with the database	Visualization is valid, supporting personnel analysis.
4	Data Retrieval Time	Average 1.2 seconds	Responsive process, supporting real-time access.
5	Hash Submission Time	Average 2.1 seconds	Blockchain recording is efficient.
6	Data Presentation Time	Average 1.5 seconds	Data visualization appears quickly and accurately.

2.9. Results Analysis

The analysis results indicate that the integration between the relational database and smart contracts on a private Ethereum network successfully maintains the integrity and authenticity of personnel data. Testing results confirmed that the recorded hash values were consistent with the data in the database, the middleware operated stably during synchronization, and the visualization was rendered accurately. The recorded average processing time of under 2 seconds demonstrates that the system is capable of supporting real-time data access. Furthermore, the use of a private network resulted in zero transaction costs, supporting the system's efficiency and feasibility for implementation in government institutions. A summary of the performance testing and overall system analysis is presented in **Table 5**, which highlights the system's consistency and stability under the tested scenarios.

Table 5. Summary of System Results Analysis

Aspect	Key Findings	Conclusion
Data Integrity	Data hashes matched the database	Data is authentic and verifiable
Middleware	Synchronization operated stably	Supports a reliable data workflow
Visualization	Data displayed accurately and consistently	Visualization is valid for personnel analysis
Performance	Average processing time < 2 seconds	Responsive system supports real-time access
Transaction Cost	Zero (private Ethereum network)	Efficient implementation without operational costs

3. RESULTS AND DISCUSSION

System testing demonstrated that the integration of a relational database with a smart contract on a private Ethereum network effectively preserved the authenticity and integrity of personnel data. The hash values recorded on the blockchain were consistent with those generated from the source database, indicating that no data tampering occurred. This is supported by the Smart Contract Transaction Log – ASN Rank Summary (**Tabel 6**), which captures timestamped transactions and verified data segments as immutable audit records.

Table 6. Smart Contract Transaction Log – ASN Rank Summary

Timestamp	Tx Hash	Sender	Data Type
2025-07-26 04:36:00	0x4afe518a38353	0x17bc5b9e10f58	Hash: ASN Rank I
2025-07-26 04:37:00	0xe6cd988ec3694	0x332a5598cacec	Hash: ASN Rank I/c
2025-07-26 04:38:00	0x21a119ad2f7a7f	0x15465b4f31281	Hash: ASN Rank I/d
2025-07-26 04:39:00	0x1f3fe9384ae1fe	0x186e4dc66002d	Hash: ASN Rank II/a
2025-07-26 04:40:00	0xfd7e3ad7f9a36	0x27e4b75bf7df4	Hash: ASN Rank II/b
2025-07-26 04:41:00	0xd92d6a3efb9ca	0x3c74ed52ba6ef	Hash: ASN Rank II/c
2025-07-26 04:42:00	0x734eb10ec6d28	0x11a91cbfa3c47	Hash: ASN Rank II/d
2025-07-26 04:43:00	0xaccf9a4e7f2a0	0x29fc738ab97d1	Hash: ASN Rank III/a
2025-07-26 04:44:00	0x3fdc4a7b8b58b	0x7e539c24c9a60	Hash: ASN Rank III/b
2025-07-26 04:45:00	0x9c15b2fc39e76	0x4f12a9d02d879	Hash: ASN Rank III/c
2025-07-26 04:46:00	0xb2d64e0b913a5	0x6a4dc8db34962	Hash: ASN Rank III/d
2025-07-26 04:47:00	0xef73cd8a46210	0x58b7e1c6ae221	Hash: ASN Rank IV/a
2025-07-26 04:48:00	0x6d3f28e91b0f7	0x33af1e7cd9814	Hash: ASN Rank IV/b
2025-07-26 04:49:00	0x7bc9d21e73a88	0x2a5c183fb54e6	Hash: ASN Rank IV/c
2025-07-26 04:50:00	0xf7de43ab67933	0x43b9a7f29b107	Hash: ASN Rank IV/d
2025-07-26 04:51:00	0x6e94cfc6dcbe0	0x2f51bd0ec8599	Hash: ASN Rank IV/e
2025-07-26 04:52:00	0x3e7a0f9d83b1e	0x7a9be27fa19d3	Hash: ASN Rank V
2025-07-26 04:53:00	0x80da7c594cc29	0x40bd173eb8a9d	Hash: ASN Rank VII
2025-07-26 04:54:00	0x9be10a72e3428	0x6b28746f1cd32	Hash: ASN Rank IX
2025-07-26 04:55:00	0xaa14de7cc58e5	0x53f6d9c73e754	Hash: ASN Rank X

The middleware component ensured stable synchronization between system layers, enabling seamless hash generation and submission to the smart contract. The visualization module accurately rendered the validated personnel data, as shown in **Figure 4** (Number of Employees by Rank). The highest concentrations of ASN were observed in ranks IX, III/b, and III/d, aligning with the original database and confirming data integrity through blockchain-based hash verification.

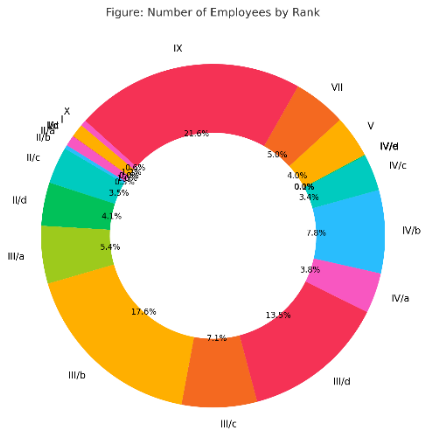

Figure 4. Number of Employees by Rank

Performance testing confirmed that the system meets real-time operational requirements, with an average data retrieval time of 1.2 seconds, hash submission time of 2.1 seconds, and visualization rendering time of 1.5 seconds. Furthermore, operating on a private Ethereum network eliminates transaction fees, making the solution cost-effective and suitable for adoption in public sector environments.

Table 7 summarizes the key outcomes, demonstrating that the proposed system successfully enhances transparency, accountability, and data reliability in the management of government personnel records.

Table 7. Summary of System Results and Discussion

Metric	Result
Data Consistency	All hashes matched (0 inconsistencies)
Synchronization	Stable across modules
Visualization Accuracy	Verified personnel data displayed
Data Retrieval Time	1.2 seconds
Hash Transmission Time	2.1 seconds
Visualization Time	1.5 seconds

Transaction Fees	None (private Ethereum)
Auditability	Available via smart contract logs

4. CONCLUSION

This research successfully developed an integrated blockchain-based personnel statistical data management system, using a case study at the Personnel and Human Resource Development Agency (BKPSDM) of the Government of Madiun Regency, East Java Province. The integration of the relational database with the smart contract on the private Ethereum network enabled accurate and consistent recording of aggregate data hashes, preserving the authenticity and integrity of personnel data.

The testing results showed that the recorded data hashes matched the database data, the middleware operated stably supporting reliable synchronization, and the visualization module displayed accurate data, with average processing times below 2 seconds, enabling real-time data access. Zero transaction costs on the private network ensured efficient implementation in government institutions. Overall, the developed system effectively improves transparency, accountability, and reliability in managing personnel statistical data, and supports the implementation of a blockchain-based digital audit trail that meets the personnel management needs of BKPSDM Madiun Regency.

REFERENSI

[1] Westerman, G., Bonnet, D., & Ferraris, P. (2014). The Digital Advantage: How Digital Leaders Outperform Their Peers in Every Industry. MIT Sloan Management Review.
[2] Li, J., & lainnya. (2019). Block-sync: A lightweight consensus algorithm for blockchain database integration. Future Generation Computer Systems, 100, 531–540.
[3] Zhang, S., Zheng, X., & Chen, J. (2018). ChainSQL: A blockchain database application platform. IEEE Access, 6, 14191–14204.
[4] Zyskind, G., Nathan, O., & Pentland, A. (2015). Enigma: A blockchain-based approach to data accountability and provenance tracking. In Proceedings of the 2015 IEEE Conference on Security and Privacy in Communication Networks (SecureComm) (pp. 1–6).
[5] Fan, K., Jiang, W., Li, H., Yang, Y., & Shen, J. (2020). Secure and scalable data sharing of electronic health records using permissioned blockchain and off-chain storage. IEEE Transactions on Industrial Informatics, 16(3), 2031–2039.
[6] Lu, Y. (2019). Design of a secure supply chain system based on blockchain and RFID technology. IEEE Access, 7, 36612–36622.
[7] Casino, F., Dasaklis, T. K., & Patsakis, C. (2020). A survey on blockchain-based systems and their integration with cloud computing and database systems. ACM Computing Surveys, 53(4), 1–34.
[8] Liang, X., Zhao, J., Shetty, S., Liu, J., & Li, D. (2018). Blockchain-oriented dynamic data management framework for health data analytics. IEEE Transactions on Network Science and Engineering, 7(3), 2211–2222.
[9] Yaqoob, I., Salah, K., Jayaraman, R., & Al-Hammadi, Y. (2021). Blockchain for data integrity in Internet of Things applications: A review. IEEE Communications Surveys & Tutorials, 23(1), 524–552.
[10] Kuo, T. T., & Ohno-Machado, L. (2019). Towards hybrid blockchain database systems: Design and implementation challenges. Blockchain in Healthcare Today, 2, 1–9.
[11] Shen, M., Deng, Y., Zhu, L., Du, X., & Guizani, M. (2019). A data storage model based on blockchain and cloud storage. IEEE Access, 7, 70816–70826.
[12] Gartner. (2022). Market Guide for Digital Transformation in Government. Gartner Research.
[13] Narayanan, A., Bonneau, J., Felten, E., et al. (2016). Bitcoin and Cryptocurrency Technologies. Princeton University Press.
[14] Eubanks, V. (2018). Automating Inequality: How High-Tech Tools Profile, Police, and Punish the Poor. St. Martin's Press.
[15] Yulianto, B., Kartika, A., & Rahmawati, F. (2020). Sistem Informasi Kepegawaian Terintegrasi untuk Pemerintah Daerah. Jurnal Sistem Informasi dan Teknologi, 9(1), 22–30.
[16] Cachin, C. (2016). Architecture of the Hyperledger Blockchain Fabric. [Hyperledger White Paper].
[17] Undang-Undang Republik Indonesia Nomor 5 Tahun 2014 tentang Aparatur Sipil Negara.
[18] Peraturan Bupati Madiun Nomor 5 Tahun 2019 tentang Sistem Informasi Manajemen Kepegawaian di Lingkup Pemerintah Kabupaten Madiun.
[19] Badan Pusat Statistik. (2023). Kabupaten Madiun dalam Angka 2023. BPS Kabupaten Madiun.
[20] Nakamoto, S. (2008). Bitcoin: A Peer-to-Peer Electronic Cash System. [Online]. Tersedia di: https://bitcoin.org/bitcoin.pdf
[21] Tapscott, D., & Tapscott, A. (2016). Blockchain Revolution: How the Technology Behind Bitcoin is Changing Money, Business, and the World. Penguin.
[22] Andryo, H., & Pratama, R. (2021). Implementasi Blockchain dalam Pengelolaan Sertifikat Digital. Jurnal Teknologi Informasi dan Ilmu Komputer, 8(2), 145-152.
[23] Kurniawan, D., & Suryanegara, M. (2020). Blockchain untuk Sistem Pemerintahan Terbuka. Jurnal Sistem Informasi, 16(1), 43–52.
[24] Arifin, Z., & Ramdhani, M. A. (2021). Studi Implementasi Blockchain pada Sistem Informasi Kepegawaian. Jurnal Ilmiah Teknologi Informasi Asia, 15(2), 85–92.
[25] Putra, Y. H., & Wibowo, A. (2022). Desain Arsitektur Blockchain untuk Aplikasi Pelayanan Publik. Jurnal Teknologi dan Sistem Komputer, 10(3), 287-293.
[26] Dewi, I. K., & Suryanto, A. (2020). Evaluasi Sistem HRIS dengan Blockchain. Jurnal Rekayasa dan Manajemen Sistem Informasi, 6(4), 311–319.
[27] Gunawan, A., & Rakhmadi, A. (2022). Aplikasi Blockchain dalam Dunia Pemerintahan. Jurnal Administrasi Publik, 13(1), 91–100.
[28] Wahyuni, L., & Hidayat, R. (2021). Pemanfaatan Blockchain untuk Meningkatkan Transparansi Data ASN. Jurnal Manajemen dan Teknologi Informasi, 9(1), 37–46.
[29] Nasution, F., & Santoso, D. (2020). Blockchain untuk E-Government: Peluang dan Tantangan. Jurnal Sistem Informasi Bisnis, 10(2), 165–172.
[30] Permana, D., & Zulkarnain, A. (2022). Analisis Blockchain pada Aplikasi Mutasi Pegawai. Jurnal Teknologi dan Informasi, 11(2), 204–212.
[31] Irawan, D., & Syahputra, M. (2021). Blockchain untuk Sistem Verifikasi Ijazah. Jurnal Pendidikan dan Teknologi, 2(1), 74–81.
[32] Siregar, B., & Hadi, F. (2020). Studi Komparatif Blockchain Ethereum dan Hyperledger. Jurnal Teknologi Informasi, 14(3), 221–229.

[33] Yusuf, A., & Dwi, R. (2021). Pengembangan Sistem Kepegawaian Berbasis Hyperledger. Jurnal Sistem Informasi dan Teknologi, 8(1), 15–22.
[34] Nugroho, A., & Kusuma, D. (2020). Hyperledger Fabric: Solusi Blockchain Private untuk Pemerintah. Jurnal Informatika dan Komputer, 10(2), 109–116.
[35] Hidayat, A., & Rosyadi, A. (2021). Pemanfaatan Blockchain dalam Proses Bisnis Pemerintah. Jurnal Riset Teknologi Informasi, 13(4), 357–366.
[36] Satria, R., & Lestari, Y. (2020). Evaluasi Arsitektur Blockchain dalam Pengelolaan Data Publik. Jurnal Teknologi Informasi dan Komputer, 9(3), 217–223.
[37] Lazuardi, A., & Ramadhan, H. (2021). Sistem Informasi Kepegawaian Terintegrasi Berbasis Blockchain. Jurnal Teknologi dan Manajemen Informatika, 7(2), 130–138.
[38] Setyawan, F., & Kurniawati, D. (2020). Keamanan Data ASN dengan Blockchain. Jurnal Sistem Informasi dan Keamanan Siber, 3(1), 67–74.
[39] Hanafiah, M. A., & Suryana, A. (2022). Blockchain dalam Transformasi Digital Pemerintah Daerah. Jurnal Informasi dan Administrasi, 5(1), 99–106.
[40] Mulyadi, H., & Fitriani, N. (2021). Studi Penerapan Blockchain di Instansi Pemerintah. Jurnal Sistem Cerdas, 2(3), 205–212.
[41] Kementerian PAN-RB. (2020). Pedoman Sistem Pemerintahan Berbasis Elektronik (SPBE). Jakarta: KemenPAN-RB.
[42] World Bank. (2020). Enhancing Government Effectiveness and Transparency: The Fight Against Corruption. Washington, DC: World Bank Group.
[43] ISO/IEC. (2018). ISO/IEC 30141: Internet of Things (IoT) – Reference Architecture. International Organization for Standardization.
[44] Kemenkominfo. (2022). Strategi Nasional Keamanan Siber 2022–2024. Jakarta: Kementerian Komunikasi dan Informatika RI.