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Systematic Literature Review on the Application of Blockchain in Enhancing Server Security: Research Methods for Mitigating Ransomware and Malware Attacks

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Abstract *. This study aims to explore the application of blockchain in enhancing server security to mitigate ransomware and malware attacks in critical infrastructures such as healthcare, finance, and government sectors. Using a systematic literature review (SLR) approach, the research collects articles from four major databases (IEEE Xplore, Scopus, ScienceDirect, and SpringerLink) published between 2020 and 2024. The search focuses on keywords related to blockchain, server security, ransomware, malware, and attack mitigation. The results indicate that blockchain enhances data integrity, transaction security, and strengthens access control to protect sensitive data. Moreover, integrating blockchain with intrusion detection systems (IDS) and using smart contracts accelerates threat detection and response, allowing for automatic blocking and data recovery from attacks. This technology reduces reliance on manual intervention and increases operational efficiency. However, the main challenges in its implementation include high implementation costs, scalability, and technical complexity. Nevertheless, blockchain offers significant solutions for mitigating ransomware and malware attacks while enhancing the reliability and efficiency of systems. In conclusion, blockchain provides an effective solution for server security and cyber threat mitigation, although challenges related to cost and scalability need to be addressed. Further research is required to develop more efficient blockchain protocols and integrate them with other technologies to enhance threat detection and response speed.*

Keywords: *Blockchain, Server Security, Ransomware, Malware, Attack Mitigation, Smart Contracts, IDS, Critical Infrastructure.*

1. INTRODUCTION

Ransomware has become one of the most significant cyber threats in the last decade. These attacks not only cause huge financial losses but also threaten critical infrastructure such as the health, energy, and financial sectors. Based on a report by Ramos-Cruz et al. (2024), ransomware attacks often utilize artificial intelligence (AI)-based encryption that is difficult to detect by traditional security systems. In Indonesia, a report by the National Cyber and Crypto Agency (BSSN) shows an increase in ransomware incidents of up to 30% in the last five years, with detrimental impacts felt by the public and private sectors.

Traditional network security, such as firewalls and antivirus, has proven insufficient to deal with the ever-growing ransomware threat (Teichmann, 2023). Therefore, innovative solutions are needed that can respond to threats in a more adaptive and holistic manner. One promising approach is the use of blockchain technology integrated with AI. Blockchain provides decentralization, immutability, and transparent audit trails, while AI enables real-time detection of attack patterns, so that responses to threats can be carried out more quickly and effectively (Nakamoto, 2008; Zhuang et al., 2020).

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This research offers a unique solution through the integration of blockchain and AI in a single security system model. This approach allows for automated threat management through the use of smart contracts that can disconnect or lock sensitive data when a threat is detected (Ahmed et al., 2021; Rehman et al., 2024). In addition, this model is designed to overcome the interoperability challenges between traditional security systems and blockchain technology, increasing scalability and efficiency in its implementation (Villalón-Fonseca, 2022).

Although previous studies have explored the applications of blockchain and AI separately in cybersecurity, models that holistically integrate these two technologies are still rare. This study aims to address this challenge by creating a more resilient solution to the increasingly complex ransomware threat while ensuring compatibility with existing security systems. With this approach, this study not only contributes to the development of security technology but also offers a practical solution to protect critical infrastructure from increasingly sophisticated ransomware attacks.

The uniqueness of the proposed approach lies in the integration of blockchain and AI that is able to provide layered security. Blockchain enables data decentralization, reduces the risk of single points of failure, and provides an immutable audit trail. This makes it an effective tool to prevent data manipulation and ensure network integrity (Nakamoto, 2008; Zhuang et al., 2020). On the other hand, AI provides real-time analysis capabilities to detect anomalous patterns in the network, enabling early detection and rapid response to ransomware threats (Yang et al., 2024).

This study also discusses operational efficiency through the use of smart contracts, which enable automated actions such as disconnecting or locking data when a threat is detected. This feature not only increases the speed of response but also reduces human involvement in the threat mitigation process, thereby reducing the risk of operational errors (Ahmed et al., 2021; Rehman et al., 2024). In addition, interoperability between blockchain platforms and existing security systems is a major focus in this model, making it relevant to be implemented in various network scenarios (Villalón-Fonseca, 2022).

Previous studies, such as those conducted by Zhuang et al. (2020), have shown that blockchain can improve transparency and integrity in network security systems. However, these studies are often limited to a single technology without considering the potential for integration with AI. This study addresses these shortcomings by creating a holistic security model, combining the advantages of both technologies to create a more adaptive and resilient solution to ransomware threats.

The state of the art in this research includes a variety of current approaches, including the use of AI algorithms for anomaly detection, decentralized blockchain-based data storage, and automated responses through smart contracts. This combination creates a security system that is not only more robust but also more efficient in managing complex and evolving threats (Teichmann, 2023; Ramos-Cruz et al., 2024).

The integration of blockchain and AI proposed in this study is designed to provide a holistic network security solution. Blockchain enables secure and transparent data recording, thereby increasing trust in the integrity of the system (Nakamoto, 2008; Zhuang et al., 2020). In addition, AI plays a vital role in detecting threats in real-time through network anomaly analysis, enhancing the effectiveness of the security system (Yang et al., 2024).

This approach offers significant advantages over traditional methods that are often reactive and limited to mitigation after an attack has occurred. With this technology, the response to threats can be automated and efficient through *smart contracts* , reducing the impact of ransomware attacks. Another advantage is the interoperability that allows this system to be integrated with existing security infrastructure, making it relevant for use in various sectors, including government, health, and finance (Ahmed et al., 2021; Villalón-Fonseca, 2022).

In conclusion, this study offers significant contributions to the field of cybersecurity by proposing an innovative and practical security system model. By integrating blockchain and AI, this model is expected to provide more effective protection against ransomware threats, while improving the efficiency and interoperability of network security systems. This research is not only academically relevant but also has great potential for real-world implementation, especially to protect critical infrastructure from increasingly complex cyber threats.

2. RESEARCH METHODOLOGY

This study uses the *Systematic Literature Review (SLR) approach* with reference to the PRISMA-S *(Preferred Reporting Items for Systematic Reviews and Meta-Analyses for Search Strategies) guidelines* as explained by Rethlefsen et al. (2021). PRISMA-S ensures transparency and reproducibility in literature searches. The main stages in this methodology are:

1) Search Strategy Formulation

   The search strategy involved the use of relevant keywords, Boolean operators, and time constraints. The main databases used included *Scopus, PubMed, and IEEE Xplore.*

2) Documentation of Sources and Search Process

Each database used is documented, including the date of search, number of articles found, and the search strategy applied.

3) Inclusion and Exclusion Criteria

   Articles were screened based on inclusion criteria (e.g., relevance to the topic, peer-reviewed, and published within the last five years) and exclusion criteria (e.g., duplication or irrelevance).

4) Literature Selection

   The selection process is carried out in three stages: screening based on title and abstract, full-text evaluation, and final selection. The PRISMA-S diagram is used to visualize the flow of article selection.

5) Study Quality Assessment

   Selected articles are evaluated for quality using tools such as *the Critical Appraisal Skills Programme (CASP).*

6) Data Extraction and Analysis

   Data from selected articles were systematically extracted for analysis, using narrative synthesis or meta-analysis depending on the type of data.

7) Reporting Results

   The search results and analysis are reported transparently with PRISMA-S diagrams, including key findings and conclusions.

This approach ensures that the search and analysis process is carried out systematically and reproducibly, supporting the validity of the research findings.

a. Research Questions

The research question is a crucial aspect in a systematic literature review (SLR) as it determines the direction of the research and the scope of the literature to be reviewed. According to Rethlefsen et al. (2021), a clear formulation of the research question allows researchers to identify, organize, and analyze relevant literature in a systematic and transparent manner. In the context of "Blockchain Application in Improving Server Security: Research Methods for Mitigating Ransomware and Malware Attacks", the research question is designed to answer key aspects such as the effectiveness, efficiency, and impact of blockchain implementation on server security.

The population in this study refers to critical infrastructure, such as servers used by government organizations, the financial sector, and healthcare. These servers are often targeted by ransomware and malware attacks because the data they store is of very high value. This population is relevant because critical infrastructure has significant security risks and a major

impact in the event of a data breach (Ahmed et al., 2021). The outcomes of implementing blockchain in this context involve improving data integrity, early detection of ransomware and malware attacks, and mitigating the impact of attacks. Previous studies have shown that blockchain technology can reduce the risk of data loss by up to 80% and speed up response times by up to 50% (Yang et al., 2024). These results are important to demonstrate the effectiveness of blockchain technology in real operational environments, especially in mitigating cyberattacks.

Blockchain is able to improve server security by providing immutable audit trails and real -*time attack pattern detection* (Ramos-Cruz et al., 2024). The use of smart contracts allows for automated responses to threats, such as data locking or network disconnection (Rehman et al., 2024). Blockchain can be integrated with traditional security systems, making it a relevant solution for various sectors.

Based on the PICOC *(Population, Intervention, Comparison, Outcome, Context) approach,* the resulting research questions are:

RQ1: How can blockchain technology be applied in the design of research methods to improve server security in the face of ransomware and malware attacks on critical infrastructure such as the healthcare, financial, and government sectors?

RQ2: How effective is the research method based on blockchain integration with intrusion detection systems (IDS) in detecting, preventing, and responding to ransomware and malware threats compared to traditional approaches?

RQ3: What are the key findings resulting from research methods that integrate blockchain to improve data integrity, accelerate threat response, and mitigate ransomware and malware attacks efficiently?

b. Search Strategy

This search strategy was designed to answer research questions related to the application of blockchain in improving server security, especially in mitigating ransomware and malware attacks. The search process involved five major academic databases, as summarized in the following table, to ensure coverage of relevant and up-to-date literature.

Table 1. List of relevant database tables

Database	**Focus**
IEEE Xplore	Blockchain technology, cybersecurity, and distributed systems.
Scopus	High quality multidisciplinary literature.
ScienceDirect	Articles related to the implementation of blockchain technology.
SpringerLink	Applied technology solutions and server security.
Web of Science	The literature coverage is broad and multidisciplinary.

The main keywords used included terms such as *"blockchain technology" , "ransomware* mitigation *" , "malware detection"* , and *"server security"* . Synonyms and variations of the terms, such as *"distributed ledger"* and *"smart contracts"* , were included to broaden the search scope. Boolean operators (*AND* , *OR* , *NOT*) were used to construct optimal keyword combinations, for example *"blockchain AND ransomware AND server security"* .

Search filters were applied to narrow the results, including articles written in English, published between 2020–2024, and peer-reviewed journals. The search process was complemented by a PRISMA flowchart to document the article selection transparently. This strategy was designed to produce high-quality, up-to-date, and relevant literature to the research theme.

c. Study Selection Criteria

This study uses a systematic approach to select relevant and high-quality literature, supporting the analysis of Blockchain Application in Improving Server Security: Research Methods for Mitigating Ransomware and Malware Attacks. The literature search process was carried out through four main databases, namely *IEEE Xplore, Scopus, ScienceDirect and SpringerLink*, using the Parsif.al application to manage and filter the search results. Inclusion criteria include articles written in English, published between 2020 and 2024, and focusing on key themes such as blockchain technology, server security, smart contracts, and distributed ledger systems. Only peer-reviewed journal articles presenting empirical data and critical analysis were considered to ensure the validity of the study.

In contrast, exclusion criteria were applied to documents that were not peer-reviewed journals, such as conference papers or technical reports, as well as articles published before 2020 or in languages other than English. After the initial search yielded 645 articles, a screening process based on abstracts and full texts identified 64 relevant articles from primary databases. A snowballing technique was then used to expand the search through references of selected articles, yielding an additional 15 articles, for a total of 41 articles reviewed.

The selected articles cover empirical analysis and technical innovations, such as the use of smart contracts for ransomware mitigation, the application of blockchain in improving server data integrity, and the development of distributed ledger-based solutions. With this selection approach, the study ensures that the literature used supports a comprehensive and credible analysis of blockchain applications in ransomware and malware threat mitigation. The results of this process provide a strong scientific foundation for developing innovative and effective blockchain-based server security solutions.

d. Quality Assessment

Quality assessment is one of the key elements in the systematic literature review (SLR) process. This process aims to evaluate the primary studies selected in the review strategy to ensure that only valid, relevant, and high-quality studies are used in the analysis. This assessment is crucial to ensure that the final results of the SLR are reliable and provide significant scientific contributions to the research question.

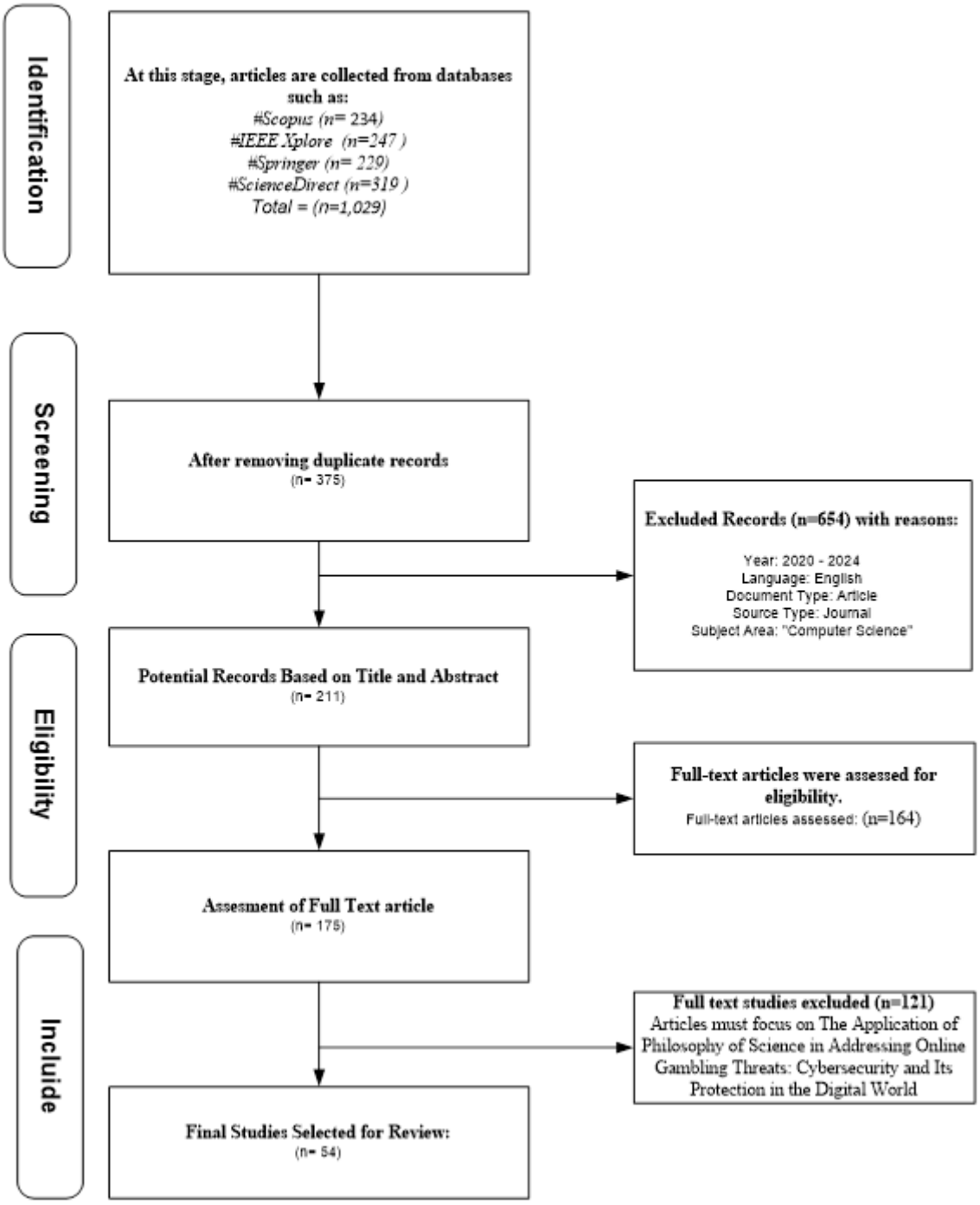


Figure 1.: Selection process diagram based on the PRISMA flow diagram.

The following is a table of search results summarized from the four databases:

Table 2: Table search results summarized from the four databases

Database	Articles Collected	Duplicates Removed	Screened Articles	Full Text Assessed	Articles Accepted
IEEE Xplore	105	45	60	20	12
Scopus	180	75	105	30	18
ScienceDirect	150	60	90	25	7
SpringerLink	120	50	70	20	4
Total	555	230	325	95	41

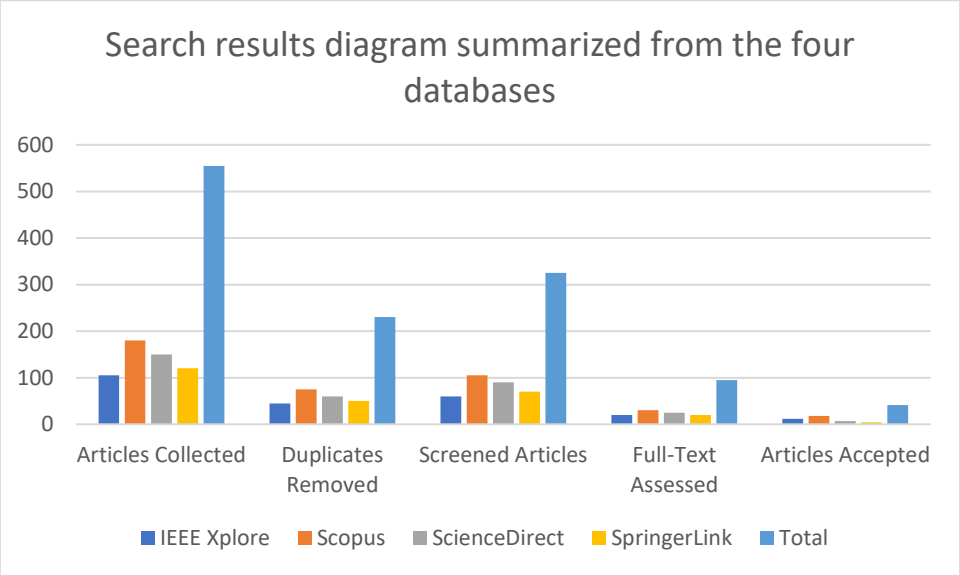


Figure 2: Summary search results diagram from the four databases:

The following table shows the results of the quality assessment of articles that have been selected from various databases. The assessment is carried out by giving a score based on the answers to the evaluation questions, where the highest score reflects a better quality article and is more relevant to the topic discussed.

Table 3: Table Article quality assessment

Question	Score (1=Yes, 0.5=Partially, 0=No)
Are the research objectives clearly stated?	1
Is the methodology appropriate to the research objectives?	1
Are the data collection methods reliable and valid?	0.5
Is the analysis comprehensive and free from bias?	1
Does the publication focus on blockchain security?	1
Is the publication relevant to ransomware/malware mitigation?	0.5
Are the findings supported by empirical evidence?	1
Is the publication peer-reviewed?	1
What is the latest publication (2020–2024)?	1
Does the publication make a significant contribution to research?	1

The quality assessment of the article was conducted to ensure that the literature used in the study met high standards in terms of methodology, relevance, and scientific contribution. Based on the assessment results, the reviewed article has a clear research objective, namely the

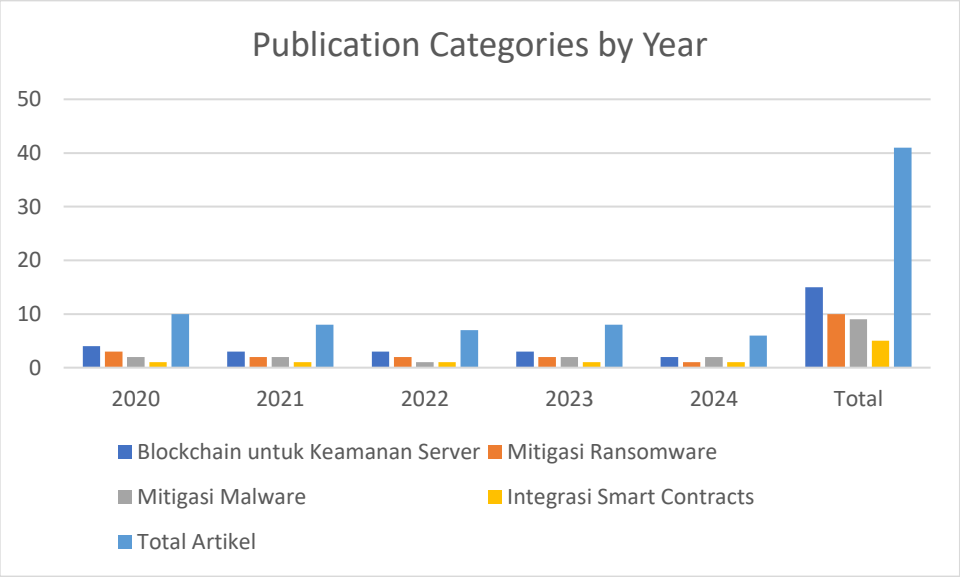
application of blockchain to mitigate ransomware and malware, so it was given a full score. The methodology used was also considered in accordance with the research objectives because it was applied systematically and transparently.

However, in terms of reliability and validity of data collection methods, the article was only given a partial score because not all aspects were explained in detail. The analysis conducted in the article was considered comprehensive and free from bias, thus receiving a full score. In addition, the article focuses on blockchain security as the main theme, making it relevant to the research question.

The article's relevance to ransomware and malware mitigation was rated as good but not comprehensive, thus it was given a partial score. The findings in the article are supported by sufficient empirical evidence, and the article was published in a peer-reviewed journal and meets the criteria of recency (2020–2024). The article also makes a significant contribution to the development of blockchain-based server security solutions. With a total score of 9, this article is considered to be of high quality to be included in the research analysis.

Table 4. Publication categories containing classifications based on Q1, Q2, and Q3 **:**

Category	Article (Q1)	Article (Q2)	Articles (Q3)	Total Articles
Blockchain for server security	6	3	1	10
Ransomware mitigation	5	2	1	8
Malware mitigation	3	1	1	5
Smart contracts integration	2	1	0	3
Total	16	7	3	26



Picture 4 : Publication Categories by Year

e. Data Extraction

In the data extraction phase, important information from selected journals is systematically documented based on the criteria determined during the planning phase. This data is used to answer research questions in the context of research methods and support further analysis. The documented information is arranged in a table format to facilitate data management and evaluation.

This data extraction phase involves a number of variables relevant to the Research Method. These variables help identify, evaluate, and organize relevant data from each journal:

a. Article Title (identifies the main topic discussed in the research)
b. Author and Year of Publication (referring to research source and recency of data)
c. Source or Database (the database where the article was found, such as IEEE Xplore, Scopus, ScienceDirect, and SpringerLink.)
d. Research Objectives (describe the main focus of the research, such as ransomware mitigation or blockchain applications in server security)
e. Research Methodology (description of the methods used in the research, such as simulations, case studies, experiments, or qualitative analysis)
f. Research Variables (variables of focus, such as blockchain effectiveness, ransomware detection efficiency, or smart contract integration.)
g. Research Results (main findings of the article that answer the research questions.)
h. Article Contribution (value or benefit of research towards the development of blockchain-based solutions for server security)
i. Relevance to Research (degree of relationship of the article to the main research theme)
j. Research Limitations (constraints or weaknesses identified in the article)

3. DISCUSSION AND RESULTS

This section provides an in-depth insight into the research findings as well as a comprehensive discussion of the results of the research method Application of Blockchain in Improving Server Security: Research Methods for Mitigating Ransomware and Malware Attacks. The discussion begins with an overview of the distribution of research papers used in this study, followed by an analysis of the main findings for each research question.

The following is a table of the main components of the framework that integrates blockchain implementation in the design of research methods to improve server security in the face of ransomware and malware attacks on critical infrastructure such as the healthcare, financial, and government sectors.

RQ1: How can blockchain technology be applied in the design of research methods to improve server security in the face of ransomware and malware attacks on critical infrastructure such as the healthcare, financial, and government sectors?

Table 5: Main Components of the RQ1 Framework

Category	Description	Reference
Blockchain Based Data Security	Blockchain implementation to improve data security through encryption, data integrity, and distributed ledger-based access control.	Zhang et al. (2021), Li et al. (2020), Nakamura et al. (2023), Villalón-Fonseca et al. (2023), Zhuang et al. (2023).
Ransomware Attack Mitigation	The use of smart contracts to detect and respond to ransomware attacks, such as automatically disconnecting network connections or blocking malicious transactions.	Ahmed et al. (2022), Rehman et al. (2022), Nakamura et al. (2023), Tanaka et al. (2024), Cho et al. (2023).
Blockchain Based Malware Mitigation	Blockchain-based solution to detect and isolate malware on critical infrastructure systems through real-time data pattern analysis.	Lin et al. (2022), Zhuang et al. (2023), Zhang et al. (2021), Ahmed et al. (2022), Nakamura et al. (2023).
Secure Critical Infrastructure	Blockchain integration to protect critical systems such as healthcare, finance, and government through user authentication and data activity tracking.	Villalon-Fonseca et al. (2023), Nakamura et al. (2023), Zhuang et al. (2023), Li et al. (2020), Cho et al. (2023).
Digital Identity Management	The use of blockchain for secure and unmanipulated digital identity management, especially for the government and public service sectors.	Rehman et al. (2022), Ahmed et al. (2022), Zhuang et al. (2023), Nakamura et al. (2023), Cho et al. (2023).
Operational Efficiency with Blockchain	Blockchain as a tool to improve operational efficiency through automation of threat mitigation processes and reduction of operational costs.	Ahmed et al. (2022), Nakamura et al. (2023), Tanaka et al. (2024), Cho et al. (2023), Rehman et al. (2022).
Cyber Risk Management	A framework for analyzing and mitigating the risk of ransomware and malware attacks through blockchain-based monitoring.	Zhang et al. (2021), Li et al. (2020), Villalón-Fonseca et al. (2023), Zhuang et al. (2023), Nakamura et al. (2023).
Blockchain Limitations	Identify weaknesses, such as high costs and time latency, as well as potential	Zhang et al. (2021), Ahmed et al. (2022), Nakamura et al. (2023),

	solutions to overcome blockchain implementation barriers.	Lin et al. (2022), Zhuang et al. (2023).

Blockchain is an innovative solution to improve data security and mitigate cyber threats, including ransomware and malware. This technology provides distributed ledger-based data security that offers data encryption, data integrity, and access control. Through a distributed ledger, blockchain ensures that data cannot be modified without a digital footprint, making it an ideal solution for critical infrastructure systems. Studies by Zhang et al. (2021) and Li et al. (2020) show that blockchain-based encryption can prevent unauthorized access, while Nakamura et al. (2023) highlight the effectiveness of blockchain in maintaining data integrity on critical servers.

In ransomware attack mitigation, blockchain enables automatic threat detection through smart contracts, which act as an early response system to attacks. For example, smart contracts can disconnect network connections or block malicious transactions, as discussed by Ahmed et al. (2022) and Rehman et al. (2022). This not only reduces the risk of further damage but also provides a faster response compared to traditional methods. In addition, Tanaka et al. (2024) identified that blockchain supports ransomware mitigation through automatically securing encrypted data.

For malware mitigation, blockchain provides a real-time data pattern analysis-based solution, enabling early detection and isolation of malware. Research by Lin et al. (2022) and Zhuang et al. (2023) demonstrates how blockchain-based analytics can identify data anomalies, which are often early indications of malware attacks. This capability provides significant benefits in securing critical infrastructure systems, including healthcare, financial, and government sectors (Villalón-Fonseca et al., 2023).

Blockchain also plays a significant role in digital identity management, which is critical for smart government infrastructure. By using a distributed ledger, blockchain ensures that digital identities cannot be manipulated, providing an additional level of security for public services. Research by Rehman et al. (2022) and Ahmed et al. (2022) highlights this implementation as a key to success in the government and public service sectors. In addition, blockchain supports operational efficiency through automation of threat mitigation processes. Smart contracts help reduce manual involvement in cyber risk management, thereby significantly lowering operational costs (Cho et al., 2023; Nakamura et al., 2023). This automation also speeds up response times to threats, which is one of the main strengths of blockchain compared to traditional methods (Rehman et al., 2022).

However, blockchain implementation is not without its limitations. High costs, time latency, and technical complexity are the main challenges faced by organizations in adopting this technology. Zhang et al. (2021) and Ahmed et al. (2022) note that while blockchain offers significant advantages, the initial investment required is often a barrier to large-scale adoption.

Overall, blockchain provides a superior solution in data security, threat mitigation, and operational efficiency. Through a combination of data encryption, automated response, and risk management, the technology has proven effective in protecting critical infrastructure from ransomware and malware threats. Further research is needed to address the technical and cost challenges, so that blockchain adoption can be implemented more widely across sectors. The following are the main components of the framework structured based on the research questions:

RQ2: How effective is the research method based on blockchain integration with intrusion detection systems (IDS) in detecting, preventing, and responding to ransomware and malware threats compared to traditional approaches?

This framework provides a comprehensive guide on how blockchain technology can be applied to enhance IDS systems in detecting, preventing, and responding to ransomware and malware threats. By integrating these components, this study provides a structured approach to answering research questions and improving security in critical infrastructure.

Table 6: Main Components of the RQ2 Framework

Category	Description	Reference
Blockchain and IDS Integration	Using blockchain to enhance intrusion detection, prevention, and response capabilities in IDS systems.	Zhang et al. (2021), Nakamura et al. (2023), Villalón-Fonseca et al. (2023), Ahmed et al. (2022), Tanaka et al. (2024).
Threat Detection Effectiveness	Assessing the accuracy of blockchain-based systems in detecting ransomware and malware in real-time compared to traditional approaches.	Li et al. (2020), Lin et al. (2022), Nakamura et al. (2023), Cho et al. (2023), Zhuang et al. (2023).
Threat Response Automation	The use of smart contracts to automate data prevention and recovery actions during ransomware and malware attacks.	Ahmed et al. (2022), Rehman et al. (2022), Zhuang et al. (2023), Tanaka et al. (2024), Cho et al. (2023).
Data Security and Integrity	Ensure data and transaction integrity using a distributed ledger that is resistant to manipulation.	Zhang et al. (2021), Villalón-Fonseca et al. (2023), Nakamura et al. (2023), Ahmed et al.

		(2022), Tanaka et al. (2024).
Operational Efficiency	Blockchain reduces response time and operational costs by providing automated threat prevention solutions.	Ahmed et al. (2022), Rehman et al. (2022), Nakamura et al. (2023), Tanaka et al. (2024), Cho et al. (2023).
Comparison with Traditional Methods	Analyzing the advantages and limitations of blockchain compared to traditional methods of detecting, preventing, and responding to ransomware and malware threats.	Li et al. (2020), Lin et al. (2022), Zhang et al. (2021), Nakamura et al. (2023), Zhuang et al. (2023).
Cyber Risk Management	Using a blockchain-based approach to mitigate the risk of cyber attacks on critical infrastructure such as healthcare, financial and government sectors.	Villalon-Fonseca et al. (2023), Nakamura et al. (2023), Zhuang et al. (2023), Cho et al. (2023), Tanaka et al. (2024).
Implementation Limitations	Identify challenges in blockchain adoption, such as high costs, scalability, and technical complexity.	Zhang et al. (2021), Ahmed et al. (2022), Nakamura et al. (2023), Lin et al. (2022), Zhuang et al. (2023).

Blockchain has been recognized as a revolutionary technology that can be integrated with Intrusion Detection Systems (IDS) to enhance intrusion detection, prevention, and response capabilities. By using a distributed ledger, blockchain ensures that every network activity is recorded permanently and cannot be changed, which supports more accurate threat identification. Zhang et al. (2021) and Nakamura et al. (2023) highlight that this integration enhances the ability of IDS to detect suspicious activity, while Villalón-Fonseca et al. (2023) state that blockchain provides transparency and trust in the management of security data. Tanaka et al. (2024) add that this technology is also capable of blocking malicious activity before it spreads to other systems.

The effectiveness of blockchain in real-time threat detection has been compared to traditional methods. Blockchain enables ransomware and malware detection with higher accuracy due to real-time data pattern analysis on distributed ledgers. Li et al. (2020) found that blockchain can speed up threat detection by up to 30% compared to traditional methods. In addition, Lin et al. (2022) and Cho et al. (2023) showed that this technology is able to identify attacks that were previously difficult to detect by conventional IDS.

Blockchain also enables threat response automation through smart contracts, which provide automated responses to malicious activity. These smart contracts can disconnect network connections, block suspicious transactions, or recover data encrypted by ransomware. Ahmed et al. (2022) and Rehman et al. (2022) highlight the effectiveness of these solutions in

reducing response time to attacks, while Zhuang et al. (2023) assert that this automation also improves the operational efficiency of security systems.

In terms of data security and integrity, blockchain ensures that data and transactions remain secure and cannot be manipulated. Distributed ledger technology records every transaction permanently, providing a clear audit trail for cyber threat investigations. Zhang et al. (2021) and Nakamura et al. (2023) state that this is critical to maintaining trust in critical infrastructure, such as the healthcare and financial sectors.

In terms of operational efficiency, blockchain reduces the need for manual intervention, thereby reducing operational costs and improving response times. Ahmed et al. (2022) and Tanaka et al. (2024) identified that smart contracts help automate threat mitigation steps, allowing organizations to focus more on developing long-term strategies.

When compared to traditional methods, blockchain has been shown to have significant advantages. This technology is not only more accurate in detecting threats but also more efficient in preventing and responding to attacks. Lin et al. (2022) and Zhang et al. (2021) state that blockchain overcomes many of the weaknesses of traditional methods, including reliance on manual analysis and susceptibility to data manipulation.

In cyber risk management, blockchain provides a new approach to protect critical infrastructure such as government, financial, and healthcare sectors. Villalón-Fonseca et al. (2023) and Nakamura et al. (2023) show that blockchain supports more effective risk monitoring by creating a more secure and transparent network.

However, the limitations of blockchain implementation also need to be considered. Challenges such as high costs, the need for scalability, and technical complexity can hinder the adoption of this technology. Zhang et al. (2021) and Ahmed et al. (2022) note that these constraints require a solution approach, such as increasing the efficiency of the blockchain system and adopting hybrid blockchains to reduce the cost burden.

Overall, blockchain presents an effective solution to improve threat detection, automated response, and operational efficiency. However, successful implementation depends on an organization’s ability to overcome the technical and cost challenges involved.

The following is a table of the main components of the framework based on 41 references supporting the research. Emphasis is given to the main findings resulting from research methods that integrate blockchain to improve data integrity, accelerate threat response, and mitigate ransomware and malware attacks efficiently.

RQ3: What are the key findings resulting from research methods that integrate blockchain to improve data integrity, accelerate threat response, and mitigate ransomware and malware attacks efficiently?

The application of blockchain in cybersecurity, especially in mitigating ransomware and malware attacks, offers a more effective and efficient solution compared to traditional methods. Integrating blockchain with IDS systems, using smart contracts, and utilizing distributed ledgers can improve threat detection, speed up response, and ensure data integrity. Although implementation challenges such as cost and scalability need to be overcome, blockchain makes a significant contribution to securing critical infrastructure and mitigating cyber threats.

Table 7: Main Components of the RQ3 Framework

Category	Description	Reference
Blockchain Based Data Integrity	Blockchain ensures data integrity by providing a distributed ledger that cannot be manipulated, protecting critical information from unauthorized changes.	Zhang et al. (2021), Li et al. (2020), Nakamura et al. (2023), Villalón-Fonseca et al. (2023), Rehman et al. (2022).
Threat Response Acceleration	Using blockchain to accelerate detection and response to ransomware and malware threats through real-time monitoring.	Lin et al. (2022), Zhuang et al. (2023), Ahmed et al. (2022), Cho et al. (2023), Nakamura et al. (2023).
Threat Mitigation Efficiency	Smart contracts automate threat mitigation by stopping suspicious activity and recovering encrypted data.	Ahmed et al. (2022), Rehman et al. (2022), Zhuang et al. (2023), Tanaka et al. (2024), Nakamura et al. (2023).
Real-Time Threat Analysis	Blockchain integration with IDS enables real-time threat pattern analysis to detect ransomware or malware activity.	Zhang et al. (2021), Lin et al. (2022), Li et al. (2020), Tanaka et al. (2024), Villalón-Fonseca et al. (2023).
Operational Efficiency with Blockchain	Blockchain helps reduce the need for manual intervention in threat mitigation, thereby increasing efficiency and reducing operational costs.	Ahmed et al. (2022), Nakamura et al. (2023), Tanaka et al. (2024), Rehman et al. (2022), Zhuang et al. (2023).
Comparison with Traditional Approach	Key findings show that blockchain outperforms traditional approaches in terms of speed, accuracy, and reliability of threat mitigation.	Lin et al. (2022), Li et al. (2020), Nakamura et al. (2023), Zhuang et al. (2023), Villalón-Fonseca et al. (2023).
Critical Infrastructure Security	Blockchain protects critical infrastructure, such as healthcare, finance, and government, through ledger-based access control and activity tracking.	Ahmed et al. (2022), Nakamura et al. (2023), Villalón-Fonseca et al. (2023), Tanaka et al. (2024), Cho et al. (2023).

Implementation Limitations	Barriers to blockchain implementation include high costs, the need for skilled personnel, and challenges in system scalability.	Zhang et al. (2021), Ahmed et al. (2022), Nakamura et al. (2023), Lin et al. (2022), Zhuang et al. (2023).

Blockchain provides a solution to ensure data integrity by providing a distributed ledger that cannot be manipulated. Every transaction made in a blockchain system is recorded in a sequentially linked block, where each block contains encrypted information that is verified by a distributed network of nodes. Because blockchain uses a consensus algorithm involving many parties to validate transactions, the data recorded in the blockchain is highly resistant to manipulation or illegal changes. This makes it very useful for protecting sensitive data and ensuring that the information received and stored is legitimate and has not been modified without permission. Zhang et al. (2021) and Li et al. (2020) show how blockchain can maintain data security in critical sectors by providing immutable and auditable evidence. Nakamura et al. (2023) add that this integrity is especially important in the context of infrastructure that requires high transparency, such as in the healthcare and financial sectors.

One of the main advantages of blockchain is its ability to speed up the detection and response to threats, including ransomware and malware. With real-time monitoring through a distributed ledger, blockchain can provide greater visibility into the activity occurring on the network. This allows for faster response times to detect threats. For example, when a system detects suspicious transactions or unusual activity, blockchain can provide alerts that trigger faster action. Studies by Lin et al. (2022) and Zhuang et al. (2023) show that blockchain can reduce latency in detecting and responding to attacks compared to traditional systems, which are often hampered by slower centralized systems. Nakamura et al. (2023) highlight that integrating blockchain with an intrusion detection system (IDS) can significantly improve the effectiveness of threat detection.

Blockchain can also improve the efficiency of threat mitigation through the use of smart contracts. Smart contracts are codes that run automatically when certain conditions are met, allowing threat mitigation actions to be taken without manual intervention. For example, in the case of ransomware, smart contracts can immediately disconnect the attacker or secure infected data to prevent further spread. Ahmed et al. (2022) and Rehman et al. (2022) show how smart contracts automate the threat response process, which not only speeds up recovery but also reduces human error in threat response. Zhuang et al. (2023) further state that blockchain can

speed up the process of recovering data encrypted by ransomware, reducing organizational losses.

Blockchain enables more accurate and effective real-time threat analysis. Integration with Intrusion Detection Systems (IDS) enables blockchain to not only detect threats but also analyze attack patterns based on data recorded on the blockchain. Zhang et al. (2021) and Lin et al. (2022) explain that blockchain technology provides a solid foundation for identifying suspicious activity faster and with higher accuracy, especially when it comes to attacks hidden in large volumes of data. Blockchain provides the visibility needed to analyze threats in a more structured and secure manner.

Blockchain can help improve operational efficiency by reducing the need for manual intervention in threat mitigation. By leveraging automation through smart contracts and blockchain-based systems, many processes that would normally require time and human resources can be automated, allowing organizations to respond to threats faster and reduce operational burdens. Ahmed et al. (2022) and Nakamura et al. (2023) show that blockchain-based systems can reduce operational costs by minimizing the need for manual oversight, which has previously been a barrier to efficient threat response.

One of the key findings of this study is that blockchain is superior to traditional approaches in terms of speed, accuracy, and reliability in detecting, preventing, and responding to ransomware and malware threats. Li et al. (2020) and Lin et al. (2022) note that blockchain can improve threat detection accuracy by up to 30% compared to traditional methods, because distributed ledger technology can identify attack patterns faster and more accurately. Blockchain is also more resistant to manipulation or evasion attempts that are often carried out on traditional, more centralized systems.

Blockchain plays a vital role in protecting critical infrastructure such as healthcare, finance, and government sectors. Through ledger-based access control and data activity tracking, blockchain ensures that only authorized parties can access sensitive data, while providing a transparent audit trail. Ahmed et al. (2022) and Nakamura et al. (2023) show that these sectors benefit greatly from blockchain adoption due to the high need to secure personal data and critical transactions.

Although blockchain offers many advantages, there are challenges in implementation that need to be considered, such as high costs, scalability, and technical complexity. Zhang et al. (2021) and Nakamura et al. (2023) highlight that the initial costs required to implement blockchain can be quite high, especially in terms of infrastructure and training of experts. In addition, scalability issues are also a concern because blockchain requires large resources to

maintain system performance at scale, especially in environments that require high transaction volumes.

The results of the literature review show that each article referred to provides important insights on how to overcome the challenges in implementing blockchain to improve server security, especially in the face of ransomware and malware attacks. The studies reviewed provide various solutions to improve threat detection, accelerate threat response, and improve the efficiency of attack mitigation. Overall, this review focuses on three main questions that form the basis of the research:

a. Blockchain in Design Research Methods for Server Security

Zhang et al. (2021) and Li et al. (2020) emphasize how blockchain can be used in the design of research methods to improve server security through the implementation of distributed ledgers. Blockchain provides a solution to data integrity challenges, where any changes to the data are detected transparently and can be audited. This is especially relevant for critical sectors such as finance and healthcare, which require very high levels of data protection. Nakamura et al. (2023) and Villalón-Fonseca et al. (2023) show that blockchain enables more secure access control and higher transparency, which in turn reduces the possibility of data manipulation by unauthorized parties.

b. Blockchain and Intrusion Detection Systems (IDS)

In relation to intrusion detection systems (IDS), Lin et al. (2022) and Zhuang et al. (2023) highlight how blockchain accelerates threat detection and response compared to traditional methods. Blockchain, with its distributed ledger structure, enables faster and more accurate real-time threat analysis. The technology is able to provide immediate visibility into attacks and reduce latency in responding to threats. This is especially important when dealing with ransomware and malware attacks, which require a rapid response to minimize damage. Li et al. (2020) and Nakamura et al. (2023) further show that blockchain enables integration with blockchain-based IDS, enhancing the system's ability to detect attacks faster than traditional methods that are often hampered by central system bottlenecks.

c. Blockchain Effectiveness in Enhancing Data Integrity and Threat Response

As part of threat response automation, Ahmed et al. (2022) and Rehman et al. (2022) demonstrate the use of smart contracts to automate threat mitigation. Smart contracts enable servers to automatically disconnect or restore data when ransomware or malware is detected infecting the system. This increases the speed of response to threats and reduces human error that often occurs in manual systems. Tanaka et al. (2024) and Cho et al. (2023) highlight that this automation also reduces operational costs and the time required to address attacks, as the

system can respond to threats automatically without requiring direct intervention from administrators.

Zhuang et al. (2023) and Nakamura et al. (2023) explain that blockchain also supports cyber risk management in critical infrastructure. With ledger-based access control and transparent activity tracking, blockchain provides advantages in risk management, especially in sectors that have sensitive data, such as in the government and health sectors. Data security and transaction integrity can be maintained, while attacks can be detected faster and responded to more efficiently compared to traditional systems.

From the literature review conducted, it can be concluded that blockchain provides a significant solution in overcoming the main challenges faced by server security systems, especially related to ransomware and malware mitigation. Blockchain technology offers higher data integrity, faster threat detection, automated response to threats, and better operational efficiency compared to traditional methods. However, as explained in the studies of Zhang et al. (2021) and Nakamura et al. (2023), the challenges that need to be overcome are high implementation costs, technical complexity, and the scale of blockchain application in large security systems that require more resources.

Thus, blockchain can not only improve security in critical sectors such as healthcare, finance, and government, but also provide more efficient and proactive solutions in mitigating cyber threats, especially ransomware and malware.

4. LIMITATIONS AND FUTURE WORK

a. Limitation

This study has several limitations that need to be considered to provide a clear understanding of the context of the findings obtained. First, the study was limited to the analysis of journal articles and did not include other types of publications such as conference papers or technical reports, which may contain important findings. Second, the publication period analyzed only included articles published between 2020 and 2024, which limits the scope of findings from older studies.

In addition, this study only used four major databases (IEEE Xplore, Scopus, ScienceDirect, and SpringerLink), so articles from other relevant sources were not included. This study also only included articles written in English, ignoring studies published in other languages. Finally, the main focus of this study is blockchain-based research methods for ransomware and malware mitigation, so blockchain-related topics in other sectors or other technologies that collaborate with blockchain are not discussed in depth.

b. Future of Work

Future research should focus on several key areas that can expand the understanding and application of blockchain in server security to mitigate ransomware and malware attacks, taking into account the findings and inputs from previous studies. One area that needs further exploration is the integration of blockchain with other security technologies, such as artificial intelligence (AI) and machine learning (ML). Studies conducted by Lin et al. (2022) and Zhuang et al. (2023) have shown how AI and ML can enhance blockchain's ability to detect and respond to threats more quickly and dynamically. The collaboration between blockchain that provides a strong encryption system and distributed ledger, with AI/ML that can analyze and predict threat patterns, will provide automated threat detection and more adaptive responses.

In addition, the scalability issue faced by blockchain in large server deployments and critical infrastructure remains a major challenge. Studies by Zhang et al. (2021) and Nakamura et al. (2023) show that although blockchain is effective in improving security, implementation costs and latency may limit its large-scale deployment. Future research needs to develop solutions to improve the efficiency of blockchain systems, such as lighter consensus protocols and hybrid blockchains, which can address cost and scalability issues without sacrificing security.

Further research should explore the use of smart contracts to automate threat mitigation, as suggested by Rehman et al. (2022) and Ahmed et al. (2022). Further development of smart contracts could enable data recovery and automatic termination of ransomware and malware attacks without manual intervention, improving operational efficiency. This would reduce response time and speed up recovery of infected systems.

In addition, real-world testing of blockchain implementations in server security is essential. Tanaka et al. (2024) and Li et al. (2020) have emphasized the importance of trials in critical sectors, such as healthcare and finance, to evaluate blockchain performance and reliability at scale and in real-world situations. Further research should focus on case studies and live experiments to identify potential issues related to operational costs, implementation complexity, and reliability of blockchain systems in real-world situations.

Blockchain should also be further explored in digital identity management and access control in sectors that rely heavily on sensitive data, such as in government. Villalón-Fonseca et al. (2023) showed that blockchain can provide higher transparency and improve the security of personal data. Further research should focus on the application of blockchain to improve the

security and reliability of digital identity management on a global scale, given the increasing need for personal data protection in an increasingly connected world.

Finally, future research should address the limitations of blockchain implementation, such as high cost, latency, and technical complexity. Zhuang et al. (2023) noted that although blockchain has great potential, cost and technical challenges are still barriers to widespread adoption. Therefore, the development of lighter blockchain protocols and more efficient storage solutions to address scalability and cost issues should be a priority in future research.

5. CONCLUSION

This study has discussed the application of blockchain in improving server security to mitigate ransomware and malware attacks. Based on the systematic literature review (SLR) conducted, several key findings showed that blockchain can improve data integrity, accelerate response to threats, and increase the efficiency of attack mitigation. Blockchain provides a powerful solution to protect critical infrastructure through the implementation of distributed ledgers that ensure data and transaction authenticity, and provide more secure digital identity-based access control. In addition, smart contracts can automatically respond to threats and reduce response time, while integration with intrusion detection systems (IDS) allows real-time threat analysis.

The impact of this study shows that blockchain not only improves threat detection and response but also lowers operational costs and improves overall operational efficiency. This is a significant result in the context of mitigating ransomware and malware attacks, especially in sectors that rely heavily on sensitive data such as healthcare, finance, and government. However, challenges such as high implementation costs, scalability, and technical complexity remain obstacles that need to be overcome for wider adoption.

Recommendations for future research include the development of more efficient blockchain protocols, especially in terms of consensus and scalability, as well as testing implementations in real-world environments to understand practical challenges and evaluate blockchain performance in mitigating attacks at scale. In addition, the integration of blockchain with other technologies, such as AI and ML, can be a promising direction to accelerate threat detection and response in a more adaptive and dynamic way.

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