BANK INDONESIA
BANK SENTRAL REPUBLIK INDONESIA

Public Consultation Report

PROJECT GARUDA

Wholesale Rupiah Digital Cash Ledger

2023

disclaimer

This report summarizes public comments on the design of the wholesale Digital Rupiah Cash Ledger and does not represent Bank Indonesia's stance. Bank Indonesia welcomes all forms of public participation and input sent to support the development of the most appropriate and suitable Digital Rupiah for the Republic of Indonesia.

Preface

Assalamu'alaikum Warahmatullahi Wabarakatuh, Peace be upon us all, Shalom, Om swastiastu, Namo buddhaya, Greetings of virtue.

On January 31, 2023, Bank Indonesia published a Consultative Paper on the design of the Immediate Stage of the Digital Rupiah, namely the Wholesale Rupiah Digital cash ledger as a form of synergy between all stakeholders in the development of the Digital Rupiah. We received inputs and insights from industries and associations, ministries/institutions, academics, and the public up to July 15 2023 as useful feedback for the development of the Digital Rupiah design. We summarize these inputs and thoughts in this report.

We publish this report as a form of Bank Indonesia's transparency in developing the Digital Rupiah design. The involvement and contribution of these diverse stakeholders is a key element in enriching the insights in designing a Digital Rupiah design that best suits the needs of the industry and the general public. To that end, Bank Indonesia is committed to continue engaging the public in the design iterations of the Digital Rupiah, through various channels and activities that will be organized.

Bank Indonesia fully appreciates the synergy of various parties in building the Digital Rupiah design. Hopefully, the efforts of the Digital Rupiah experimentation under the Garuda Project can lead the Indonesian nation to a more advanced future and provide benefits and blessings for the whole society.

Jakarta, October 30, 2023

Filianingsih Hendarta

Deputy Governor of Bank Indonesia

Table of Content

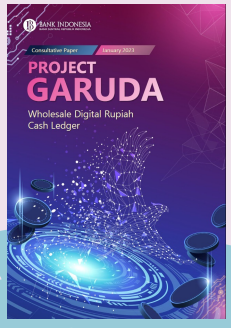
Executive Summary

- **In general, the top-level design of w-Digital Rupiahl[1] is in line with public expectations.** This report summarizes the public input gathered by Bank Indonesia through the Consultative Paper from 31 January to 15 July 2023.
- **Participation procedures must be designed in a balanced manner.** Validating node functions need to be distributed appropriately to mitigate single points of failure. The roles of wholesalers and non-wholesalers need to be separated to maintain stability. Opening membership access to non-banks will encourage innovation and healthy competition, although the number of validators remains to be determined based on effectiveness, efficiency, scalability and resilience.
- **The role of issuing and managing wallets needs to be allocated appropriately.** Wallets can be issued directly by Bank Indonesia. Meanwhile, its management can be transferred by Bank Indonesia to the industry. Bank Indonesia also needs to establish provisions or standards in the management of transaction data and/or identity to protect privacy and ensure the effectiveness of supervision.
- **Digital Rupiah Depository (KDR) needs to be managed by Bank Indonesia.** Conversely, the function of validating the validity of tokens at issuance can be performed by participants to mitigate single points of failure, accelerate the transaction process, increase innovation, ensure security, and reduce Bank Indonesia's operational burden.
- **Integrated solutions are required in gridlock resolution on Distributed Ledger Technology (DLT).** Appropriate consensus mechanisms, efficient transaction queue management, as well as the use of appropriate technologies, including the use of smart contracts in this regard are required.
- **Permissioned DLT with Proof-of-Authority (PoA) consensus mechanism is viewed as optimal.** DLT promises better security and reliability than centralized systems due to the absence of a single point of failure and the availability of features for regulating access, distribution, and encryption of transaction data. Meanwhile, the guarantee of settlement finality in PoA is considered better than other consensus mechanisms.
- **Standardization and the availability of middleware that guarantees cross-platform transferability are necessary in fulfilling the 3i aspects (interconnection, interoperability, and integration).** This step will ensure coexistence between w-Digital Rupiah platforms.
- **The impact of w-Digital Rupiah is believed to be positive on Monetary, Financial System, and Payment System.** Payment system efficiency is expected to increase. Similarly, product innovation, market efficiency, and financial market deepening. The money market and forex market are expected to be more active with the 24/7 operation of w-Digital Rupiah and more diverse use cases.

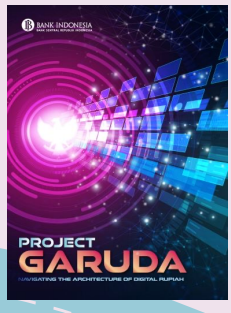
[1] See Rupiah Digital White Paper on "Project Garuda: Navigating the Digital Rupiah Architecture", November 2022.

Chapter 1
Introduction

This Public Consultation Report is a **summary of public comments and input** for the first phase of development, the Immediate State, regarding the design, impact and benefits of Rupiah Digital. This is also the **follow-up** to the Consultative Paper Phase I titled "Project Garuda: Wholesale Rupiah Digital Cash Ledger", as well as the White Paper.



Consultative Paper Phase I titled "Project Garuda: Wholesale Rupiah Digital Cash Ledger"
Januari 31, 2023



Project Garuda White Paper
November 30, 2022

Rupiah Digital's Milestone

35 Questions

Bank Indonesia published Consultative Paper Phase I titled "Garuda Project: Wholesale Rupiah Digital Cash Ledger" on January 31, 2023, as a follow-up to the issuance of the Garuda Project White Paper. Through this Consultative Paper, Bank Indonesia seeks public comments and inputs on the design, impact, and benefits of Digital Rupiah in the first phase of development, i.e., immediate state[1].

A total of 35 questions were asked in this Consultative Paper. The questions are divided into two categories, namely functionality and general considerations, which are then further derived into six sub-categories namely: i) technology (scalability and resilience); ii) access (membership, data access and wallet); iii) issuance and redemption; iv) fund transfer, gridlock resolution and settlement finality; v) technical capability and 3i aspects (interconnection, interoperability and integration); and vi) implications for Payment System, Financial System Stability and Monetary Stability (Appendix 1).

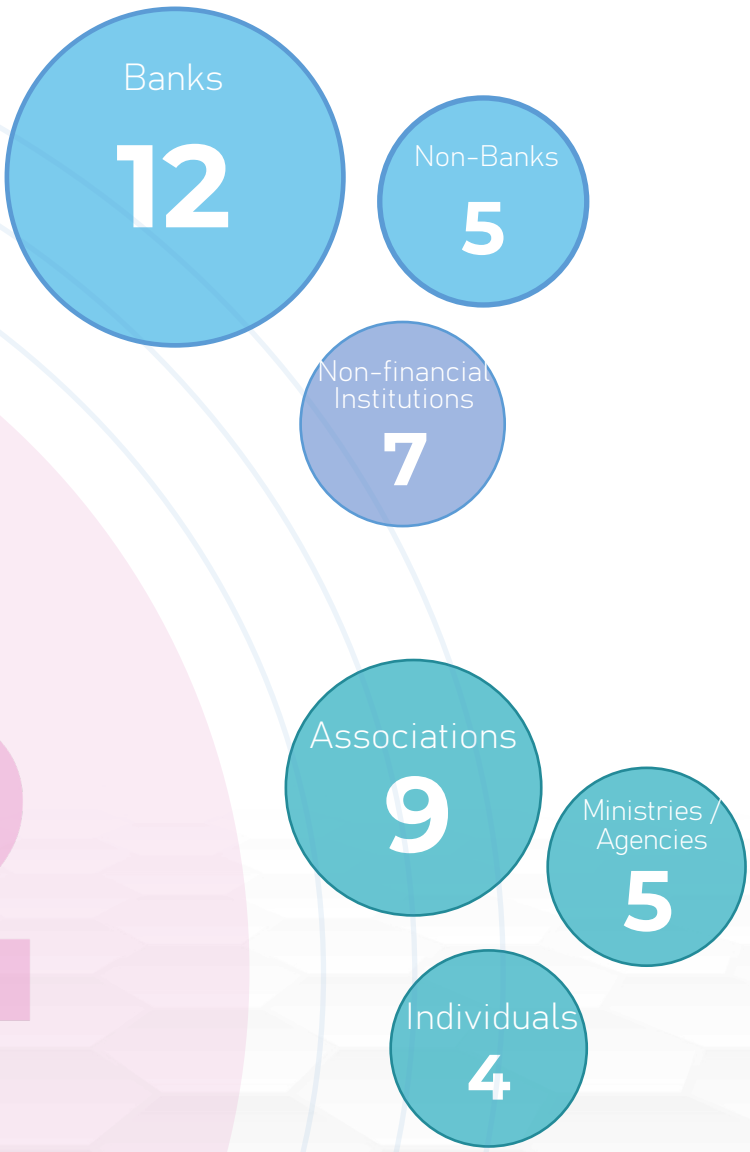
6 subcategories

[2] The development phases of Project Garuda: Phase I (immediate) w-Rupiah Digital cash ledger; Phase II (intermediate) w-Rupiah Digital cash and securities ledgers; Phase III (end state) integrated w-Rupiah Digital and r-Rupiah Digital.

A total of 42 comments and inputs were collected from Banks, LSBs, Ministries/Institutions, Associations, Academics, Non-Financial Corporations, International Institutions and Individuals. The comments and inputs were collected through written communication and Focus Group Discussion during the period of January 31 – July 15, 2023.

This report is a summary of the public input gathered by Bank Indonesia on the immediate use cases of issuance, transfer, and destruction of wholesale[3] Digital Rupiah (w-Digital Rupiah).

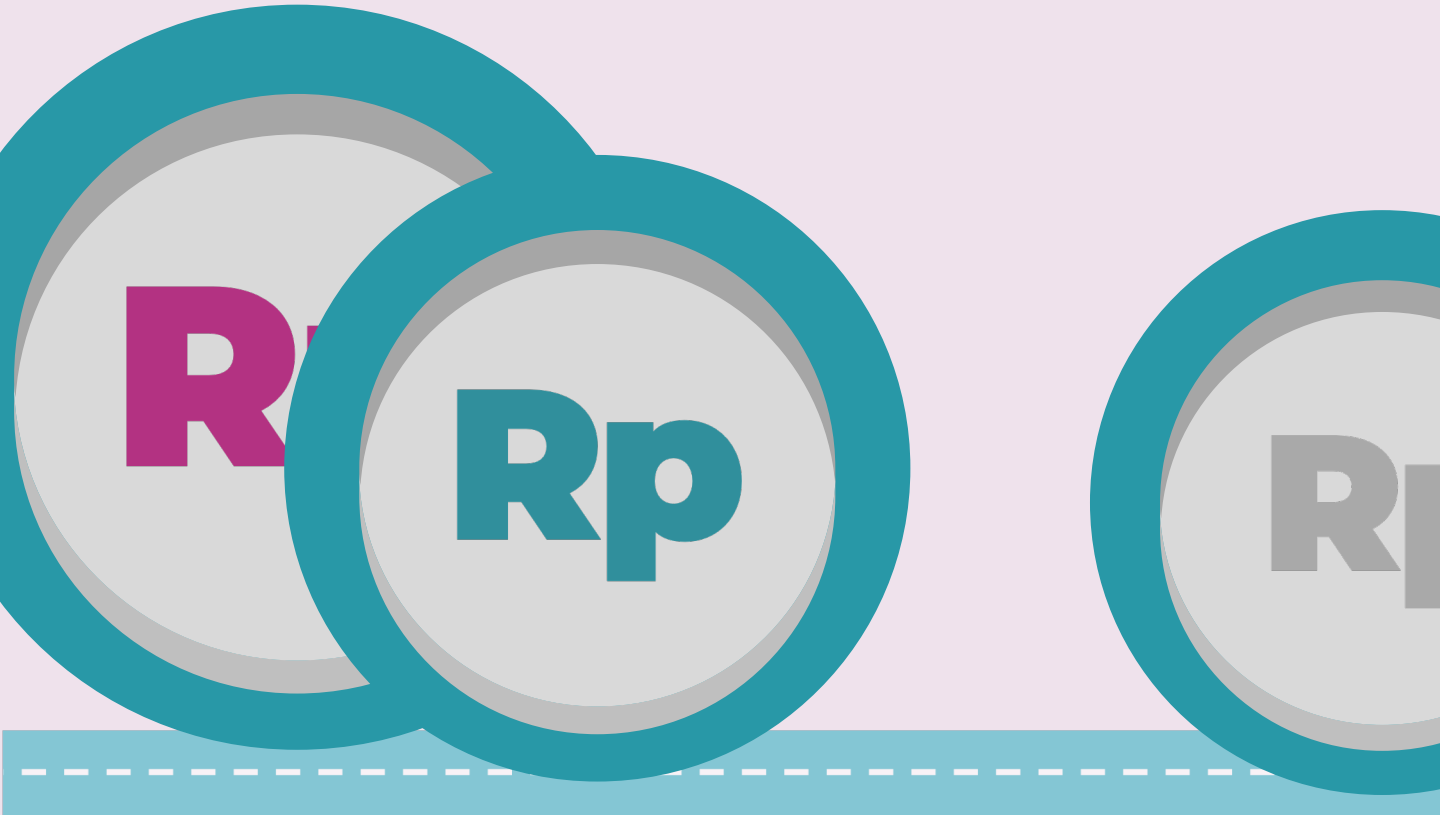
Commenters



[3] In this report, wholesale refers to various transactions in financial market, including money market, stocks, bonds, FX trading, and derivatives. These are typically large value transactions.

Chapter 2
Summary of Public Consultation

The public consultation is summarized into 6 subcategories of questions, which are i) technology (scalability and resilience); ii) access; iii) issuance and redemption; iv) gridlock resolutions, funds transfer, and settlement finality; v) technical capabilities and 3i aspects; and vi) implications towards Implications for Payment System, Financial System Stability, and Monetary System



2.1 Choice of Technology

Bank Indonesia is developing Digital Rupiah based on technology neutral principles. This section summarizes public opinion on the appropriate technology choice for w-Digital Rupiah, including the risks that Bank Indonesia needs to consider in its implementation.

Regarding the choice of technology, **respondents' opinions narrowed down to permissioned DLT.** This option is believed to be superior to a centralized system, especially in the aspect of controlling the risk of single point of failure with the availability of backups that work independently at a number of points. DLT is also able to stimulate the development of new and innovative use cases. The availability of features for regulating access, distribution and encryption of transaction data in a permissioned paradigm enables Bank Indonesia to define and regulate the role of entities in the w-Digital Rupiah platform so that the system can work more efficiently, safely and scalably.

Regarding consensus algorithms, **respondents' opinions narrowed down to the Proof of Authority (PoA) mechanism**. Compared to other mechanisms, PoA is more capable of meeting throughput needs, scalable to transaction spikes, and is more resilient, especially against cyber attacks.

However, **these solutions are not risk-proof.** There are risks such as cyber-attacks (e.g., Sybil, Eclipse, 51% attack, DDoS), single point of failure at the notary node, and operational disruption due to transaction spikes.

Risks also arise from the use of smart contracts and wallets. Smart contracts are vulnerable to exploitation, which can lead to data leaks and inaccuracies. Similarly, wallets are vulnerable to theft and illegal use of private keys.

The materialization of risks will erode user confidence in data integrity and validity. Therefore, **Bank Indonesia must take a number of mitigation measures.** Hardware standardization (including cloud), server location calibration, standardization and diversification of technology vendors are needed to mitigate cyber risks3. More than one notary node should be developed to mitigate a single point of failure. A scalable system with proper capacity planning is required to ensure system readiness to accommodate transaction surges. Bank Indonesia also needs to study in depth the fulfillment of the security features of smart contracts and wallets that will be used to prevent data leaks and illegal access.

The implementation of permissioned DLT with PoA consensus mechanism is also faced with challenges. Implementation and maintenance of DLT demands greater resources than centralized systems. In addition, determining the ideal number of validating nodes in PoA can also pose

> Bank Indonesia is developing Digital Rupiah based on technology neutral principles...

[4] Minister of Communication and Information Technology Regulation No. 3 of 2021 concerning Business Activity Standards and Product Standards in the Implementation of Risk-Based Business Licensing in the Post, Telecommunications, and Electronic Systems and Transactions Sectors regulates business standards for the development of blockchain technology.

a challenge. The impact of the failure of a single validating node in PoA will be greater than other consensus mechanisms in the event of an insufficient number of validating nodes.

The steps needed to address these challenges are:

A sufficient number of validating nodes. PoA needs to be designed in a resilient and tested manner that takes into account the needs of the network. An optimal formulation of validating nodes is needed so that the w-Digital Rupiah platform built is able to meet transaction processing needs without reducing security aspects. The formulation needs to consider network topology and size, consensus mechanism implementation, access control, data privacy, scalability targets and system resilience.

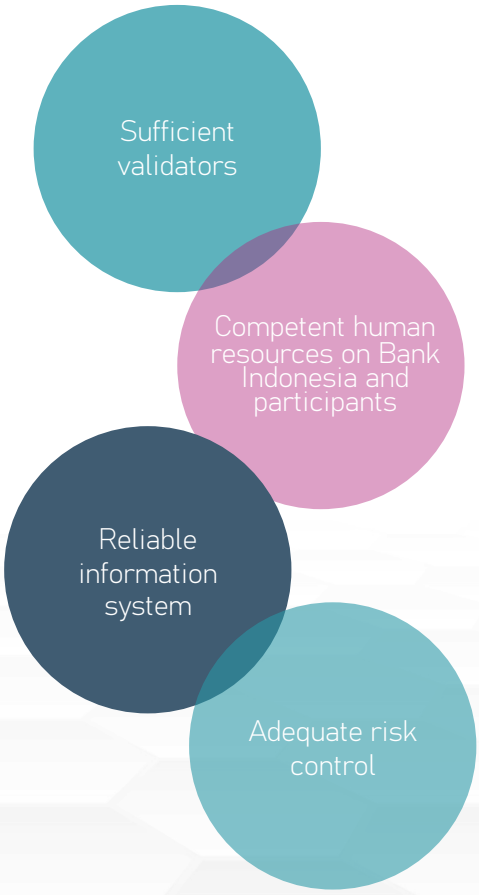
Adequate human resource competencies, both on the Bank Indonesia and participant sides. These competencies include technical competencies, in particular the practice of consensus mechanisms, mastery of smart contracts, network governance, and risk control including capabilities in responding to operational incidents.

Reliable information system capabilities. The w-Digital Rupiah platform needs to be equipped with encryption and authentication mechanisms capable of protecting sensitive data that facilitates the process of auditing and tracing activities on the network.

Adequate risk control. The w-Digital Rupiah system requires solid risk mitigation, namely a comprehensive Business Continuity Plan (BCP). Some respondents highlighted the importance of maintaining active backups on the validating nodes to mitigate risks and respond quickly to operational incidents.

DLT *permissioned*

***Proof of Authority* (PoA)**

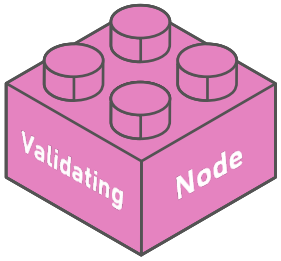


2.2. Access

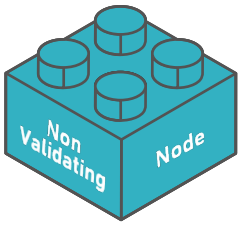
This section summarizes public opinions on participation arrangements, wallet management, and data access.

A. Participation Arrangements

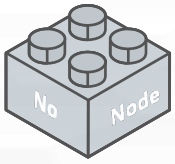
This aspect includes the construct of the roles of Bank Indonesia and industry, the roles of wholesalers and non-wholesalers and the distinction of their functions into validating, non-validating, and no-node. These aspects influence network stability and participants' investment. Related issues are segregation of participation roles and the optimal number of validators.



Bank Indonesia
Industri – Wholesaler



Industri – Non Wholesaler



Industri – Non Wholesaler

The function of validating node should be conducted by Bank Indonesia and industry to mitigate the risk of a single point of failure. The roles of wholesalers and non-wholesalers also need to be differentiated to maintain stability. Wholesalers will function as both validating node and distributor. Meanwhile, non-wholesalers can act as either non-validating node or no-node.

Non-validating node option should not be granted to wholesalers to prevent an inadequate number of validating nodes that could put platform integrity at risk. In contrast, **validating node should be restricted to wholesalers** as allowing too permissive access might lead to increased risk, especially in cyber, resulted from low computing capacity.[5]

Regulatory instruments covering the differentiation of roles, rights and obligations should be prepared. It is also the case for definition, roles, and minimum security criteria for wholesalers and non-wholesalers. Security standards for both wholesalers and non-wholesalers should at least include the procedures, infrastructure readiness, DLT practice and understanding, data privacy, and risk mitigation.

In terms of the optimal number of validators, **there are trade-offs between system scalability versus resilience and system efficiency versus security.** The greater the number of validators, the lower the system's vulnerability to cyber risks[6]. Conversely, lack of validators may increase system efficiency but heighten operational risk.

Determining the number of validators needs to consider in the effectiveness,

[5] A non-financial institution commenter argued that further disaggregation could be implemented to accommodate various risks depending on the use case. For example, custodial services should be designated to wholesalers. Wholesalers will manage customer access, administer customer accounts, and interact with BI in the event of customer insolvency.
[6] For example, the 51% attack.

efficiency, scalability, and resilience of the system design[7]. Bank Indonesia needs to determine the number and criteria of wholesalers acting as validating nodes. Suppose Bank Indonesia allows non-wholesalers to function as validating nodes. In that case, Bank Indonesia will also need to establish criteria that can ensure consistent capabilities across non-wholesalers and wholesalers. In addition, Bank Indonesia should establish incentives and technology standards that consider return on investment, operating costs, and business continuity.

LSB's participation could spur innovation and competition. Diversified participation help facilitate standardization and expand membership. Nevertheless, this may complicate security, data confidentiality, and surveillance risks management.

Thus, **non-discriminatory participation criteria based on risk profile should be established in case non-bank can partake in the platform.** These should incorporate minimum capital requirements, transaction limits, infrastructure standardization, and risk management. Equivalent requirements relevant to banks (e.g., BI-RTGS participation, technical and regulatory standards), including IT investment, should also be applied. Bank Indonesia needs to regulate the limitation in the features and roles of LSBs to prevent misuse of participation and reduce potential systemic risks.

B. Wallet Management

This aspect includes the formulation of roles for issuing and managing of wallets, including options for wallet types between cold and hot wallets. Related issues are the industry's role in wallet management and the use of cold wallets to mitigate cyber risk.

Wallet issuance should be entrusted to Bank Indonesia to ensure complete control over all services and data. The involvement of the industry in formulating the regulations and technological solutions is needed to ensure the system's interoperability and security and build user trust.

The industry should handle wallet management to promote adoption and innovation for a robust Rupiah Digital ecosystem. Therefore, Bank Indonesia must establish regulations and standards as well as oversee wallet administrators.

Commenters' views were diverged regarding options for wallet types. An individual commenter argued cold wallets should be mandatory considering the higher security level compared to hot wallets[8]. Another commenter emphasize the importance of keeping abreast of trends in wallet technology supported with a private key management framework[9].

> Wallet issuance should be entrusted to Bank Indonesia to ensure complete control over all services and data. Conversely, The industry should handle wallet management to promote adoption and innovation....

[7] In Project Stella, transaction processing time increased with additional validating nodes up to a certain number. The increase in the number of nodes, from 4 to 13, increased the transaction volume by 20%.
[8] Cold wallets are part of a multi-layered wallet security system that protects against cyberattacks and the loss of digital assets.
[9] For example, the adoption of cold storage is becoming less favorable than multi-signature (multisig) and Multi-Party Computation.

In contrast, the majority of commenters from associations and non-financial institutions suggested that **cold wallets should be optional.** Although being more secure than hot wallets, cold wallets' accessibility and convenience are relatively limited, and they require a greater investment. Cold wallets are regarded as more appropriate for retail transactions and consumers with limited Internet access.

C. Data Access

This aspect includes the construction of personal data management and security within w-Rupiah Digital. The main issue is on balancing confidentiality and auditability.

Commenters stated that **it is necessary to establish arrangements/standards for administering transaction/identity data.** Concerning technology, commenters viewed **privacy-enhancing technology (PET) as a prospective solution** for secure and efficient data exchange that could preserve personal data. Some methods in PET, such as zero-knowledge proof (ZKP) and privacy group[10] allow configuration for partial disclosure of data to the public.

> Commenters viewed privacy-enhancing technology (PET) as a prospective solution for secure and efficient data exchange that could preserve personal data...

Regarding the compliance to Anti-Money Laundering and Countering the Financing of Terrorism (AML-CFT) principles, **commenters recommended the use of key randomization**[11] for AML-CFT monitoring that could preserve privacy. The Ring signature technology and encryption[12], combined with a personal data protection mechanism (ZKP or Privacy Group), also present as potential solutions.

Nonetheless, **the implementation of PET should consider relevant risks.** PET implementation may reduce throughput scalability. Therefore, the PET selection must consider its impacts on platform reliability and performance. In addition, standards regarding data access, view, and publication should be established to maintain a balance between confidentiality and auditability .

[10] ZKP is a validation method to a statement without requiring the disclosure of the statement itself. Privacy group utilizes a private channel between network entities so that only the transacting parties can view the transactions.
[11] With key randomization, parties involved in a transaction is identified with their public key, while fresh key pairs are generated for each transaction.
[12] These methods separate individual transaction data.

2.3 Issuance & Redemption

This section summarizes public opinions on validation of token during issuance and redemption, including the roles of Digital Rupiah Depository (KDR) and token validator.

KDR mainly operates in the management, storage, and distribution of w-Rupiah Digital. Commenters highlighted **potential expansion of the KDR functions** for custodian services, illegal transactions monitoring, and interoperability of the Rupiah Digital.

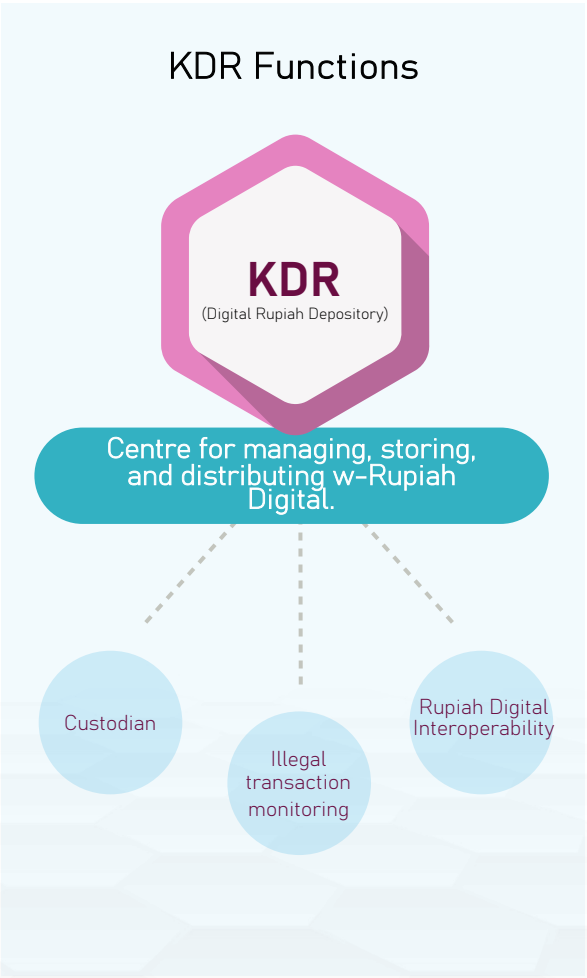
Commenters argued that **KDR could be managed by Bank Indonesia.** To prevent a single point of failure, **token validation functions for issuance is performed by participants.** This would also accelerate transaction processes, stimulate innovation, ensure security, and reduce Bank Indonesia's operational burden.

In the operationalization of the w-Rupiah Digital issuance and redemption, several risks may arise. These include the risks of delays, errors, and faults in the issuance and redemption as well as increasing cyber risks due to 24/7 operations.

Regulations concerning the issuance and redemption of w-Rupiah Digital should be established. Specifically, the regulations should cover areas such as the issuance and redemption of w-Rupiah Digital outside of BI-RTGS operating hours, the selection of redemption mechanisms[13], identity

> Commenters argued that KDR could be managed by Bank Indonesia. On the other hand, token validation functions for issuance is performed by participants...

verification and authorization, digital signatures, network and system security, data storage security, monitoring, auditing.



[13] Commenters from non-financial institutions conveyed two mechanisms for the redemption of w-Rupiah Digital: (i) in DLT system, resulting in a decrease in the stock of w-Rupiah Digital; (ii) deposited in Bank Indonesia, resulting in no change in the stock of w-Rupiah Digital.

2.4 Gridlock Resolution, Funds Transfer and Settlement Finality

This section summarizes public opinions on gridlock resolution application, liquidity provision arrangements, and settlement finality in DLT.

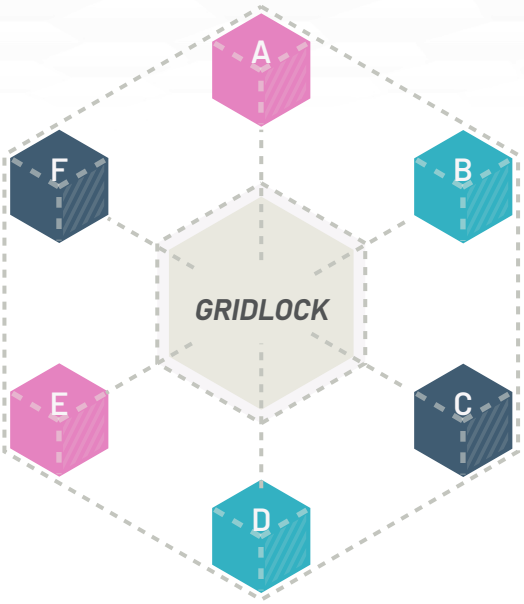
A. Gridlock Resolution

Most commenters agreed that **the high complexity of gridlock[14] resolution in DLT is an important issue.** Only a small fraction of commenters that expressed this is only relevant to retail transactions (r-Rupiah Digital).

Commenters suggested gridlock resolution in a DLT platform would require **proper consensus mechanisms, efficient transaction queue management, and appropriate technology adoption.** The implementation of the intraday/overdraft facility scheme, performance standards for validators, early warning indicators, and ZKP are highly advised[15]. These solutions are deemed as suitable for ensuring smooth operation and improving overall platform efficiency and scalability.

Specifically, commenters elaborated several strategies to prevent gridlock in DLT:

- Association commenters recommended grouping of transactions, increasing the number of validators, sharding, and the use of Zero-Knowledge Rollups (ZK Roll-Ups).
- Commenters from financial and non-financial institutions observed the use of smart contracts and Liquidity Saving Mechanisms (LSMs), in addition to queue management systems.



Strategies

Associations	Financial and non-financial institutions
▪ Grouping of transactions ▪ Increasing the number of validators ▪ Sharding ▪ Zero-Knowledge Rollups (ZK Roll-Ups).	▪ The use of smart contracts ▪ Liquidity Saving Mechanism (LSM) ▪ Queue management system

B. Funds Transfer

This aspect include the implementation of liquidity provision functions in DLT.

[14] According to the BIS, gridlock is a situation that can arise in a funds or securities transfer system in which the failure of some transfer instructions to be executed (because the necessary funds or securities balances are unavailable) prevents a substantial number of other instructions from other participants from being executed.

[15] Project Ubin Phase 2 described the experimentation of gridlock mechanism on three DLT platforms. One of them is Quorum which adopted zero-knowledge proof to resolve gridlocks.

Commenters tend to diverge on the role of liquidity providers. Some argued that such role is necessary to ensure an adequate supply of w-Rupiah Digital, support the smooth transfer of funds, ensure security and efficiency in the transaction process, monitor and estimate the demands for w-Rupiah Digital, and perform gridlock resolution. This role could be fulfilled by Bank Indonesia, wholesalers, commercial banks, and other institutions appointed by Bank Indonesia.

In contrast, several commenters expressed that **the role is no longer necessary with the advent of smart contract.** In addition, participants' liquidity requirements can be covered using their BI-RTGS balance. Due to the on-demand nature of the w-Rupiah Digital, liquidity mismatch can be facilitated by Intraday Liquidity Facility (FLI)[16].

Financial institutions commenters suggested that w-Rupiah Digital design could focus on interoperability with BI-RTGS. In addition, Bank Indonesia should explore an early warning system for managing participant liquidity, including the use of Automated Market-Making (AMM) and Liquidity Management Capabilities, commonly found in Decentralized Finance (DeFi) platforms.

C. Settlement Finality

Issues on settlement finality[16] in DLT include the suitability of consensus mechanism and legal basis that ensures settlement finality in a decentralized system.

> Most commenters regarded PoA as the most appropriate consensus mechanism. Nonetheless, there are risks associated with PoA...

Most commenters regarded **PoA as the most appropriate consensus mechanism.** It is seen as more capable in guaranteeing finality that the Proof-of-Stake (PoS) and Proof-of-Work (PoW). Settlement finality in DLT also needs to accommodate transaction reversibility and correction features, both of which can be facilitated by smart contracts or network configurations, before the settlement finality point is reached.

Nonetheless, there are risks associated with PoA. Those risks include compromised validating nodes and violation of rules by validating nodes[18]. To mitigate such risks, Bank Indonesia should carefully select validating nodes, in addition to a reliable and secure system.

The effectiveness of PoA also depends on its validation design and configuration. For this reason, designing such consensus mechanism would require comprehensive understanding and careful planning. These are also relevant to settlement finality in DLT, especially with regards to immutability, including specifying the distinction between the definitions of finality according to the system and law.

[16] According to PBI no.6/6/2004 regarding Intraday Liquidity Facility for Commercial Banks, intraday liquidity facility (FLI) is funding facility offered by Bank Indonesia to facilitate banks overcoming their shortage in liquidity during the operating hours of the BI-RTGS System given the value of outgoing obligation is greater than the balance of their Rupiah reserve account at Bank Indonesia.
[17] Settlement finality is funds that have been transferred from one institution to another that is final and irrevocable in principle. This procedure is regulated in Law Number 3 of 2011 concerning Funds Transfer to guarantee/ensure the point in time when the transaction is declared final or irrevocable.
[18] Validating nodes are considered compromised when they have been accessed or controlled by unauthorized or malicious parties.

2.5 Technical Capabilities and 3i Aspects (Interconnectivity, Interoperability, dan Integration)[19]

This section summarizes public opinions on the technical harmonization between DLT systems and financial market infrastructures (FMIs) as well as the use of cloud.

A. Harmonization of DLT Systems with Traditional Systems

This aspect includes issues on the interoperability between DLT and traditional systems, including the prerequisites for coexistence and relevant risk factors.

Commenters argued that integrating DLT with FMIs could be the solution to improve transactional efficiency. Thus, **there is a need for standardization and risk mitigation** through the adoption of the latest technical standards, i.e., protocols, data formats, APIs, and encryption, as well as regulatory support.

Bank Indonesia should use a DLT platform that supports interoperability and prepare middleware for systems integration. These aim to achieve cross-chain transferability, complement the existing systems and provide those systems with added values while promoting innovative use cases.

However, **integration between w-Rupiah Digital and FMIs encounters several risk factors.** The risks include cybersecurity, regulatory compliance, ineffectiveness, scalability, asset price volatility, asset loss (partially or completely) due to technological disruptions, and the systemic impact of a failure in one participating node on the overall system stability.

Commenters argued that integrating DLT with FMIs could be the solution to improve transactional efficiency...

In particular, commenters highlighted the differences between technological design of the decentralized w-Rupiah Digital platform and the centralized r-Digital Rupiah from the high-level configuration's perspective of Rupiah Digital. The Rupiah Digital conversion between these two platforms can introduce security risks. In this regard, the commenters considered **the use of reliable middleware and connectors would overcome this issue.** The 3i aspects needs to consider compatibility, cost effectiveness, scalability, and transaction complexity between w-Rupiah Digital platform and FMIs.

Integrating DLT with existing financial market infrastructures provide a solution to improve transaction efficiency and capability for the future. Certainly, this decision is based on a clear understanding of risks associated with interoperability and

[19] The forms of connectivity between financial market infrastructures. Interconnection is the ability of two systems to exchange information or transact indirectly through intermediaries. Interoperability is the ability of two systems to communicate or transact directly. Integration is the harmonization of post-trade infrastructure in one institution for a value chain of transaction services.

regulatory harmonization. Bank Indonesia and stakeholders must consider compatibility, cost-effectiveness, scalability and complexity of transactions across the w-Digital Rupiah platform and existing infrastructures.

Participations from the industry would require appropriate incentives.

B. Cloud Usage

This aspect includes the use of cloud provider which could enhance the resilience of the DLT system for w-Rupiah Digital.

Commenters viewed that standardization of cloud used for the DLT platform is crucial to mitigate risks related to the regulators and participants[20]. The unstandardized use of cloud services possesses challenges for nodes to establish connection and share data, triggering system vulnerabilities and data leakage (e.g. illegally copying data and replicating data overseas).

Standardization of cloud would depend on use cases and network design, service level agreement (SLA), business continuity plan (BCP), and audit and compliance. It is also needs to consider landing zone, network, compute, security, logging, monitoring, and compliance. **Commenters suggested the use of masking and limiting the types of data that can be transferred based on sensitivity.**

Bank Indonesia should consider the **prerequisites for the use of multiple cloud services** with different provider locations spread across Indonesia.

Commenters believed that **the use of cloud should be optional.** In this case, participants may build an on-premise data center tailored to their specific needs. Flexibility, scalability, and services (such as usability, cost, and security) are the main factors influencing these needs.

For the early stages of the w-Rupiah Digital implementation, **commenters suggested that Bank Indonesia might offer an on-chain cloud to participants.** In the next stage, participants can connect to the Rupiah Digital system through their cloud or independent on-premise data center.

> Commenters viewed that standardization of cloud used for the DLT platform is crucial to mitigate risks related to the regulators and participants. Furthermore, the use of cloud should be optional...

[20] Kesetaraan standar teknis antara lain penggunaan platform DLT *permissioned* yang saat ini umum digunakan dalam *web* 3.0.

2.6 Implications towards Payment System, Financial System Stability, and Monetary System

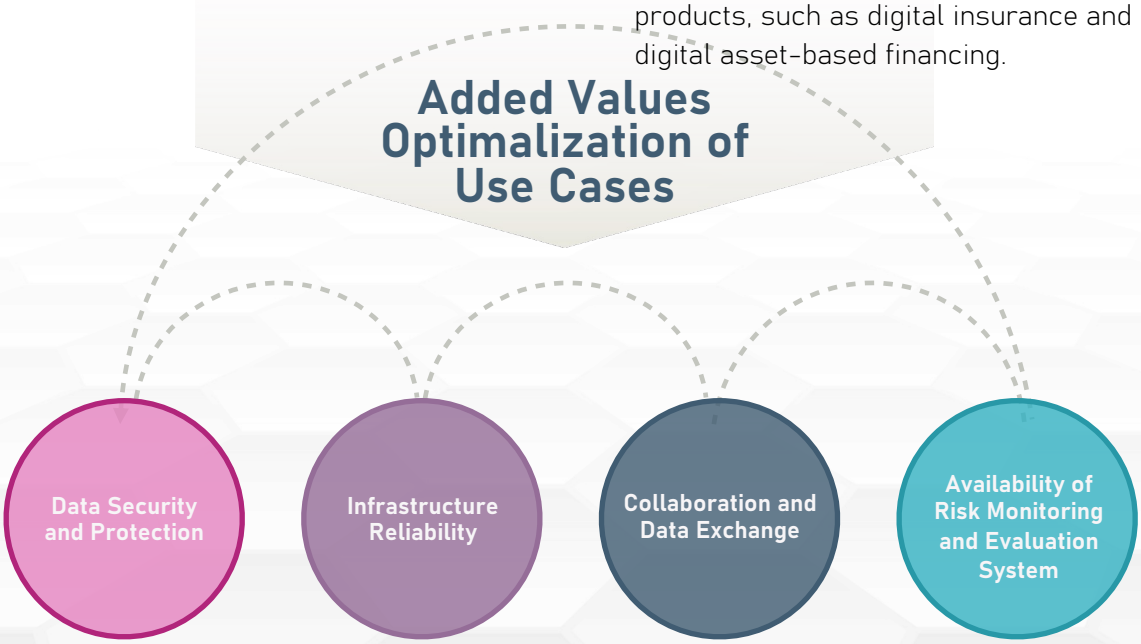
This section summarizes public opinions on the implications of w-Rupiah Digital on the payment system, financial system, and monetary system.

The w-Digital Rupiah implementation will alter the role of FMIs and increase the payment system's efficiency. The implementation and securities tokenization will reduce the importance of Central Securities Depositories (CSD)21 and Central Counterparty (CCP)22. The payment system's efficiency will increase after a decrease in transaction costs and an increase in transaction speed. The 24/7 operations of w-Digital Rupiah facilitate real-time settlement with immediate finality and reduce human errors.

Participants' compliance with rules and standard aspects and the availability of various use cases can optimize Digital Rupiah value added. The aspects include (i) data security and protection (encryption, authentication, firewalls, monitoring, recovery procedures); (ii) reliable infrastructure; (iii) collaboration and sharing information among participants; (iv) the availability of risk monitoring and evaluation systems, to manage the risk of interdependencies between infrastructures and between participants.

Several potential use cases, such as securities bonds, forex transactions with Payment versus Payment (PvP)23, and Delivery versus Payment (DVP)24, and its application on Interbank Money Market (PUAB), can accelerate the adoption of Rupiah Digital.

The implementation of Rupiah Digital could contribute to the financial market deepening. The 24/7 Rupiah Digital operation will assist banks to fulfilling their daily liquidity needs. The implementation will also encourage innovation in certain products, such as digital insurance and digital asset-based financing.



However, the integration of w-Digital Rupiah with existing FMIs carries with it certain risks. The risks include cyber security, ineffective system integration, low scalability, high volatility, operational disruption, and systemic risk because of node failure. Even though industry participation could aid in reducing concentration risk and easing the need for liquidity outside of BI-RTGS operating hours, their participation could increase liquidity and credit risks. In addition, respondents highlight the risk of disintermediation and the rise in banks' average cost of funds.

Respondents believed **the existence of a lender of last resort on w-Rupiah Digital was necessary** to mitigate the risks described above. In addition, they recommend that **Bank Indonesia closely monitor participant compliance to participation requirements and design risk management proportionally.** Moreover, Rupiah Digital must be a **non-interest-bearing asset,** similar to fiat money, to prevent price volatility and disintermediation risks.

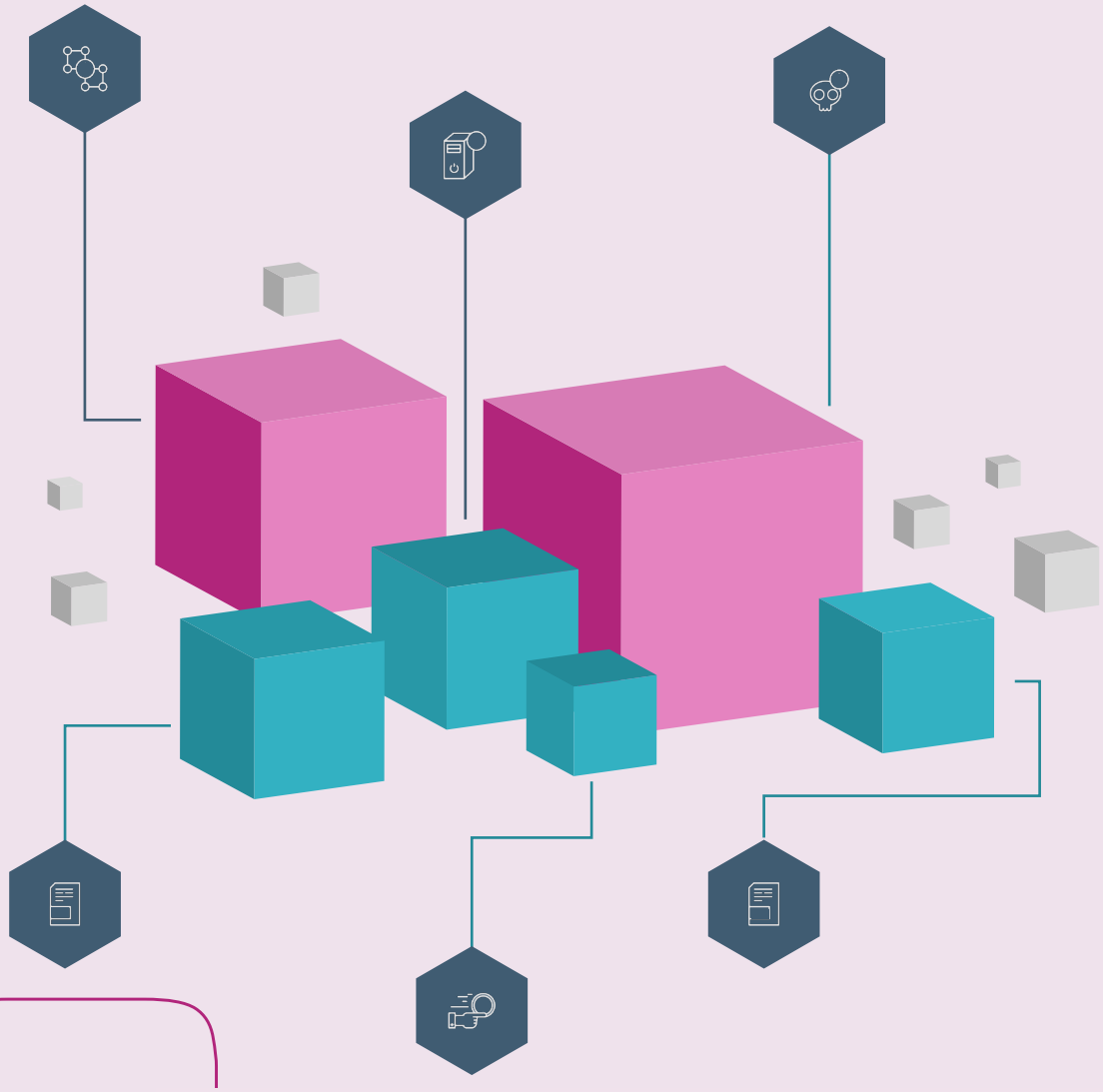
W-Rupiah Digital implementation faces a number of challenges. The majority of respondents are concerned about Rupiah digital's real-time settlement and 24/7 operations, which may have an impact on participant profiles and liquidity structure. The 24/7 operational hours of the digital w-Rupiah, which are outside of the BI-RTGS operating hours, will have an impact on how participants manage their liquidity and treasury activities, particularly back-office settlement and nostro monitoring.

On the monetary side, respondents were most concerned with the impact of w-Rupiah Digital on reserve requirements (GWM), monetary operations (OM), and PUAB. Participants' GWM will decrease, resulting from Digital Rupiah issuance via the conversion of BI-RTGS balances. However, only a small proportion of respondents believe that GWM or OM construction will remain unchanged following the implementation of the w-Digital Rupiah. Focusing on PUAB, the 24/7 operations, and the variety of use cases will increase activity in PUAB, the foreign exchange and the securities market.

In terms of risk factors, respondents were concerned about the possibility of moral hazard exploiting the DLT system's transparent features. Using the w-Rupiah Digital platform in OM transactions, for instance, may result in collusion between participants acting as DLT validators. On the DLT platform, participants can store and access data and information regarding the liquidity positions and conditions of other participants for use in OM transactions. If this risk materializes, Bank Indonesia's monetary policy may become less effective.

Most respondents believe **the w-Digital Rupiah must be included in the GWM calculation.** The w-Rupiah Digital design **must incorporate data protection features** to reduce the possibility of collusion among validating nodes. Bank Indonesia must also calculate issuance and redemption to maintain control over its balance sheet and the effects of w-Rupiah Digital's substitute of fiat currency.

Chapter 3
Conclusion



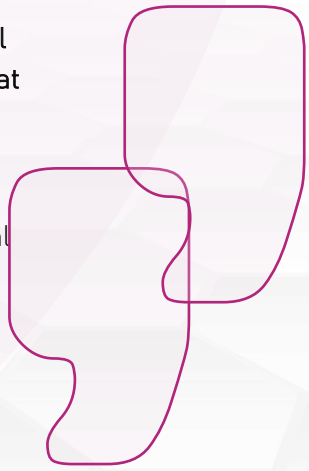
In general, the top-level design of w-Digital Rupiah as described in the publication "Project Garuda: Navigating The Architecture Of Digital Rupiah" is in line with public views and expectations...

1. **The high-level design of w-Rupiah Digital, as presented in the publication "Garuda Project: Navigating Digital Rupiah Architecture," aligns with the public perspective and expectation.** The public perspective concurs with the key elements of the Digital Rupiah configuration, such as technological choices on DLT permissioned, the two-tier distribution model through wholesalers, and the 3i aspects (interconnection, interoperability, and integration).

2. Additionally, **public input significantly contributes to the improvement of the Digital Rupiah's design**, particularly in its initial development stage (immediate stage). Several inputs, including the PoA consensus mechanism, the procedures for validator functions in the w-Rupiah Digital platform, and the PET application for gridlock resolution, present opportunities to refine the Digital Rupiah's design comprehensively.

3. **The public consultation results also revealed several challenges and risk factors that Bank Indonesia must address.** The results of the public consultation also revealed a number of challenges and risk factors that Bank Indonesia must consider. An in-depth examination of operational risk, especially cyber risk, which is highly scrutinized by the public, provides Bank Indonesia with invaluable insights for identifying critical points when exploring Rupiah Digital Design.

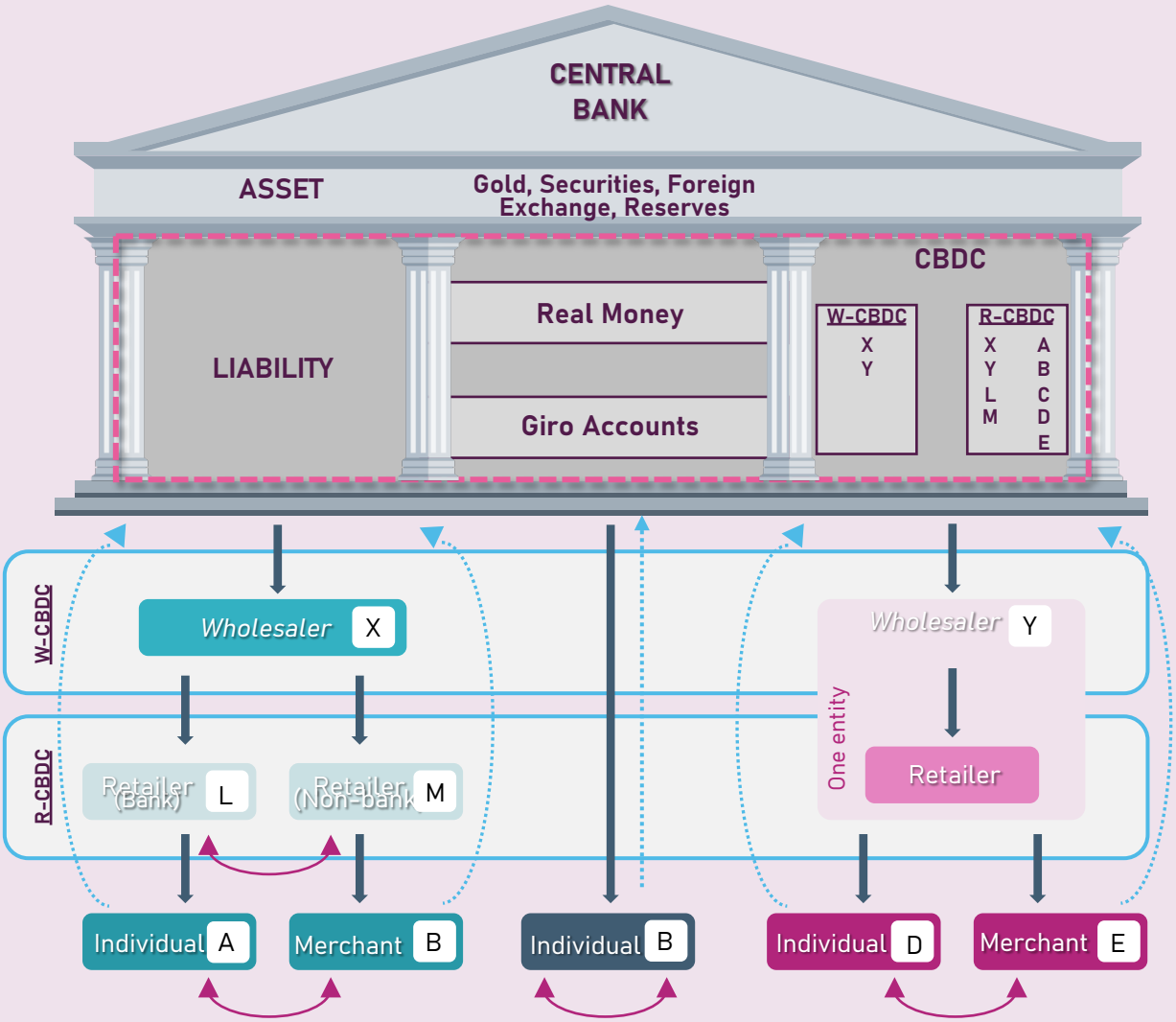
4. **Inputs and feedback from the public will assist w-Digital Rupiah in the development and refinement, particularly at the Proof of Concept (POC) stage.** Given that Rupiah Digital is a national effort to safeguard Rupiah's sovereignty, the Garuda project possesses a strong sense of nationalism. Collaboration with stakeholders is essential to its development, and public consultation is evidence of this engagement.



DIGITAL RUPIAH TIERING SYSTEM

Through wholesalers and retailers (open 1-tier)

Distribution
Transaction
Legal Claim



Appendix A
Consultative Paper Question List

1 Access (Participation, Data Access, and Wallet)

- In your view, what are the implications of segregating participation into wholesaler and non-wholesaler? Would this segregation adequate to mitigate risk?
- In your view, does the number of validators for w-Digital Rupiah platform need to be large to ensure its operational efficiency and effectiveness? What would be your considerations?
- In your view, how should incentives/rewards be designed in order to encourage participants to take a role as a validating node?
- In your view, what would be the risk if wholesalers have options to select non-validating node?
- In your view, what would be the risk of non-wholesalers who act as a validating node?
- Has it been possible to expose data content partially in DLT, e.g., only transaction value, to allow for the implementation of gridlock resolution without violating privacy? To what extent could data visibility be set?
- What are the arrangements/standards for identity management in the w-Digital Rupiah platform (identity service) that could protect user privacy and enable traceability, including monitoring of illegal transactions?
- What are the factors that need to be taken into consideration in selecting the privacy-enhancing technology?
- How can confidentiality and auditability be balanced in a decentralized system?
- In your view, should the issuance and management of w-Digital Rupiah wallet be directly performed by Bank Indonesia, or should it be handed over to the industry?
- Should cold wallets be mandatory for the w-Digital Rupiah design?

2 Issuance and Redemption

- What is your view on KDR role?
- In your view, should the role of validating the authenticity of Digital Rupiah be delegated to participants other than Bank Indonesia?
- What would be the risk embodied in the withdrawals and redemption process of w-Digital Rupiah that need to be taken into consideration?

3 Gridlock Resolution, Funds Transfer, Settlement Finality

- In your view, does w-Digital Rupiah require the role of liquidity providers? If required, who should take the role?
- In your view, is the risk of gridlock relevant in a DLT system as is in a centralized system? If so, how could gridlock resolution be implemented fairly in a DLT system?
- Is proof of authority sufficient to ensure settlement finality?
- Are the current legal provisions sufficient to ensure settlement finality in a decentralized system?

Technical Capabilities and 3I

4

- In your view, what would be the conditions for a DLT system to coexist with existing centralized systems like BI-RTGS? What are the potential use cases that could stimulate systems' coexistency other than issuance and redemption?
- What risks might arise from the coexistence between w-Digital Rupiah DLT platform and the current financial market infrastructures, including in the event that effective coexistence fails to occur?
- How could Digital Rupiah be designed to achieve transferability across multiple payment platforms (cross-chain platforms)? Are new technologies or technical standards required?

Appendix A
Consultative Paper Question List

5 Technology: Scalability and Resilience

- Would a decentralized system provide better operational resilience than a centralized system? Would proof of authority be adequate in mitigating cyber-attack?
- To what extent does DLT risk management differ from centralized systems? What capabilities must be built by each party involved?
- What aspects must be considered and ensured in designing backups and Business Continuity Plan (BCP) for decentralized systems? Must each node in DLT maintain an active backup to ensure resilience of each node within the DLT?
- Does the use of cloud in DLT networks require standardization? If so, to what degree should cloud standardization be implemented within a resilient DLT ecosystem?
- In your view, is a permissioned DLT comparable to centralized systems in handling low-volume and high-value transactions, including its capacity to tackle the surge in transaction volume?
- What is the optimal level of distribution/decentralization in the Digital Rupiah ledger to achieve the optimal combination of resilience, speed, efficiency, and scalability?
- Would there be other operational risks that have not been clearly mapped in the use of DLT, especially those affecting system resilience, reliability and security and how could they be addressed? What operational or cyber risks may be unavoidable?

Implications for Payment System, Financial System, and Monetary System 6

- How would the use of w-Digital Rupiah change the financial structure, particularly the interbank money market structure, including its implications for the asset pricing? Does the classification of participation into wholesalers, non-wholesalers, and retailers affect the market structure and resilience of the financial industry and payment systems?
- Should the quantity of w-Digital Rupiah in circulation be capped? If so, what factors should be considered for such policy?
- What implications would arise due to the 24/7 operation of interbank money market, enabled by the use of w-Digital Rupiah?
- What are the minimum requirements that must be met by each participant to manage risk arising from interdependencies?
- In your view, what opportunities and challenges could arise from active involvement of nonbank entities in financial markets? Is it necessary to have specific criteria regarding the participation of non-bank financial institutions in the w-Digital Rupiah platform? Are capital requirements considered sufficient to mitigate risks?
- Which features should be adopted by Digital Rupiah to optimize its potential added value to financial market deepening (i.e., potential smart contracts that could be leaveraged to overcome classic problems related to financial market deepening)?
- What factors must be considered to ensure effective adoption of Digital Rupiah in the wholesale market? What use cases are needed to ensure effective adoption of w-Digital Rupiah?

Appendix B
Glossary

Auditability	The degree on how easy a system or process or historical data is to be examined and evaluated by auditors effectively and efficiently,
Automated Market Makers (AMM)	A decentralised exchange using a bonding curve and a liquidity pool to price and exchange tokenised assets (i.e. a constant function market-maker).
BI- RTGS	Financial infrastructure used for electronic funds transfer where the settlement is instantaneous on a gross basis.
Blockchain	An immutable digital ledger shared across computers within a network that supports recording digital transactions and tracking assets.
Bonding Curve	A function determining the relative price of the assets traded through an AMM.
Business Continuity Plan (BCP)	Strategies to overcome certain circumstances where business must continue after a disaster.
Central Counterparty (CCP)	An entity that interposes itself between counterparties to contracts traded in one or more financial markets, becoming the buyer to every seller and the seller to every buyer and thereby ensuring the performance of open contracts.
Central Securities Depositories (CSD)	An entity that provides securities accounts, central safekeeping services and asset services, which may include the administration of corporate actions and redemptions and plays an important role in helping to ensure the integrity of securities issues (that is, ensure that securities are not accidentally or fraudulently created or destroyed or their details changed).
Cloud	Data storage and processing facilities provided by third parties allowing shared computing resources to multiple parties with all data encrypted.
Cold Wallet	Physical hardware wallet for storing private keys offline.
Cold Storage	See Cold Wallet.
Compliance	Acts of complying with standards of cloud usage regulations.
Compute	Provision of cloud computing resources such as servers, data storage, networking, and software over the internet.
Cross-Chain Platform	Interoperability of crypto technology where multiple blockchain networks are connected allowing exchanges of information and value.
Decentralized Finance (DeFi)	A new paradigm in the provision of services including lending, investing or exchanging cryptoassets that uses DLT and do not rely on traditional (decentralized) intermediary institutions.
Delivery versus Payment (DvP)	A new paradigm in the provision of services including lending, investing or exchanging cryptoassets that uses DLT and do not rely on traditional (decentralized) intermediary institutions.
Digital Rupiah Depository	Digital Rupiah Depository, is one of the nodes in the w-Digital Rupiah platform involved in the issuance and redemption of w-Digital Rupiah tokens.
Distributed Ledger Technology (DLT)	An approach that records and shares data across multiple data storage locations (journals). This technology enables transactions and data to be recorded, shared and synchronized across distributed networks with different network participants.
Early Warning System	A preventive measure to detect indications of potential hazards. In this report, potential hazards refer to shortage of liquidity.
Encryption	A form of data security technique through conversion of data into secret codes (obscuring data sent, received, or stored) so that it can only be accessed by certain people with access.
Ethereum 2.0	An improved version of Ethereum 1.0 (a public blockchain network) aimed to improve scalability, accessibility, and transaction throughput.
Fresh Key Pairs	New symmetric lock pairs generated from public key cryptography.
Gridlock	Situation that can arise in a funds or securities transfer system in which the failure of some transfer instructions to be executed (because the necessary funds or securities balances are unavailable) prevents a substantial number of other instructions from other participants from being executed.
Hot Wallet	Software wallet for storing private keys that is connected online.
Immediate Finality	In this context, immediate finality refers to the settlement of transactions in DLT which conceptually will be faster compared to centralized systems. In technical blockchain terms, immediate finality refers to the period when a block is added to the local ledger.

Immutability	A condition where data that has been stored can no longer be deleted, overwritten, or modified.
Intraday Liquidity Facility (ILF)	Funding facility offered by Bank Indonesia to facilitate banks overcoming their shortage in liquidity during the operating hours of the BI-RTGS System given the value of outgoing obligation is greater than the balance of their Rupiah reserve account at Bank Indonesia..
Key Randomization	Public key cryptography with hash functions that can accommodate signing, confidentiality and tamper-proofing processes of transactions in the network.
Landing Zone	Modular and scalable configurations that allows organizations to adopt the cloud for their business needs.
Layer-2 Scaling Technology	Layer 2 is a collective term for solutions designed to help scale your application by handling transactions off the Ethereum Mainnet (layer 1) while taking advantage of the robust decentralized security model of Mainnet.
Lender of the Last Resort	Authorities provide liquidity in times of crisis.
Liquidity Management Capabilities	The ability to manage liquidity through the placement or transfer of funds across instruments to maintain smooth transactions or gain returns.
Liquidity Pool	Smart contract with the ability to hold and transfer tokenised assets based on pre-defined logic.
Liquidity Saving Mechanism (LSM)	The features/mechanisms which include frequent netting or offsetting of transactions (payments and/or securities) in the course of the operating day. A typical approach is to hold transactions in a central queue and to net or offset those transactions on a bilateral or multilateral basis at frequent intervals.
Logging	Enabling customers to manage, analyze, monitor, and derive insights from log data in the cloud in real time.
Masking	Obfuscating sensitive information by replacing it with proxy data.
Middleware	The term for the hardware or software components that connect various computers or applications.
Multi Signature (Multisig)	Types of wallets with multiple layers of security features; requiring two or more private keys to perform a specific task.
Multi-Party Computation	Cryptographic security technology that allows multiple parties to assess computing without revealing personal information or related confidential data held by each party.
Network	Cryptographic security technology that allows multiple parties to assess computing without revealing personal information or related confidential data held by each party.
Node	An integral piece of distributed ledger technology that store ledgers.
No-Node	A type of participation where the participant does not have a node and only needs to provide a network to connect to the operator's ledger service.
Non-Interest Bearing Asset	Types of financial assets that do not provide and/or promise over time returns or remuneration (e.g., interest rates) from the issuer to its holders and/or owners.
Non-Wholesaler	Parties that have access to Digital Rupiah directly from Bank Indonesia and can transact on the w-Digital Rupiah platform.
Non-Validating Node	A type of participation where the participant is granted the rights to control the management/custody of their w-Digital Rupiah tokens without a right to perform as validator.
Notary Node	Dedicated servers that perform notarized transactions.
Off-Chain	Transaction processing outside the blockchain, involving third parties who guarantee, facilitate deals, and execute transactions. The agreement between transacting parties is made outside the blockchain. The third party set the terms of the agreement, and it will execute and record the transaction into blockchain after the terms are met.
On-Chain Cloud	A public cloud that everyone on the network can see
On-Premise	Data storage and processing facilities owned and managed by the company itself (in-house).
Operating Costs	In the context of this CP Report, the definition of operating costs refers to costs arising from wholesaler/non-wholesaler operational activities in carrying out their functions as validating/non-validating/no-node.
Payment versus Payment (PvP)	A settlement mechanism that ensures that the final transfer of a payment in one currency occurs if and only if the final transfer of a payment in another currency or currencies takes place.
Permissioned DLT	A paradigm in DLT that restricts access to distributed ledger to certain parties. Participants, including validators, are known and authorized.

Permissionless DLT	A paradigm in DLT that open access to the DLT platform to the public. Any party can participate in the network, including as validator.
Privacy Enhancing Technology (PET)	Technology designed to extract the value of data without compromising data protection principles.
Privacy Group	A private channel between entities on the network so that transactions are known only to the transacting participants.
Private Key	A key used to decrypt information encrypted with a public key.
Private Key Management Framework	Private key management solutions for enhanced security where transactions from a wallet can only be authorized/executed if/when a group of clients sharing the wallet have enough private key fragments to authorize a transaction.
Proof-of-Authority (PoA)	A consensus mechanism for DLT characterized by only certain parties performing validation of transactions which are appointed by an authority.
Proof-of-Stake (PoS)	A consensus mechanism for DLT characterized by only certain parties performing validation of transactions which are selected based on computing capabilities and pledged/staked coins.
Proof-of-Work (PoW)	A consensus mechanism for DLT characterized by all network participants having the right to validate transactions through competition to solve complex mathematical puzzles/problems (a.k.a. mining).
Public Key	A key that can be used to encrypt information and used to verify a digital signature.
Queue Management System	System which has specific configuration for handling transaction queues.
Real Time Settlement	Immediate settlement occurs once assets are received and transferred at the same time.
Return on Investment	In the context of this CP, the return on investment of participants in carrying out their functions as validating/non-validating/no-node in the w-Rupiah Digital design.
Reversibility	Features where transactions can be reversed.
Ring Signature	Digital signatures created by members of a group, each with their own key, are useful for maintaining authenticity, integrity, and non-denial.
Roll-Up	Batch of transactions for processing.
Scalability	The ability of an IT system (such as applications, storage, or networks) to work properly under increasing workloads.
Securities Bond	Debt securities with a certain tenor and interest rate.
Service Level Agreement (SLA)	Contractual agreement between service provider and client on the type and standard of service that needs to be met.
Smart Contract	A programmable digital contract that can be executed given certain conditions.
Settlement Finality	Funds that have been transferred from one institution to another that are in principle final and irrevocable.
Sharding	Method for splitting transactions into smaller, more manageable parts.
Single Point of Failure	Any point in a system, whether a service, activity, or process, that, if it fails to work correctly, leads to the failure of the entire system.
Throughput	A measure of how many transactions a blockchain can process in a given period of time.
Token	A verified digital version of banknotes and coins.
Transferability	The ability of data or entities in different circumstances
Use Case	Overview of the functionality of a system, so that system users understand and understand the usefulness of the system to be built.
Validating Node	A type of participation where the participant is granted the rights to perform as validator of transactions and control the management/custody of their w-Digital Rupiah tokens.
Wallet (E-wallet)	Services that are electronic and function to store data and payment instruments and transact on digital platforms.
Wholesaler	A party who obtains the right to access Digital Rupiah directly from Bank Indonesia and distributes it to retailers and end users.
Transferability	A way of proving the validity of a statement without revealing the statement itself. The 'prover' is the party trying to prove a claim, while the 'verifier' is responsible for validating the claim.
Use Case	Layer 2 scaling solutions that increase throughput on Ethereum Mainnet by moving computation and state-storage off-chain.

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