
Blockchain-Based Customer Data Management Systems: A Framework for Insurance Service

Oliver Hasan Padmanegara & Riska Marlina Febriana

Widyatama University

Email: oliver.hasan@widyatama.ac.id

Abstract

This research examines the use of blockchain-based insurance services' customer data management in Indonesia and its effects on privacy and security risks. The study employs a qualitative methodology with an exploratory approach. It proposes six research propositions and a blockchain-based architecture model for managing insurance services' customer data. The findings suggest that blockchain can reduce privacy and security risks if implemented by the insurance sector in Indonesia. The insurance services in Indonesia currently use legacy internal servers to store customer data, accessible by insurance and customers through the cloud. This centralized storage poses security and privacy risks, as customer data is sensitive information. Blockchain technology, with its decentralized and tamper-proof characteristics, presents a viable solution to mitigate these risks. By employing blockchain for customer data management, institutions can ensure the integrity and security of sensitive information, thereby safeguarding against unauthorized access and potential misuse. Implementing blockchain-based solutions for data management requires careful consideration of various factors, including the financial and technical resources necessary to support high-end computing infrastructure. Despite these challenges, the potential benefits of blockchain in enhancing security and privacy are substantial.

Keywords: blockchain, distributed ledger, insurance services' customer data management, privacy risk, security risk

1. Introduction

Historically, businesses competed for resources like oil and coal. However, the digital age has shifted the focus to data, which has become more valuable than traditional resources. The rise of computers and the Internet has led to numerous technology companies aiming to improve real-time data flow. The insurance services in Indonesia currently uses legacy internal servers to store customer's data, accessible by insurance and customers through the cloud. This centralized storage poses security and privacy risks, as the customer's data is a sensitive information. Customers must evaluate the risk of privacy breaches, as privacy is a fundamental right. Violations of this right by the provider are unethical.

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According to TEMPO Indonesia, over two million BRI Life's customer data were sold on the dark web in 2021 (TEMPO Indonesia, 2021). The compromised data included a wide array of personal and sensitive information, such as customers' full names, phone numbers, residential addresses, email addresses, and even details related to their insurance policies. This breach not only put customers at risk of phishing scams but also made them vulnerable to unauthorized profiling, identity theft, and other unethical practices. Criminals could exploit this information for fraudulent activities spanning financial theft, manipulation, or impersonation, potentially causing significant personal and financial harm to the affected individuals.

The ramifications of such data breaches are profound. Victims often experience emotional distress due to the sudden loss of privacy and security, coupled with the fear of their information being exploited. Additionally, financial institutions suffer irreparable reputational damage, as customer trust is eroded. Rebuilding this trust requires demonstrating a commitment to implementing stronger cybersecurity frameworks and transparency in handling sensitive data.

In 2024, the National Data Center (PDN) Indonesia fell victim to an extensive cyber-attack orchestrated by the hacker group Lockbit 3.0, which employed advanced ransomware tactics to infiltrate the system (CNN Indonesia, 2024). This breach impacted over 200 government institutions, disrupting a wide array of critical services such as administrative functions, public sector databases, and essential operations related to healthcare and social services. The sophisticated nature of the attack rendered traditional security measures ineffective, showcasing the limitations of centralized data storage systems.

The exposed data included sensitive information such as identification numbers, financial records, and confidential governmental documents, which raised significant privacy and security concerns. The ransomware encrypted files, rendering them inaccessible, and demanded substantial payments for their release, further straining the affected institutions. Beyond the immediate operational disruptions, the attack emphasized the critical need for robust cybersecurity frameworks. Public trust in the government's ability to safeguard citizen and institutional data was profoundly shaken, leading to calls for improved security protocols and the adoption of decentralized technologies like blockchain to mitigate future risks.

This breach serves as a stark reminder of the vulnerabilities inherent in centralized systems, where a single point of failure can compromise an entire network. As cyber threats grow increasingly sophisticated, the urgency for innovative solutions such as blockchain to ensure data integrity and security has never been more pronounced.

Blockchain technology, with its ability to create a distributed ledger of transactions, offers a promising alternative. By decentralizing data storage and enhancing transparency, blockchain can

provide a more resilient and secure framework for managing sensitive data. This technology reduces the likelihood of single points of failure, making it more difficult for attackers to compromise entire systems.

Implementing blockchain-based solutions for data management requires careful consideration of various factors, including the financial and technical resources necessary to support high-end computing infrastructure. Despite these challenges, the potential benefits of blockchain in enhancing security and privacy are substantial. This research aims to explore the feasibility of blockchain implementation for managing insurance services' customer data and its impact on reducing security and privacy risks.

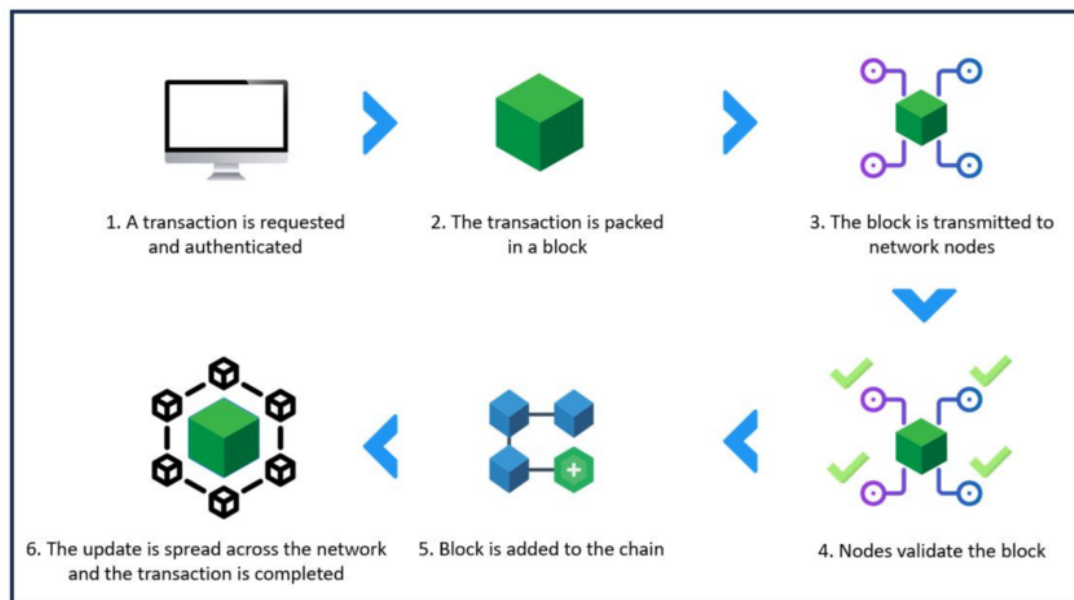
2. Literature Review

Insurance, Privacy, and Data Security Risks. The insurance industry, by its very nature, handles vast amounts of sensitive personal data, making it a prime target for cyber-attacks and data breaches. Privacy and data security are paramount concerns, as breaches can lead to severe consequences for both individuals and institutions. The incidents mentioned in the introduction, such as the BRI Life data breach and the National Data Center hack, underscore the vulnerabilities inherent in centralized data storage systems. Insurance companies collect and store extensive data, including personal identification numbers, health records, financial information, and more. This data is crucial for assessing risk, underwriting policies, and managing claims. However, the concentration of sensitive data within centralized servers poses significant privacy risks. Unauthorized access, data leaks, and cyber-attacks can expose individuals to identity theft, financial fraud, and other malicious activities. According to a report by the Ponemon Institute, the average cost of a data breach in the insurance sector was \$5.85 million in 2021, highlighting the financial impact of such incidents (Ponemon Institute, 2021). Moreover, the reputational damage resulting from data breaches can be irreparable, leading to a loss of customer trust and loyalty. Customers must be vigilant in assessing the privacy practices of their insurance providers and demand robust security measures to protect their personal information. The implementation of blockchain technology in the insurance industry offers a promising solution to these challenges. Blockchain's decentralized nature ensures that data is not stored in a single location, reducing the risk of widespread data breaches (Gatteschi et al., 2022). Each transaction and interaction is recorded in an immutable ledger, enhancing transparency and accountability. Furthermore, blockchain's encryption protocols can safeguard data integrity, ensuring that personal information remains secure and private (Wang et al., 2022).

Blockchain. Nakamoto's seminal paper introduced bitcoin as a peer-to-peer electronic cash system designed to facilitate direct online payments between parties without the need for intermediaries

such as banks. At the heart of this system lies the necessity for a robust ledger mechanism to ensure the security and integrity of transactions, which is effectively provided by blockchain technology. Blockchain is essentially a distributed ledger that maintains a continually growing list of confirmed data records managed by a network of participants, known as nodes. When a transaction occurs within the bitcoin network, the initiating individual uses their private key to generate a digital signature, which serves as a binary code. This signature can then be verified by other participants in the network using the initiator's public key. The transaction involves the transfer of bitcoin along with a hash value generated based on the previous transaction's information. The robust nature of this hashing process makes it exceedingly difficult to tamper with, as it would necessitate guessing the precise input used to generate the hash value. Once the nodes reach a consensus on the validity of the transaction, it is recorded in a block. Each block possesses a unique hash value and is intricately linked to both the preceding and succeeding blocks, thereby forming an immutable and comprehensive history of all transactions. This sequential recording mechanism intrinsic to blockchain technology effectively prevents tampering; altering a single element within the chain would require modifications to the entire transaction history (Gerardi et al., 2023).

Figure 1. Blockchain Mechanism



Source: Gerardi et al. (2023).

The concept of smart contracts, introduced by Nick Szabo in 1997, has further revolutionized blockchain technology. Smart contracts are computerized protocols that automatically execute the terms of a contract when pre-defined conditions are met. By encoding these contract terms into code, blockchain combined with smart contracts allows for the secure transfer of assets between parties who may not trust each other. Moreover, it facilitates complex, multi-step procedures involving several distrustful parties, ensuring that all steps are executed as agreed upon. Blockchain's broader application extends beyond mere financial transactions; it has the potential to facilitate secure, autonomous processes among multiple nodes in a variety of networks. This versatility makes blockchain an attractive solution for numerous industries seeking to enhance security, transparency, and efficiency in their operations.

3. Research Method

Exploratory studies are particularly valuable for investigating phenomena that are not yet well understood, generating ideas and hypotheses for future research. These studies typically focus on answering "what" and "how" questions, making them well-suited for the objectives of this research (Saunders et al., 2023). Given the limited resources and specific aims of this study, an exploratory approach is deemed appropriate. The data collected for this research will primarily consist of secondary data, due to constraints related to time and resources. Secondary data sources include organizational databases, official reports, books, peer-reviewed journal articles, magazine and newspaper articles, interview transcripts, press releases, and conference proceedings that are pertinent to cloud computing and blockchain technology. The analysis of this data will be performed in three distinct steps: (1) Extracting Important Passages: This initial step involves identifying and isolating crucial segments of text from the collected secondary data sources. (2) Defining the Meaning of Extracted Texts and Labelling: The extracted texts will be thoroughly analysed to ascertain their meaning, after which they will be labelled into distinct codes and concepts. (3) Finding Meaningful Patterns and Relationships: The final step entails examining the labelled codes and concepts to uncover significant patterns and relationships, thereby providing deeper insights into the research topic. Through this meticulous methodological approach, the study aims to provide a comprehensive understanding of the feasibility and implications of implementing blockchain technology for managing customers' data, with a specific focus on its potential to reduce security and privacy risks in various contexts.

4. Finding and Discussion

Based on the data collected, there is pattern that indicates blockchain's dimension as described on Table 1.

Table 1. Blockchain Dimensions.

Dimension	Sub-Dimension	Author(s)
Cost	Initial Investment	(Zhang Y., et al. 2023); (Lorenz J., 2023); (Li J., 2023); (Deloitte, 2023); (Allianz Global Corporate & Specialty, 2023);
	Time	(Capgemini Research Institute 2023); (Chien, C. F., 2023)
Flexibility	Formation	(Nguyen, Q. K. et al, 2023) ; (Zhang Y., et al. 2023)
	Provider Involvement	(Lamberti, F. et al., 2022); (Lorenz J. et al., 2023)
	Mechanism	(Gatteschi, V. et al. 2022); (Leiding, B. et al., 2022)
Security	Data Integrity	(Chien, C. F. et al. 2023); (Hans, R. et al. 2022); (Wang, S. et al. 2022).; (Zhang Y., et al. 2023) (Lorenz J. et al., 2023); (McKinsey & Company 2023); (Boston Consulting Group. 2022);
	Transparency	(Sharif, A. et al. 2023); (Nguyen, Q. K. et al, 2023) ; (Zhang Y., et al. 2023); (World Economic Forum 2023); (AXA Strategic Ventures Research 2023)
	Regulations	(Dorfman, A. et al., 2023); (Lamberti, F. et al., 2022); (Lorenz J., 2023); (Deloitte 2023)
Scalability	-	(Hans, R. et al. 2022); (Wang, S. et al. 2022).; (Zhang Y., et al. 2023); (PwC 2022); (Swiss Re Institute 2022)
Performance	-	(Zhang Y., et al. 2023); (Lorenz J., 2023); (Li J., 2023); (Institute of International Finance. 2022)

Cost. Cost refers to the resources required for implementing, maintaining, and enhancing technology, whether cloud computing or blockchain. The most common cost pattern observed is the initial investment in blockchain technolog. Due to its decentralized nature, users must invest

in above-average computing hardware (Zhang et al., 2023). Enterprises need significant resources for hardware infrastructure for storage and computational power. Organizations considering blockchain adoption must account for substantial investments in computing hardware. Blockchain requires more time for data processing, demanding high computational power from enterprise users (Li et al., 2023). Blockchain adoption within the insurance sector requires significant financial investment and additional time for data processing. The costs are not limited to hardware alone; software development for blockchain applications demands skilled personnel who are proficient in blockchain technology, which can also add to the overall expenses. Additionally, ongoing maintenance and upgrades to the system will require continuous investment, posing a financial challenge to sustaining the technology.

Research Proposition 1 (RP1): The initial investment required for implementing blockchain in insurance services' customer data management is expensive.

Flexibility. Flexibility refers to the level of customization available in blockchain. Blockchain's deployment model allows enterprise users to implement the technology according to their specific business process requirements. This flexibility enables blockchain to be used beyond cryptocurrency (Nguyen et al., 2023). Despite access limitations, blockchain provides similar flexibility, leading to the emergence of blockchain as a service (BaaS) offered by cloud providers like IBM and Microsoft. However, BaaS could endanger citizens' data as it involves entrusting data to the provider's server. Blockchain's adaptability allows organizations to tailor their implementations according to their unique needs, such as customizing smart contracts for various applications beyond finance, including supply chain management, healthcare, and insurance services customer data management. This level of customization can foster innovation and efficiency within the organization (Gatteschi et al., 2023). However, the flexibility comes with challenges of ensuring security and privacy, as different implementations may require specific security measures. Additionally, the interoperability between different blockchain platforms and existing systems poses technical challenges that must be addressed for seamless integration.

Research Proposition 2 (RP2): Blockchain is sufficiently versatile to be implemented in managing customer data for insurance services.

Security. Security refers to the level of protection against malicious attacks. As data is valuable, security is a major concern. Codes embedded in blockchain can introduce vulnerabilities, making data susceptible to attacks (Hans et al., 2022). Blockchain's decentralized nature requires transparency to ensure data immutability, but this transparency may be perceived as a privacy breach (Chien et al., 2023).

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Blockchain's hype suggests it could replace cloud computing due to its secure mechanism (Zhang et al., 2023). Public blockchains offer high transparency, enhancing security but raising privacy concerns. Tracing data provenance through blockchain architecture allows auditors to track data usage, preventing improper use by cloud providers. Permissioned blockchain models restrict transaction visibility to specific nodes, enabling users to manage transparency by adding a node to monitor data flow. However, security concerns persist, as blockchain is not immune to attacks like the 51% attack or collusion between nodes and providers/auditors. Indonesia's Ministry of Communication and Informatics has published one regulation concerning blockchain implementation. The lack of regulation generates concern about blockchain's benefits, but premature regulation could hinder technology growth. The secure nature of blockchain makes it a promising technology for protecting sensitive information, especially in industries like insurance, where customer data management requires stringent safeguards. Blockchain's decentralized architecture ensures that data is distributed across multiple nodes, reducing the risk of single points of failure. Furthermore, its immutable ledger guarantees that once information is recorded, it cannot be altered without consensus, offering robust protection against unauthorized modifications. Despite these security benefits, blockchain is not without risks. The technology must address potential vulnerabilities such as cryptographic attacks, where hackers attempt to exploit weaknesses in encryption algorithms to gain access to sensitive data. These attacks could compromise the integrity and confidentiality of stored information, underscoring the need for continuous advancements in cryptographic techniques. Legal and ethical considerations surrounding data transparency also present challenges, particularly when balancing security and privacy. Blockchain's inherent transparency, which allows all participants to access and verify transaction details, may conflict with privacy regulations, such as GDPR, that require organizations to protect personally identifiable information. Establishing clear guidelines and frameworks for data handling within blockchain systems is essential to navigate these complexities. Moreover, implementing robust security protocols like multi-factor authentication, zero-trust frameworks, and regular audits can further fortify blockchain against emerging threats. These measures not only strengthen the technology's defenses but also enhance trust among users by demonstrating a proactive approach to safeguarding their data. In addition, the adoption of permissioned blockchain models could mitigate some security concerns. By restricting access to transaction visibility, these models enable organizations to exercise greater control over data transparency while maintaining the advantages of blockchain's decentralized nature. Regular updates to software and hardware are also crucial to ensure that the system remains resilient in the face of evolving cyber threats. Finally, a collaborative approach involving technology vendors, regulatory bodies, and industry stakeholders can play a pivotal role in addressing security challenges. By fostering innovation, sharing best practices, and developing standardized protocols,

such collaboration can help harness blockchain's security potential while ensuring its sustainable growth across various sectors.

Research Proposition 3 (RP3): Blockchain has the potential to enhance security in managing customer data for insurance services.

Scalability. Scalability focuses on technology's ability to adapt to users' needs (Wang et al., 2022). Blockchain faces challenges in adjusting to varying demands. When an enterprise joins a consortium blockchain ecosystem, the network must reconsider the consensus mechanism, requiring deliberation among nodes. Blockchain's sequential transaction recording introduces complexity and time-consuming processes, unsuitable for data requiring frequent movement (Zhang et al., 2023). The dynamic nature of insurance services' customer data management, with frequent node changes, adds complexity to blockchain implementation. Changing nodes intermittently affects network rules and imposes additional workload for maintaining data integrity. Scalability is essential for the widespread adoption of blockchain technology. However, the inherent design of blockchain, which involves sequential transaction processing and decentralized consensus mechanisms, poses scalability challenges. As the number of users and transactions increases, the network may experience delays and reduced efficiency. For insurance services' customer data management, the frequent changes in nodes and data movement require a scalable approach to ensure consistent performance. Advanced consensus algorithms and optimized data structures may help in addressing these scalability issues. Additionally, collaboration among stakeholders to develop standards and protocols can enhance blockchain's scalability and adaptability.

Research Proposition 4 (RP4): Implementing blockchain for managing customer data in insurance services will demand significant time and effort.

Performance. Performance refers to task execution efficiency (Zhang et al., 2023). Blockchain demands high processing power as data is not stored in a centralized database. Users must invest in hardware for sufficient processing power for data storage and transfer. As blockchain blocks grow in size, proper computing hardware is necessary for effective performance (Lorenz et al., 2023). If the insurance sector adopts blockchain, it must invest in computational power for nodes maintaining data (miners) to perform effectively. The insurance sector may not face budget constraints, but computing performance alone cannot ensure effective implementation. Stakeholders within the blockchain ecosystem must work accordingly, requiring efforts and time invested by nodes. Effective performance is a cornerstone of successful blockchain technology implementation, particularly in the context of managing insurance services' customer data. The decentralized architecture of blockchain demands substantial computational resources to execute,

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verify, and record transactions across the network. As the blockchain grows in scale, the size of blocks and the complexity of associated data transactions increase correspondingly, necessitating continuous investments in high-performance computing hardware. This includes processing units capable of handling intricate cryptographic algorithms and large-scale data operations without compromising speed or accuracy. Beyond hardware requirements, software optimization plays a pivotal role in enhancing blockchain performance. Advanced algorithms designed to streamline consensus mechanisms can significantly reduce transaction latency, ensuring quicker data validation and reporting. These improvements are particularly valuable in scenarios where real-time data access is critical, such as in the insurance sector's customer data management. Collaboration among stakeholders—comprising insurance providers, technology vendors, auditors, and regulatory bodies—is indispensable for achieving synchronized efforts across the blockchain ecosystem. This collaboration is critical for addressing performance bottlenecks and ensuring consistency in the application of network protocols. Effective communication and coordinated strategies allow participants to integrate and upgrade resources seamlessly, minimizing disruptions and fostering trust within the network. Moreover, regular monitoring and system upgrades are essential to sustaining peak performance levels. Proactive identification of inefficiencies or vulnerabilities enables stakeholders to implement timely solutions, thereby maintaining the integrity and reliability of the blockchain network. These upgrades might involve implementing faster processing frameworks, enhancing user interfaces, or scaling storage capabilities to accommodate increasing data volumes. By combining robust computational infrastructure with ongoing system improvements, blockchain technology can deliver the efficiency and reliability required for managing sensitive customer data securely and transparently.

Research Proposition 5 (RP5): Implementing blockchain for managing insurance services' customer data requires significant computational power.

Figure 2. Proposed Blockchain Mechanism for Insurance Sector.

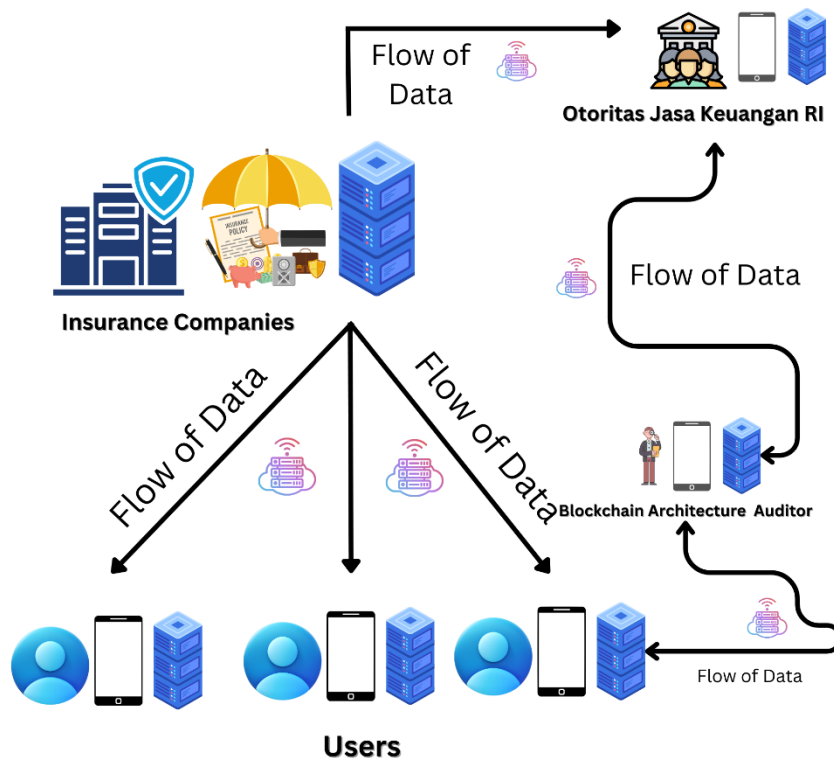


Figure 2 illustrates the potential future implementation of blockchain for insurance services' customer data management, showcasing various stakeholders, including the insurance companies, customers, vendors, and blockchain architecture auditors. In this model, users can track data movements concerning their personal data, providing them with greater control and transparency over their information. This level of transparency is one of the key advantages of blockchain technology, as it enables users to monitor their data and ensure that it is being used appropriately and securely. Blockchain's robust security mechanisms make data tampering and unauthorized access extremely difficult, thereby safeguarding personal information. The deployment of blockchain technology, complemented by the role of blockchain architecture auditors, ensures that nodes within the network act responsibly and adhere to established protocols, thereby potentially

mitigating privacy concerns. These auditors would oversee the network's operations, ensuring compliance with security standards and fostering a trustworthy environment for data management. Furthermore, the integration of advanced consensus algorithms and optimized data structures can enhance blockchain's scalability and performance, addressing the challenges identified in RP3, RP4, and RP5. By continuously upgrading computational hardware and software algorithms, stakeholders can achieve faster transaction processing and maintain high network integrity. Collaborative efforts among all parties involved, including regular monitoring and system upgrades, are essential to sustain seamless operations and reliability, paving the way for effective and efficient insurance services' customer data management through blockchain technology

Research Proposition 6 (RP6): Blockchain has the potential to address security and privacy concerns regarding customer data management in insurance services.

This proposition emphasizes the potential of blockchain technology to address the critical concerns of security and privacy in managing insurance services' customer data. Through its decentralized nature and immutable ledger, blockchain offers a secure framework for storing and transferring personal data, reducing the risk of breaches and unauthorized access. By ensuring that nodes behave appropriately and that data movements are transparent, blockchain can significantly enhance the protection of personal information, providing a reliable solution for data management in the digital age.

5. Conclusion

This extensive research delved into the potential of blockchain technology for improving the management of insurance services' customer data and its effects on privacy and security. By thoroughly analyzing secondary data sources, the study aimed to understand how blockchain implementation could transform data handling practices within the insurance sector. Experiments conducted during the study presented promising results, indicating that blockchain could significantly enhance security measures and increase transparency in data management. The decentralized nature of blockchain allows for the creation of an immutable ledger where each transaction is securely recorded, reducing the risk of data breaches and unauthorized access. Furthermore, the ability of users to monitor the movement of their personal data provides an additional layer of transparency, empowering them with greater control over their information. For blockchain technology to be effectively deployed in the insurance sector, it is crucial that the nodes within the network behave appropriately and adhere to established protocols. The role of blockchain architecture auditors is vital in this context, as they oversee the network's operations and ensure compliance with security standards. These auditors would act as guardians of the blockchain ecosystem, fostering a trustworthy environment for data management. Despite the

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potential benefits, there are significant challenges associated with the implementation of blockchain in the insurance industry. One of the primary obstacles is the high initial investment required for computational hardware and software. Advanced computing resources are essential to process and verify transactions efficiently, especially as the blockchain network expands and the complexity of transactions increases. Additionally, the immaturity of blockchain technology in Indonesia poses further hurdles, with stakeholders needing to invest considerable effort and time to optimize software algorithms and enhance scalability. The insurance sector is recommended to consider adopting blockchain technology for managing customer data, as it promises to address critical concerns related to security and privacy. However, there is currently no indication of the industry moving towards deployment, possibly due to the aforementioned challenges. Collaborative efforts among all parties involved, including regular monitoring and system upgrades, are essential to sustain seamless operations and reliability, paving the way for effective and efficient insurance services' customer data management through blockchain technology.

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