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## Working Paper

# Project inthanon and the project DLT scripless bond

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**ADB Working Paper Series**

**PROJECT INTHANON AND THE  
PROJECT DLT SCRIPLESS BOND**

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**Abstract**

Distributed ledger technology (DLT) has the potential to disrupt many financial service domains. Aiming to explore the use of DLT to enhance financial system efficiency and resiliency, the Bank of Thailand (BOT) launched the Project Inthanon and Project DLT scripless bond initiatives in 2018. Project Inthanon is a proof-of-concept for wholesale domestic and cross-border funds transfer using central bank digital currency. The Project DLT scripless bond is an initiative to increase efficiency for the saving bond registration and sales processes. With these two projects, the BOT aims to catalyze an industry-wide effort to innovate digitally by exploring and assessing the potentials and applications of DLT. In addition, the BOT focuses on cultivating people's way of thinking and redesigning work processes to accommodate decentralized settings. In this paper, we discuss the project design, key findings, and future considerations of both projects. In brief, we find that DLT demonstrates promise for enhancing the financial infrastructure by enabling digital value direct transfers among parties, along with immutable record keeping, and programmable automation using smart contracts. However, further explorations of technology capacity, governance arrangement, and regulatory issues are needed as a prerequisite before moving these proofs-of-concept into production.

**Keywords:** distributed ledger technology, central bank digital currency

**JEL Classification:** G21, M13, O33

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# 1. INTRODUCTION

Technological advancement is accelerating, impacting our lives, experiences, industries, and economies. This transformative force is also reshaping the financial services industry and challenging traditional business models. To support Thailand's long-term competitiveness, the Bank of Thailand (BOT) fosters technologies that will prepare Thailand's financial sector for a new digital era.

Among disruptive technologies, distributed ledger technology (DLT) demonstrates promise for enhancing the financial infrastructure. DLT enables direct transfers of digital value among parties, with immutable record keeping, smart contracts, and enhanced security. The BOT launched two DLT initiatives in 2018, namely Project Inthanon and Project DLT Scripless Bond, aiming to catalyze an industry-wide exploration and assessment of the potentials and applications of DLT. In addition, these initiatives also focus on redesigning work processes to anticipate a widely decentralized system.

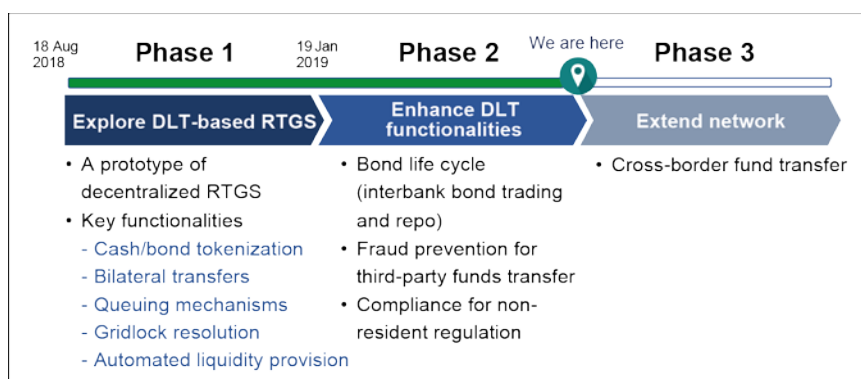
Project Inthanon is a proof-of-concept (POC) for wholesale central bank digital currency (CBDC) for interbank and cross-border settlements. More details on the project's design, key findings, and future considerations are discussed in Section 2. Project DLT Scripless Bond aims to improve the registration and sales process. Further details are in Section 3.

# 2. PROJECT INTHANON

## 2.1 Overview

Project Inthanon is a collaborative effort initiated by the BOT, together with eight commercial banks. The prime focus is to develop and test a DLT-based, real-time gross settlement system (RTGS) by issuing wholesale CBDC. Project Inthanon is divided into three phases as shown in Figure 1. Each phase builds upon the findings and learning of the previous phase.

**Figure 1: Overview of Project Inthanon**



DLT = distributed ledger technology, RTGS = real-time gross settlement system.  
 Source: Bank of Thailand.

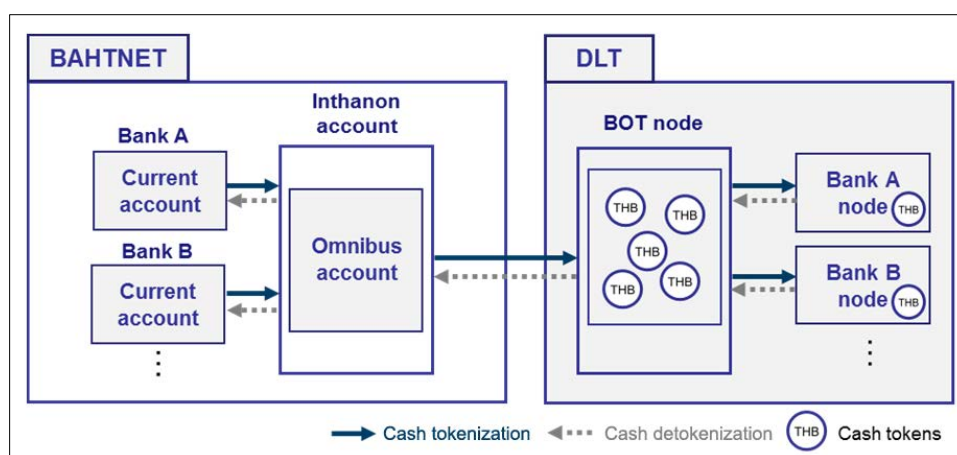
## 2.2 The Design

### 2.2.1 Project Inthanon Phase 1

The focus of Phase 1 is to build a prototype of a decentralized RTGS with key payment functionalities, that is, the tokenization of cash and bonds, bilateral transfer, queueing mechanisms, gridlock resolution, and automated liquidity provision (ALP). The last functionality, along with tokenization of bonds, is considered an innovative addition to other central bank studies.

A decentralized payment network is set up on the Corda<sup>1</sup> platform with the BOT node and participating bank nodes. The BOT node has the sole capability to create and destroy Thai baht cash tokens on the network. Other participating bank nodes are entitled to convert their RTGS balance into cash tokens, as shown in Figure 2. Once cash tokens are on hand, bank nodes can use them to make payments to other nodes on a peer-to-peer basis.

Figure 2: Tokenization of Cash



BOT = Bank of Thailand, DLT = distributed ledger technology, THB = Thai baht.

Source: Project Inthanon phase 1 report.

When bank nodes encounter temporarily insufficient liquidity for settlement, they can set priorities to their outgoing payment queues to meet business and operational needs. The system also provides gridlock resolution<sup>2</sup> in order to save cash liquidity by netting the queued payments. The design of gridlock resolution in Phase 1 is enhanced from models explored in previous central bank studies (Figure 3). In the new gridlock resolution mechanism, a node performs centralized calculation of the possible solution to preserve transaction privacy, while participating bank nodes execute the settlement in a decentralized manner to avoid a single point settlement risk. This resolves the inherent

<sup>1</sup> Corda is an open-source distributed ledger platform built to record and manage contracts between mutually distrusting parties. Corda was built by R3 in collaboration with the world's largest financial institutions. It was designed to meet the rigorous requirements imposed by financial service regulators, conform to industry standards, and deliver on the promise of DLT. Corda is unique among blockchain platforms in that multiple networks can join to create a wider network with assets that can be transferred between them.

<sup>2</sup> Gridlock is a group of transactions that cannot settle individually in gross due to insufficient liquidity, but two or more transactions are resolvable with one or more net payments. Gridlock resolution is an optimization process to help resolve a gridlock situation. The system searches for a combination of transactions that can be netted, in which these transactions are executed simultaneously.

privacy issues of a decentralized gridlock resolution process and provides participating nodes with full anonymity.

**Figure 3: Gridlock Resolution Comparison**

Project	GR Steps	
	Initiation, detection and planning	Execution (net payments)
Jasper	Centralized (Oracle node)	Centralized (Oracle node)
Inthanon	Centralized (Oracle node)	Decentralized (Involved node)
Ubin	Decentralized (Any node)	Decentralized (Involved node)

GR = gridlock resolution.

Source: Project Inthanon phase 1 report.

As noted, the innovative functionalities explored in Phase 1 are bond and ALP tokenization. The bond token is introduced in the RTGS system through a process similar to cash tokenization. Having a bond token in the system enables the central bank liquidity provision to be seamlessly automated. The ALP mechanism allows banks to enter into a repurchase agreement with the BOT where they can exchange their bond tokens for cash tokens when they are temporarily short of liquidity. The exchange of bonds and cash tokens occurs in a real-time and atomic<sup>3</sup> manner. The introduction of ALP, therefore, allows banks to increase efficiency of bond usage and reduce the opportunity cost of holding eligible bonds.

### 2.2.2 Project Inthanon Phase 2

Phase 2 aims to explore the applicability of DLT to more complex use cases, leveraging on the smart contracts. The functional objectives of Phase 2 include (1) the addition of a securities settlement system to Phase 1 by enabling bond life cycle activities in a secondary market such as trading, repurchase, and coupon and margin management; and (2) the integration of a fraud prevention mechanism and a regulatory compliance module into the DLT workflow for third-party funds transfer. An overview of these functionalities is shown in Figure 4.

- **Bond life cycle**

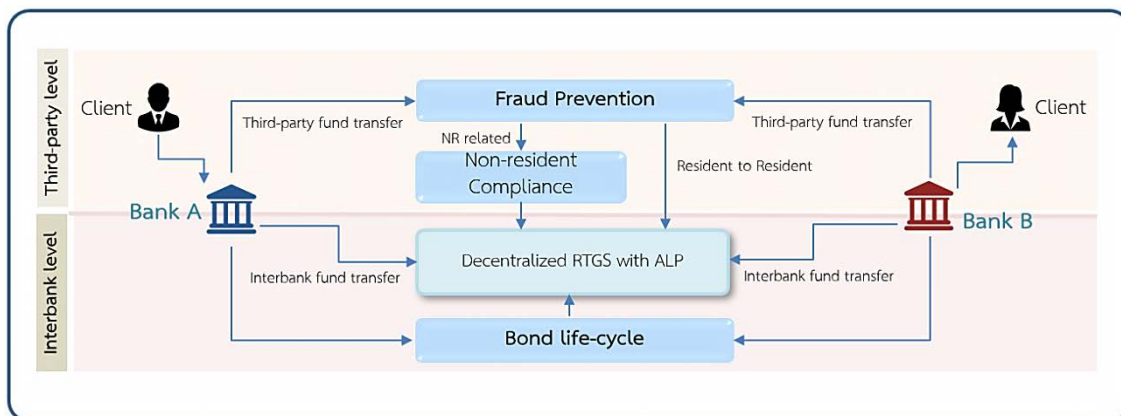
The life cycle of debt-securitized BOT bonds was modelled in Phase 2’s POC. The activities include the tokenization of the bonds as representing fungible assets and then using smart contracts to automate coupon payments and final redemption at maturity. Bond tokens then can be traded and repurchased between bank nodes. The exchange of bond and cash tokens is settled on an atomic delivery-versus-payment (DvP) basis.

To fully operate repurchase activities, the smart contract generates daily scheduled events as part of decentralized margin management process initiated by each bank node. A net margining mechanism collates calculation inputs, which are ongoing repo contracts, margin thresholds, and prices of bond tokens posted as collateral. A margin call is then issued by a payee to a payer to review and confirm for subsequent settlement.

<sup>3</sup> Atomicity is a transaction property which either succeeds or fails as a whole, that is, all or nothing. An exchange of two assets with atomic transaction will never leave a transaction partially completed.



**Figure 4: Design of Functionalities in Phase 1 and Phase 2**



ALP = automated liquidity provision, RTGS = real-time gross settlement system.

Source: Bank of Thailand.

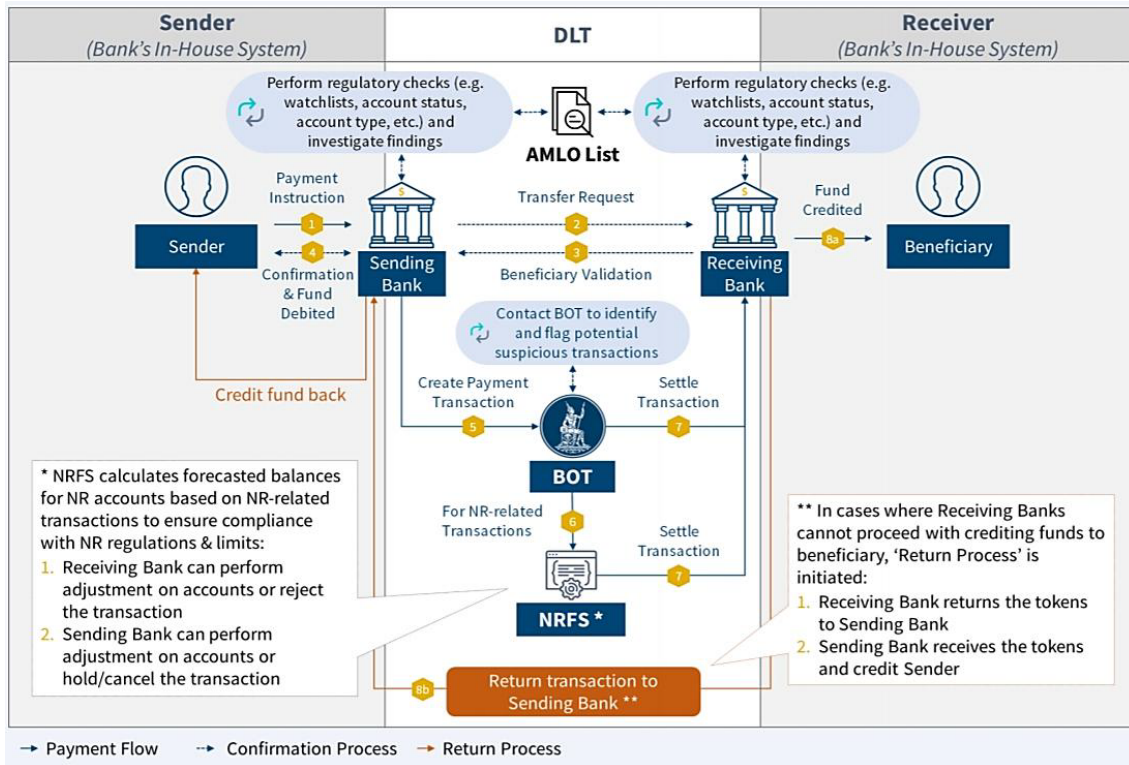
The gridlock resolution for bond tokens is also explored in the POC. Leveraging on Phase 1 gridlock resolution, the new model is further developed to handle both cash and bond tokens. The redesigned gridlock resolution, which is known as a multi-asset liquidity-saving mechanism, supports DvP gross settlement and optimizes liquidity saving across cash and bond tokens.

- **Fraud prevention and regulatory compliance**

In Phase 2, the third-party funds transfer’s end-to-end process is extended on top of Phase 1’s interbank funds transfer workflow. This allows the pre-settlement operational steps, which include creation, checking, validation, and confirmation to be integrated with the settlement mechanism.

To prevent fraudulent transactions, a sending bank and a receiving bank need to reconcile and validate beneficiary information. Currently, there are no automated functions available for this. Sending banks create a transaction with the information given by the sender, regardless of the validity of its correctness. Once a receiving bank receives the funds, it is obliged to investigate and perform necessary compliance checks before crediting the funds to the beneficiary accounts, thus reducing the efficiency of payment operations. In Inthanon Phase 2, a peer-to-peer reconciliation process has been developed that allows sending banks to directly reconcile the information with receiving banks on a need-to-know basis. The system also provides anti-money laundering and suspicious pattern checks, as well as allowing senders to confirm the transaction before settlement. In addition, banks receive a channel where they can track the status of their transactions in real time, from initiation to final settlement and funds crediting to end beneficiaries. The step-by-step workflow is demonstrated in Figure 5.

**Figure 5: End-to-End Funds Transfer Workflow**



AMLO = Anti-money-laundering organization, BOT = Bank of Thailand, DLT = distributed ledger technology, NR = non-resident, NRFS = non-resident forecasting system.

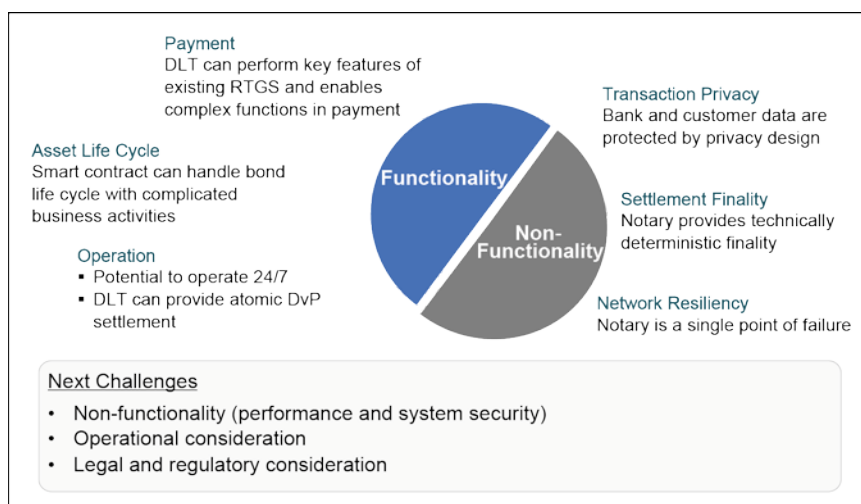
Source: Project Inthanon phase 2 report.

Under foreign exchange regulations, non-residents can open two types of Thai baht accounts, that is, non-resident baht accounts (NRBAs) and non-resident baht accounts for securities (NRBSs). Transfer between NRBAs and NRBSs is prohibited. The NRBA/NRBS balances are not allowed to exceed a limit at the end of the day. The limit is imposed on per account type and per non-resident entity, so if a non-resident opens an NRBS with three banks, at the end of the day, the aggregated balances of the accounts are required to stay within the limit. In current practice, banks perform a manual reconciliation to ensure compliance, resulting in operational burdens. Phase 2 has incorporated the non-resident forecasting system, which draws on all balances and transactions to calculate the forecasted balance of each account. All non-resident-related transactions are processed in this module before settlement takes place. The transactions are settled only when the regulation is compiled through the non-resident forecasting system. The system also notifies banks when forecasted balances exceed limits and require banks to mitigate potential non-compliance. This automated mechanism allows banks to manage their non-resident flows and accounts more efficiently. It also helps the BOT to better monitor compliance in near real-time fashion.

### 2.3 Main Findings and Future Consideration

The findings of Project Inthanon phases 1 and 2 are as follows (Figure 6).

**Figure 6: Summary of Key Findings and Next Challenges**



DLT = distributed ledger technology, DvP = delivery-versus-payment, RTGS = real-time gross settlement system.

Source: Bank of Thailand.

### 2.3.1 Functional Finding

DLT can implement key functionalities of RTGS. Smart contracts can handle complex use cases that include bond life cycle events, fraud prevention, and regulatory compliance. The technology also demonstrates the ability to support 24/7 payment operation and provides an atomic DvP settlement without intermediaries.

### 2.3.2 Non-Functional Finding

*Settlement finality* describes the way a system reaches consensus when a change of ownership occurs. The system can provide a technical settlement finality for the funds transfer and the exchange between cash and bond tokens. In Corda, the point of finality is when the notary<sup>4</sup> signs against a transaction. The notary guarantees that every transaction state can be consumed at most once, thus preventing double spending.

Transaction and settlement *privacy* are achieved given the Corda platform design, where the information is shared on a need-to-know basis. Meanwhile, the network *resiliency* is still a key challenge, as the Corda platform requires a notary node to validate the transaction, becoming a single point of failure issue.

After Phase 1 and 2, several issues remain that need to be explored as a prerequisite before moving the POC into production, including (1) technology capacity: performance testing and cybersecurity; (2) governance arrangement: role and responsibility among parties in a decentralized network; and (3) legal and regulatory consideration: the review of related laws and regulations needed in advance of going to production.

<sup>4</sup> The notary service in Corda serves to prevent double spending within the network. Once the notary service is satisfied that a digital token has not been spent before, it issues a signature to indicate transaction finality.

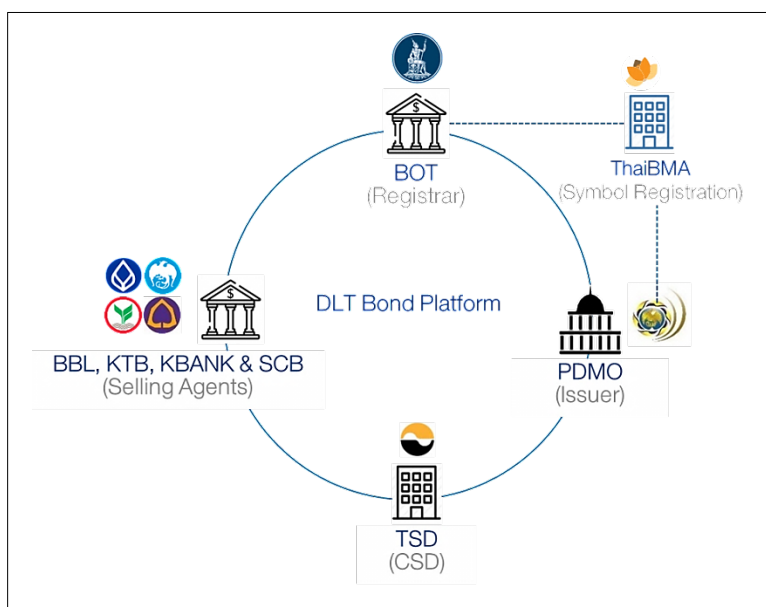
### 3. PROJECT DLT SCRIPLESS BOND

#### 3.1 Overview

The BOT initiated the DLT Scripless Bond Project and conducted a POC around blockchain technology. The project was built with Hyperledger Fabric, an open-source blockchain framework to assess benefits and business values that could potentially improve efficiency.

The BOT spearheaded the project with the collaboration of key industry participants employing their considerable expertise and experience. Key stakeholders with their roles and responsibilities are described in Figure 7.

**Figure 7: Stakeholders with their Roles and Responsibilities**



Notes:

1. Bank of Thailand (BOT): Registrar and Paying Agent
2. Thailand Securities Depository (TSD): Central Securities Depository (CSD) and International Securities Identification Number and Classification of Financial Instruments code registration
3. Public Debt Management Office (PDMO): Bond Issuer
4. Bangkok Bank (BBL), Kasikorn Bank (KBANK), Krungthai Bank (KTB), and Siam Commercial Bank (SCB): Selling Agents
5. Thai Bond Market Association (ThaiBMA): Bond Symbol Registration

Source: DLT Scripless Bond Executive Meeting.

The Thai government savings bond sales process has several points of friction, that is, a non-real-time system and duplicate validation steps with manual reconciliation requirements that are prone to data errors, which blockchain could potentially resolve. Delivery of savings bonds to investors currently takes 15 business days, while other government bonds can be delivered in just 2 business days according to market best practice.

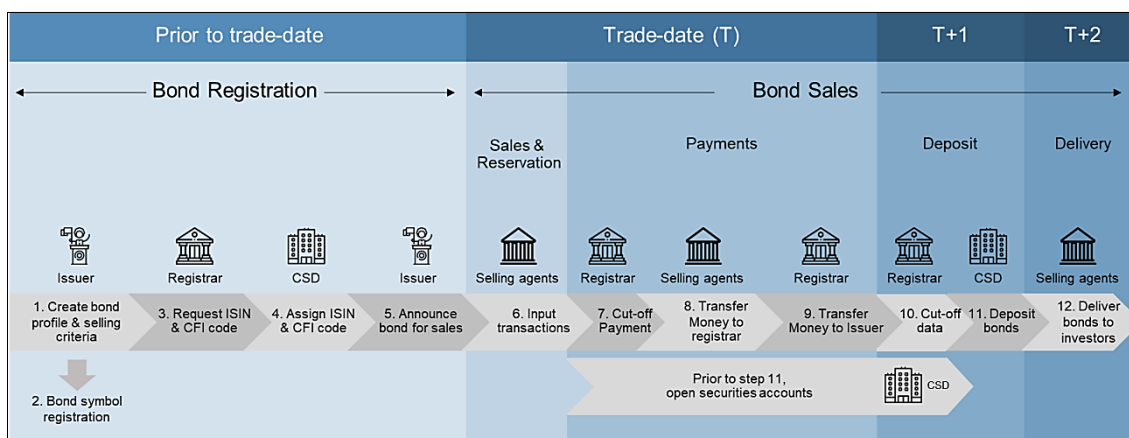
### 3.2 The Design

The main features improving process efficiency and transparency of Thai government savings bond sales are as follows:

- **Single validation.** This feature allows participants to validate any transactions by using the same set in the smart contracts before it is committed to a ledger.
- **Single source of information.** All participants can access the same information, such as bond profiles, selling criteria, and the remaining available amount.
- **Common standard within the blockchain network.** One set of standards is adopted for data format, reference data, and transactional data used in business processes to improve data quality and remove duplicated processes.
- **Flexible information management.** Before the bond deposit process, all sales transactions are editable to allow flexibility in timing of processing. Selling agents can update details as required. Any time a modification is made, the sales transaction would be digitally time-stamped and recorded for transaction transparency.

According to these key elements and considerations to reduce the savings bond settlement cycle from trade date plus 15 business days (T+15) to 2 business days (T+2), the processes and all operational improvements relating to bond registration and sales are designed as illustrated in Figure 8.

**Figure 8: T+2 Process of Bond Registration and Sales**



CFI = Classification of Financial Instruments, CSD = Central Securities Depository, ISIN = International Securities Identification Number.

Source: Project DLT Scripless Bond White Paper.

#### 3.2.1 Bond Registration (Prior to Trade-Date)

The bond registration process was piloted on the blockchain-based system, where relevant information was digitalized onto the common shared ledger for stakeholders.

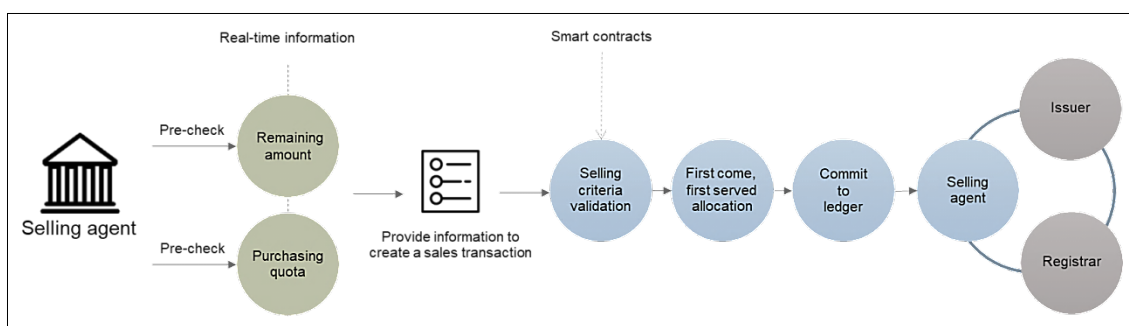
With regard to the newly designed process, the issuer is required to enter full bond profile details and their selling criteria into the blockchain. Once the information is entered, the smart contract will send bond information to the Thai Bond Market Association (ThaiBMA) and the Thailand Securities Depository (TSD) to assign a unique symbol and International Securities Identification Number (ISIN) and Classification of Financial

Instruments (CFI) codes. The issuer will then officially announce the completion of the bond profile and selling criteria.

### 3.2.2 Bond Sales (T to T+2)

Once a selling agent receives an order from their client investor, the agent will need to validate whether the investor has the right qualifications to purchase, and whether there is still a sufficient amount remaining in the central pool. The pilot system is redesigned to enable selling agents to send their client’s order and update the quota from the central pool on a first-come, first-served basis. Such practice helps elevate the efficiency and transparency in bond sales, in comparison with the current practice in which the total amount of bond issuance is divided to each selling agent. Once the order is entered into the common ledger, it is visible to the relevant parties, including the registrar and Central Securities Depository (CSD), to monitor transactions in real time.

**Figure 9: The Processes of Sales and Reservation**



Source: Project DLT Scripless Bond White Paper.

In the case of new investors that require an opening of a new securities account with the CSD, the selling agents will be able to enter their client’s information, and the smart contract will automatically send the request in real time. The CSD will then be able to relay back the status of the account opening, and the selling agent and the registrar would then be informed.

In transferring the funds received from bond sales to the issuer, each selling agent will be notified to transfer funds at the end of each business day. The selling agent will then transfer the specified funds to the registrar, who will accumulate them from all selling agents and send to the issuer in a single transaction. The funds transfers are performed externally via BAHTNET system.

On the next business day (T+1), the CSD is notified to credit bonds to the investor’s securities accounts, as well as to notify the selling agents on the status. Once this process is completed, the investors will then be able to update their balances via channels provided by their selling agents on the next business day (T+2).

## 3.3 Findings and Next Considerations from the POC

### 3.3.1 Functional Findings

The POC has demonstrated that the DLT Scripless Bond could successfully meet core business demands, while generating business values for all relevant parties. These key benefits are: (1) individual investors are able to receive bonds within 2 business days, from the current setting that takes 15 business days, and they can purchase bonds with

their full rights from any selling agent without the current purchasing limit per bank; (2) selling agents, the TSD, and the BOT can reduce the complexity of their operational processes; and (3) bond issuers can monitor and manage sales in real time, increasing competition among selling agents. Overall, the project will lead to greater efficiency, transparency, security, and reduction in operating costs across the entire value chain.

### **3.3.2 Non-Functional Findings**

Security and data privacy are critical to preserve the sensitive information of all participants in the blockchain network. Several methods can be implemented in Hyperledger Fabric such as Access Control Language and a private channel to ensure that the data are safe, secure, and available to everyone on a need-to-know basis.

In terms of performance, decentralized systems may experience some constraints in handling a high volume of transactions and workloads, as well as scaling up their capacity.

## **3.4 Current Progress**

Following the POC's success, the DLT Scripless Bond project has been developed into production to transform processes related to the sales of government savings bonds. However, more research is required to address certain issues discovered through the POC, for instance, the performance capacity of blockchain-based systems, in particular, the Hyperledger platform. Alternative mechanisms and solutions have been adopted in order to elevate the performance of the overall system to achieve the business requirements.

Furthermore, cybersecurity, data privacy, governance structure, roles and responsibilities, procedures, as well as related business and technical issues have been continually addressed in order to implement the production system.

## **3.5 Next Steps**

The project is expected to be launched by the first half of 2020, which will support the first annual issuance of the government savings bonds. The expected success of this project will pave the way for Thailand's bond market infrastructure in the future.

## **4. CONCLUSION**

The BOT gained invaluable experience and insights from these two initiatives, not only regarding the benefits and capabilities of the technologies, but also the innovative power of collaboration among industry-wide participants. We strongly believe that despite DLT being still a fledgling system, the early preparation and profound understanding of the technology will constitute a foundation for Thai financial sector to seize the opportunities when it is widely adopted in the future.



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