



ธนาคารแห่งประเทศไทย
BANK OF THAILAND

Retail **PILOT**
CBDC



Pilot Program

Retail CBDC Conclusion Report

March 2024

Study project under
BOT Directional Paper on Financial Landscape

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Executive Summary

Thailand's payment landscape is undergoing rapid and continuous transformation. As outlined in the Bank of Thailand (BOT)'s "[Directions for Development of Payment Systems Under the New Financial Sector Landscape of Thailand](#)" paper issued in September 2022, the BOT has been continuously studying and testing the feasibility of a Central Bank Digital Currency (CBDC) and related considerations. The BOT has also been exploring the potential of CBDC in both wholesale and retail domains, with the Retail CBDC Pilot Program marking the latest milestone achieved by the country.

Central banks around the globe have continuously initiated and developed CBDC projects, with over 93% of central banks being engaged in some form of CBDC work as of 2023.¹ For Thailand, the BOT embarked on its CBDC journey since 2018.² Our ongoing Wholesale CBDC project, Project mBridge, focuses on using CBDC for cross-border payments to reduce the associated with these transactions. Additionally, the BOT initiated its Retail CBDC study in 2022 and successfully completed a pilot test in 2023, to assess the underlying technology's capacity to serve as a supportive infrastructure for new financial innovation. The BOT anticipates that the results from the pilot will serve as invaluable input for further development of the payment infrastructure in Thailand, benefiting both financial institutions and the general public in the future.

In this report, we summarize our Retail CBDC Pilot Program, including the use cases and key findings. The pilot took place during late 2022 to October 2023 in a pre-defined environment, involving selected financial service providers (FSPs), users and merchants. The design and scope of the pilot were driven by four intended outcomes, namely (1) to assess the technological readiness and fundamental functions of Retail CBDC, (2) to evaluate the potential of Retail CBDC for harnessing financial innovation by exploring use cases that extend beyond the capabilities of the current payment infrastructure, (3) to explore whether the CBDC infrastructure can securely facilitate open access for both bank and non-bank entities, and (4) to determine whether Retail CBDC can serve as an alternative payment infrastructure in the retail payment sector for individuals and businesses.

¹ Source: BIS: BIS Papers, No 136: Making headway – Results of the 2022 BIS survey on central bank digital currencies and crypto

² Thailand has been at the forefront of global ranking CBDC initiatives and has been recognized as 1st Rank for wholesale CBDC and 3rd Rank for retail CBDC in 2023. *Source:* PwC: PwC Global CBDC Index and Stablecoin Overview 2022

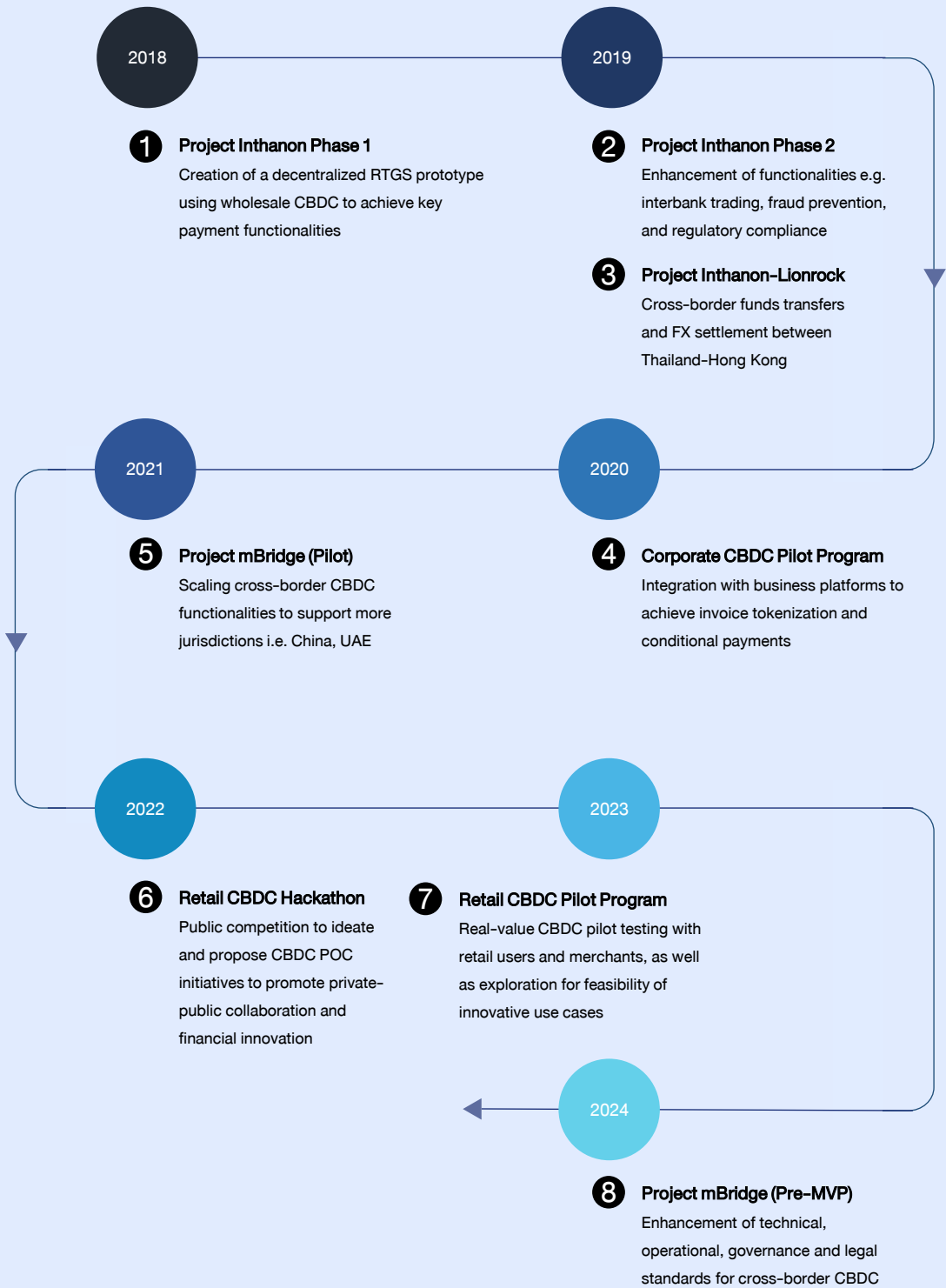
From the pilot, the Retail CBDC infrastructure demonstrated the following satisfactory results; (1) The latent capability of Retail CBDC as a retail payment infrastructure, evidenced by its ability to handle various retail transactions including top-up, withdrawals, transfers, and payments. (2) The potential of CBDC as an enabler for innovation, through the setting of programmable payments using common functionality features. This was explored by experimenting with programmability, and through a conceptual feasibility study of universal escrow and fraud response use cases. These explorations showed that CBDC could create new opportunities and innovations beyond what the existing financial system can deliver. (3) The capability of the CBDC system to serve as an open infrastructure accessible to all types of FSPs, including non-banks. (4) The capability of the CBDC system to serve as an alternative payment infrastructure for retail payments, to enhance resiliency in the future.

In a nutshell, the BOT envisions that CBDC can foster competition among FSPs, enable new financial innovations, and make more capable and cost-efficient services available to the public in the future. Nonetheless, challenges associated with Retail CBDC remain such as user adoption, as well as its consequences on the business models of FSPs. Meanwhile, the value-added benefits of CBDC remain unclear to many central banks, leading them to designate their respective CBDC plans as long-term endeavors.³ At present, the BOT has no immediate plan to officially issue Retail CBDC, but the BOT will use the results from the pilot, especially insights related to the technology design, to apply to new areas and future studies on enhancing the payment system.

3

For instance, the Bank of England and the European Central Bank have set long-term plans for CBDC-related initiatives without a near-term launch plan. Source: <https://www.bankofengland.co.uk/news/2021/november/statement-on-central-bank-digital-currency-next-steps> and <https://www.ecb.europa.eu/press/pr/date/2023/html/ecb.pr231018-111a014ae7.en.html>

FIGURE 1 : Thailand's CBDC Journey



Source: Bank of Thailand

1 — Pilot Objectives

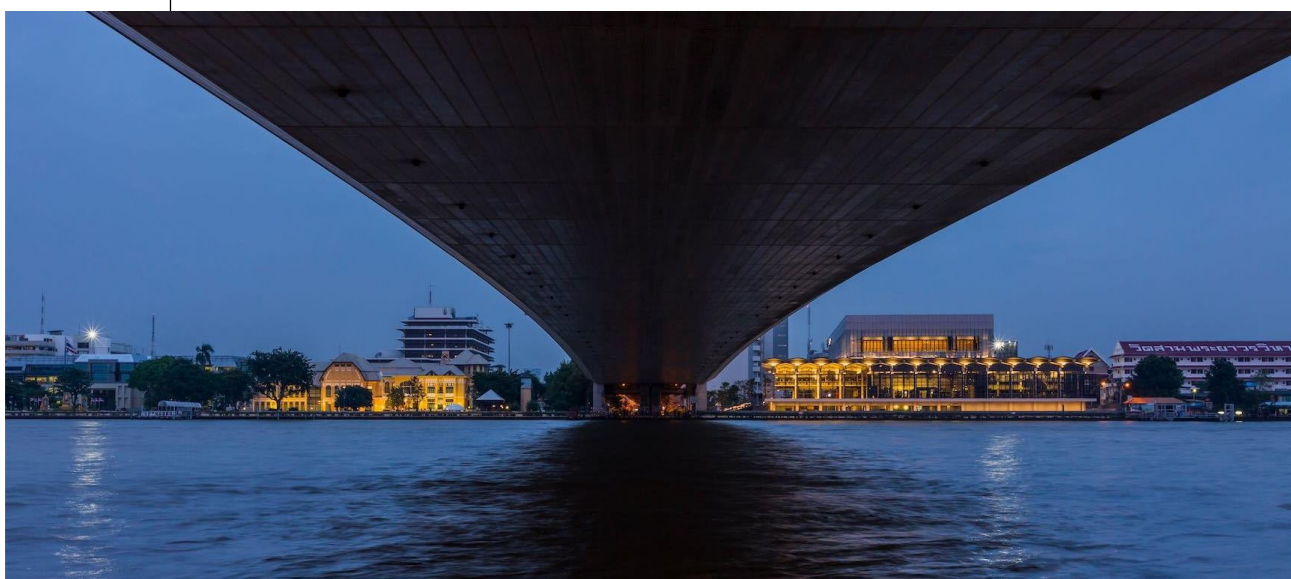
Since late 2018, the Bank of Thailand (BOT) initiated a number of studies and explorations on retail and wholesale CBDCs (as summarized in Figure 1). In 2021, the BOT published the “The Way Forward for Retail Central Bank Digital Currency in Thailand” paper to shape the design of the Retail CBDC infrastructure, and requested public consultation on the topic. The BOT received great interest and ideas from the general public as well as conducted extensive consultation with industry associations, technology developers, academics, legal experts, startups and other relevant government agencies, on the potential benefits of Retail CBDC.⁴

Subsequently, the BOT, driven by the received interest and feedback, initiated a pilot program for the study and development of Retail CBDC based on four main intended outcomes (Figure 2), namely:

- (1) **to assess technological readiness and fundamental functions of Retail CBDC**, including those related to business processes, operations, laws and regulations, accounting standards and treatment,
- (2) **to evaluate the potential of Retail CBDC in harnessing financial innovation beyond the existing payment infrastructure,**

- (3) **to explore whether CBDC infrastructure can safely enable open access for both banks and non-banks,** and
- (4) **to assess whether Retail CBDC can be an alternative payment infrastructure in the retail payment sector for individuals and businesses** (as summarized in Figure 1).

To address the objectives and achieve the intended outcomes, the BOT conducted a pilot test within a confined environment which was divided into two tracks: the foundation track and the innovation track.



⁴ Submissions were received from both domestic and global firms, ranging from small fintech firms to large financial institutions and multinational corporations (MNCs). Feedback collected showed that most respondents agree with the BOT’s approach to Retail CBDC development and view CBDC as a beneficial infrastructure for open competition, with the potential to foster greater development of safe financial innovation in the future.

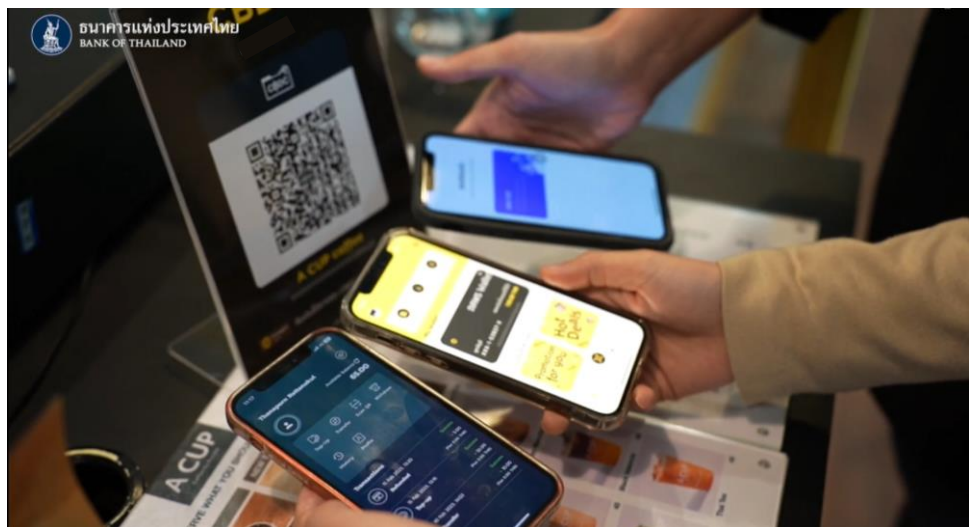
FIGURE 2 : Objectives of Thailand Retail CBDC Pilot Program



Source: Bank of Thailand

The “Foundation Track” consisted of testing the CBDC’s core functionalities, open access feasibility, and the possibility to be an alternative payment infrastructure. The BOT conducted testing of the Retail CBDC’s end-to-end life cycle by allowing for real-value transactions in a ring-fenced environment, with both bank and non-banks industry participants acting as financial service providers (FSPs), and selected (whitelisted) users and merchants. Issuance and redemption of Retail CBDC as a legal claim on the BOT was conducted as part of the test. This assessment aimed to determine business and technology feasibilities, as well as capabilities for open access infrastructure and financial innovation for retail payments.

The “Innovation Track” consisted of public engagements and exploration of CBDC for financial innovation. The BOT invited the general public and participating FSPs to showcase how Retail CBDC could facilitate innovation, value-added payments and settlement services beyond the limits of the existing infrastructure. Following the publication of the “Retail CBDC Whitepaper” in August 2022, the BOT invited the public to propose Retail CBDC use cases through a Retail CBDC Hackathon in the same year, resulting in active industry participation.⁵ The BOT then selected the first prize winning use case to be experimented further. Meanwhile, the use cases proposed by the FSPs were further explored on a proof-of-concept (POC) basis. This public engagement was aimed at gathering insights from the industry on whether CBDC could extend beyond basic payment functionalities to foster financial innovation and address needs of individuals and businesses in an increasingly digitalized economy.



Source: Bank of Thailand

⁵ The project attracted over 100 proposals received from various entities and individuals keen to engage in the POC phase.

2 — Project Design & Testing Scope

2.1 Foundation Track

The design and scope of the Foundation Track were driven by the studies and experience of central banks and feedback received from the general public.

ECOSYSTEM, STRUCTURE AND ROLES OF PLAYERS IN THE RETAIL CBDC ECOSYSTEM

The BOT designed the Retail CBDC ecosystem using a two-tier model, similar to the way cash is currently distributed, by preserving the roles of FSPs as being an intermediary between the BOT and users. Additionally, in the pilot, the BOT designed the CBDC to be equivalent to cash and consistent with cash usage e.g., no interest for holding Retail CBDC (unremunerated CBDC) and set limits for holding Retail CBDC (capped amount)

Retail CBDC Ecosystem (as summarized in Figure 3):

BOT

Responsible for distributing Retail CBDC to FSPs, which involves issuing (minting) and redeeming (melting) Retail CBDC upon request, and validating Retail CBDC transactions.

FSPs

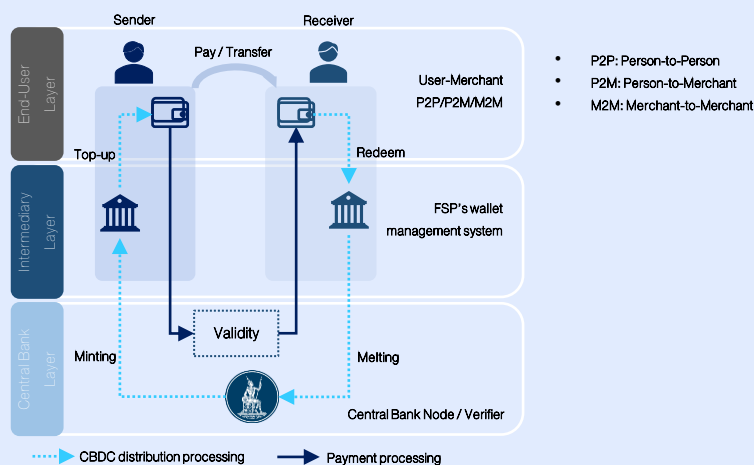
(commercial banks and non-banks), are responsible for:

- managing and distributing Retail CBDC to users and merchants upon request
- being a Retail CBDC wallet provider for users and merchants
- providing mobile applications/interfaces supporting Retail CBDC for users and merchants to top-up, withdraw, transfer, receive transfers, make payments and receive payments with Retail CBDC, as well as check transaction status and history

Users and merchants

being the users of Retail CBDC for online testing via mobile application where they may top-up, withdraw, transfer, receive transfer, make payment and receive payment with Retail CBDC, and check transaction status and history of Retail CBDC used in their wallet for day-to-day transactions.

FIGURE 3 : Ecosystem in Retail CBDC Pilot Program 2023



Source: Bank of Thailand

TECHNICAL DESIGN

The BOT collaborated with Giesecke + Devrient advance52 GmbH (G+D), and chose G+D's Filia solution for the Retail CBDC pilot based on the following reasons:

- **Flexible ledger solution choice:** The settlement protocol itself has no dependency on the underlying ledger database. It can be either DLT-based for additional resiliency or traditional centralized/distributed database system for sheer throughput performance.
- **Maximized privacy enhancement with token-based architecture:** The Verifier (core settlement module operated by BOT) only requires token-related information for finalizing transactions without any need for wallet identification and/or user account information, which is managed by FSPs, similar to current electronic payments. This is somewhat equivalent to the analogy of physical cash in that the central bank will ensure the validity of the cash itself regardless of who owns it.

- **Built-in programmable payment feature:** Conditional payments are easily configurable and attached to each wallet. FSPs can provide additional services for customers in common manner, as the same use case can be horizontally scaled across FSPs.
- **Ease of integration through SDK:** FSPs can easily adopt the solution to interact with their own systems with a ready-to-use software development kit (SDK).
- **Capable to support consecutive offline transactions** (See more details in *BOX A: CBDC Offline Testing*)



TESTING SCOPE

- **The Foundation Track tested the core functionality of CBDC during late 2022 to September 2023** covering the end-to-end operations of the BOT, FSPs, users and merchants. The pilot comprised of:
 - **3 FSPs:** 2 commercial banks and 1 non-bank⁶
 - **Approximately 4,000 individual users**
 - **140 participating merchants** (both individual and corporate entities)
 - **Testing hours: 6:00 AM – 10:00 PM everyday**
- **Participating users and merchants were pre-determined (whitelist) prior to testing⁷**
- **Transactions tested in the Retail CBDC pilot program were retail transfers among individuals, and retail payments with merchants for purchasing goods and services within a live environment** e.g., restaurants, coffee shops and e-commerce, **via online channels by using QR codes or wallet IDs for making retail transactions with Retail CBDC.**

A quick summary of the transaction (txn) numbers and values from the pilot are as follows (as summarized in Figure 4):

- **BOT** minted Retail CBDC upon 11 requests from FSPs totaling 2.16 mTHB and melted Retail CBDC upon 14 requests from FSPs at the same amount of 2.16 mTHB
- **Users and merchants** conducted 16,184 top-up txn totaling 3.85 mTHB and 7,640 withdrawal txn totaling 3.96 mTHB
- **Users** conducted 44,134 txn for payment of goods and services totaling 2.77 mTHB and conducted 11,561 txn for transfers totaling 1.72 mTHB

FIGURE 4 : Foundation Track - Online Testing in Retail CBDC Pilot Program 2023



⁶ Prior to the pilot, the BOT invited applications from both banking and non-banking sectors to participate as FSPs. Given the constrained scale and duration of the pilot program, the BOT established specific criteria to select only three FSPs for participation. This selection process was to ensure an effective and focused pilot, balancing the need for diverse representation with the practicalities of managing a limited-scale initiative. The selected FSP candidates are Bank of Ayudhya Public Company Limited, Siam Commercial Bank Public Company Limited, and 2C2P (Thailand) Company Limited.

⁷ The users in this pilot were BOT and FSPs' staff who opted to participate in the pilot on a voluntary basis, while the merchants were selected by FSPs. Given the limited number of users and merchants, the BOT decided to limit the operating hours to align with the setting environment.

BOX A : CBDC Offline Testing

The Foundation Track covered testing of offline CBDC capabilities, which was tested in a separate environment from online testing. CBDC offline testing aimed to assess the potential of CBDC in enhancing payment system resiliency in scenarios involving internet dead spots, temporary shortages, or disasters that could lead to disconnection from the internet for certain users. In this offline testing, physical smartcards were used to store CBDC.

Initially, CBDC can be topped-up through an application by tapping the physical card to a smartphone with Near-Field Communication (NFC) technology. Once CBDC has been deposited to the physical card, the user may use the card to make payments without connecting to the internet, and the outstanding CBDC will be deducted from the physical card at the amount used.

The BOT utilized an offline CBDC solution in a **fully-offline form**.⁸ It is designed to support consecutive offline payments, allowing transactions to be conducted without internet connectivity by locally connecting two physical cards together with smartphones via Bluetooth Low Energy (BLE) and NFC technology. Users can then transact with the CBDC received via offline transactions with one another without the need to connect the internet.⁹

The solution demonstrated the capability to **handle hundreds of transactions during periods of disconnection before requiring synchronization with the core validation system (time spent offline)**. Nonetheless, some challenges offline CBDC remain unsolved as elaborated in *Section 4 (4 – Challenges)* of this report.



Source: Bank of Thailand

The outcome of the testing from the Foundation Track suggested that the technical and system design of the Retail CBDC, as tested in the pilot, effectively handled online retail payment and demonstrated its interoperability in connecting with the FSPs' internal systems and services, including both banks and non-banks. In addition, the Retail CBDC possesses characteristics that enable a level-playing field across players by allowing non-banks to connect to the CBDC system, and to receive and redeem CBDC directly with the BOT.

Having a level-playing field for all payment service providers could subsequently lead to greater access and choice of financial services that better serve the people in Thailand.

⁸ BIS: Project Polaris: A Handbook for offline payment with CBDC, May 2023

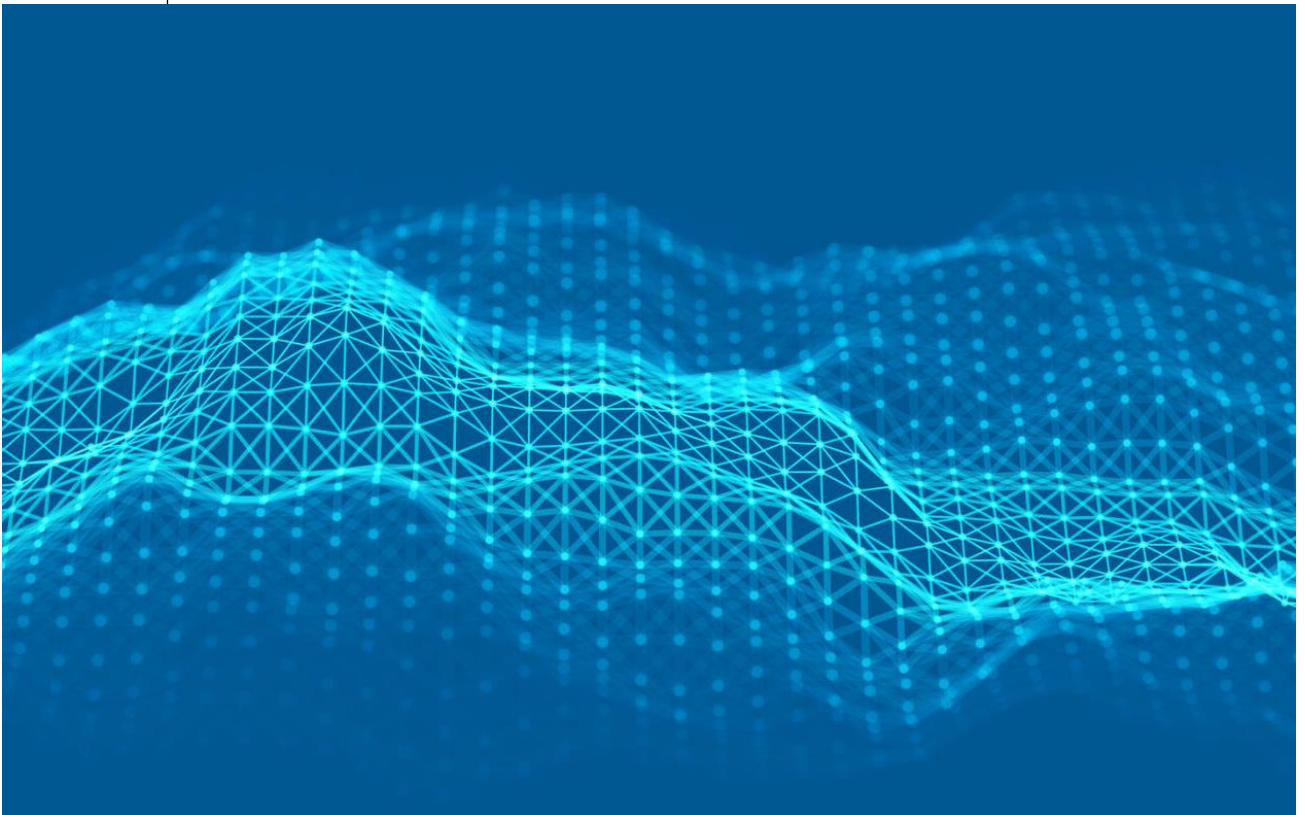
⁹ There are other options to execute offline transactions, too e.g., connect smartcards together with 8-pin chip adaptor and/or NFC-capable devices, etc.

2.2 Innovation Track

The Innovation Track explored the feasibility of harnessing financial innovation using the Retail CBDC infrastructure. This track introduced use cases for testing, explored a proof of concept (POC) proposed by the private sector, and conceptual feasibility studies on how FSPs might generate use cases for Retail CBDC to test new financial innovation and services that enhance payment system capability.

The BOT published the “Retail CBDC Whitepaper” and organized a Retail CBDC Hackathon competition in 2022. The objective was to solicit use cases from the public that could benefit payment systems universally and more effectively meet the needs of the private sector and individuals. Subsequently, the first prize winning case from the “Retail CBDC Hackathon” (more details in *Box B: Retail CBDC Hackathon*) was selected to be further tested with FSPs in an experimental environment.

The BOT also accepted use cases proposed by FSPs for POC studies during the Innovation Track. A separate environment for experimental testing was used for risk mitigation purposes, with no connection or dependencies on the Foundation Track.



BOX B : Six key themes from Retail CBDC Hackathon

RETAIL CBDC HACKATHON

Recognizing the significant role the public plays in driving financial innovation and financial services, the BOT invited the public to participate in a “Retail CBDC Hackathon” during 5 August–12 September 2022. Applicants submitted ideas that demonstrated potential use cases for Retail CBDC in Thailand, based on the Retail CBDC design described in the “Retail CBDC Whitepaper” published earlier in the same year. The top ten final teams received mentorship from experienced financial institution participants from Project Inthanon, which was Thailand’s inaugural in exploring CBDC.¹⁰ The winning use case was chosen for further experimentation under the Innovation Track to assess its technical feasibility.

The Retail CBDC Hackathon attracted significant interest from the public, with over 100 applications received. The submissions covered a wide range of Retail CBDC use cases that could potentially benefit Thailand’s retail economy and businesses, summarized across six key themes:

-  Financial literacy
/SMEs/Micro payment
-  Investment
-  Green finance
-  Interoperability
/Digital Asset
-  Insurance
-  Tourist
/Cross-border payment



Source: Bank of Thailand

¹⁰ Financial institutions participants from Project Inthanon are Bangkok Bank Public Company Limited, Bank of Ayudhya Public Company Limited, Kasikorn Bank Public Company Limited, Krungthai Bank Public Company Limited, Standard Chartered Bank (Thai) Public Company Limited, Siam Commercial Bank Public Company Limited, and Hong Kong and Shanghai Banking Corporation Limited (Bangkok Branch).

USE CASES STUDIED AND TESTED IN THE INNOVATION TRACK

1. **The first prize winning use case from the Retail CBDC Hackathon was called “Grow Up Wallet”, which entailed conditional payments for children using conditions set by parents.** A PoC was conducted in a controlled testing environment which included distinct programmable payment test scripts tailored for parents, children, and merchants. Two key conditions were tested: 1) parents can set conditions for payment with Retail CBDC to be made by children, with merchants having Retail CBDC wallets with the same or different wallet providers as or from parents, and 2) parents can alter the set-programmable logic as the experiment runs without disrupting the system, efficiently and correctly.

The experiment and respective conditions had been pre-determined in advance by the programmable payment test scripts for 200 experimental users (including parents, children and merchants) with three services providers. Approximately 4,000 payment transactions were conducted during a 10-day period.

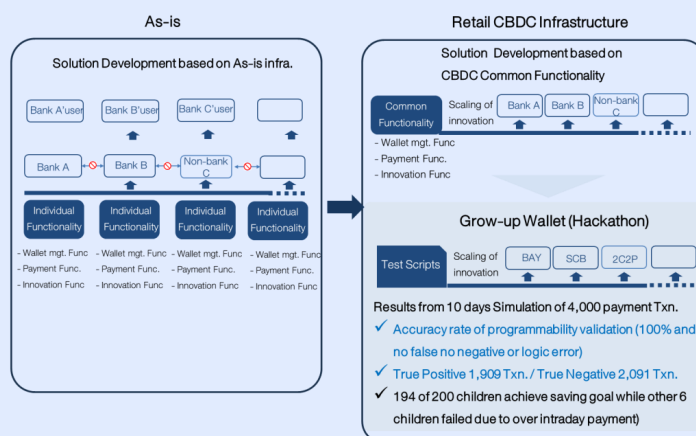
The results from the experiment indicated that the Retail CBDC system can respond well to conditions set for payments both in the case of same service providers and across different providers without logic error. Furthermore, the conditions set by one service provider can be effectively passed to others through common functionality. Over a longer term, this capability could help efficiently lower the costs associated with adapting legacy systems when embracing new use cases and financial innovation (as summarized in Figure 5).

2. **The BOT studied the conceptual feasibility of two use cases** proposed by FSPs, including 1) **Universal Escrow** (conditional payments across FSPs for the delivery of goods versus payment by buyers and sellers without platform intermediaries), and 2) **Fraud Detection and Handling** (traceability of illicit transfers of Retail CBDC and fraud handling of such illicit CBDC transaction e.g., preventing illicit Retail CBDC to be further used in the CBDC system).

The evaluation found that the infrastructure of the Retail CBDC system theoretically holds the capability to enable the two aforementioned use cases, given the exceptional common functionality feature supporting Delivery versus Payment (DvP). This means the Retail CBDC system could adopt a use case developed by one FSP to the system and apply it across FSPs (i.e., it is scalable across FSPs), with lower costs of adjustments needed to alter FSPs’ legacy systems. Additionally, token-based CBDC holds potential for these breakthroughs through scaling for innovation and common functionality features while retaining unique characteristics, similar to the unique serial number of physical cash, with digitally traceable features without exploiting user privacy.

Nevertheless, these use cases in the Innovation Track were explored on conceptual feasibility basis only and are subject to further exploration and design consideration. See *Appendix 1 - Innovation Track Use Cases* for more details.

FIGURE 5 : Innovation Track – Experiment of programmability in Grow Up Wallet use case



Source: Bank of Thailand





3 – Pilot Findings

A key advantage of the Retail CBDC Pilot Program was its **hands-on approach** to exploring various scenarios by **testing the end-to-end life cycle of CBDC in collaboration with diverse industry experts, as well as with users and merchants in a real-life environment using real-value transactions.** This exploration provided **valuable insights into many issues** that could arise from Retail CBDC, spanning business, legal, technical, accounting, and operational aspects.

3.1



Foundation

1. Functionality



Business and Operational Considerations

The real-value testing of Retail CBDC in the pilot and end-to-end operations of the Retail CBDC system included the operations done by the BOT (request/validate/transfer/redeem), the connectivity with FSPs' systems (to distribute CBDC and interoperate with the banking system), as well as payment channels for users and merchants (via Standard QR codes, Online channels, point of sales (POS), Wallet IDs) in daily live payment activities. **The tests indicated that the CBDC design functioned well for minting, distribution, and melting of CBDC, and was well-integrated and interoperable with the existing payment infrastructure and efficiently used across the FSPs, offering a similar user experience to the mobile banking applications currently available in Thailand (as shown in Figure 6).**

FIGURE 6 : Mobile application for Retail CBDC in the pilot



Source: Bank of Thailand



Regulatory, Legal and Accounting Considerations

End-to-end testing of the Retail CBDC in a live environment led the BOT to **consider associated considerations and have dialogues with relevant government agencies**, including on the following:

- **Legal aspects:** The BOT is empowered by its law to develop and run the pilot.¹¹ However, given the limited scope of the testing, it was not necessary to amend respective laws and regulations to endorse CBDC as legal tender. However, considerations regarding law amendments will be needed going forward if Retail CBDC will be launched for general public.

- **Accounting aspects:** The BOT and the Federation of Accounting Professions reached a conclusion to record the outstanding Retail CBDC as cash equivalent.

- **AML/CFT aspects:** The BOT and the Anti-Money Laundering Office consulted the guideline for compliance by FSPs as well as business rules setting transaction and wallet limits during the pilot for AML/CFT purposes.

¹¹ The BOT developed and ran the Retail CBDC pilot by virtue of Section 8(6) and Section 44 of the Bank of Thailand Act B.E. 2485 (1942), as amended.

The Retail CBDC Pilot Program led the BOT and FSPs to prepare for and manage associated risks in a real-life setting, including having a business continuity plan (BCP) in place for the pilot testing and taking technology, cyber, and operational risks into consideration during the pilot. For instance, the BOT set up a governance structure between FSPs and the BOT to monitor and response to incidents, which led to non-disrupted testing throughout the pilot.

2. Performance

The pilot results revealed a satisfactory outcome demonstrating that the Retail CBDC efficiently maintained the capability to handle retail payment transactions of users and merchants, without any material system errors preventing transactions from completing. The testing was gradually scaled from internal usage within the BOT among 1,000 staffs (users) and was later extended to include staff of the FSPs, reaching approximately 4,000 users throughout the pilot period. In addition, the FSPs successfully and efficiently connected and transacted between the Retail CBDC system and each FSP's existing payment system (legacy system), without any material or continuous system errors.

3.2



Innovation

1. Scalable programmability

Our Retail CBDC design encompasses the **capability for scaling-up innovation through the common functionality feature** e.g., programmability feature. This enables FSPs with retail payment systems to develop and **apply use cases across other FSPs, with low cost and minimal efforts in adapting their in-house legacy systems over the long term.**

2. Token-based use case development

Our Retail CBDC, being a token-based design, unlocks the potential for developing financial innovation and use cases for retail payments beyond existing financial services on an account-based basis e.g., conceptual feasibility of fraud traceability and fraud handling cases, where illicit funds could potentially be frozen at the token-level, unlike the current practice of freezing accounts.

3.3



Open-access infrastructure for both existing and new financial service providers

Having non-banks join the pilot as one of the FSPs, the pilot results demonstrated that Retail CBDC's business features can support **access and integration to CBDC infrastructure for all FSP players (bank/non-bank)**. Retail CBDC therefore addresses existing pain points of the payment infrastructure by allowing direct access to central bank system for non-bank. Consequently, Retail CBDC could help reduce transaction costs for non-banks and stimulate retail payment services, as well as foster the development and creation of new use cases.

3.4

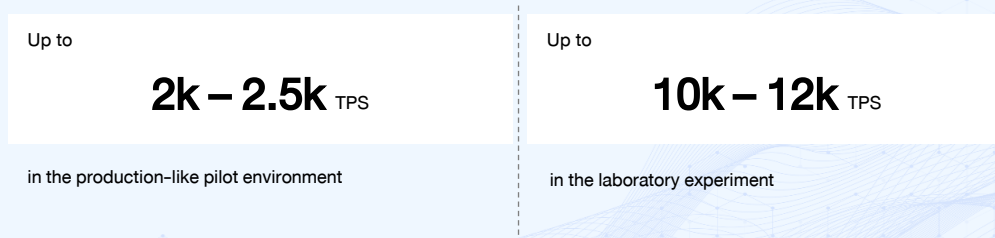


As alternative retail payment infrastructure

Based on information from the pilot test, Retail CBDC holds capabilities to be an alternative channel for retail payment. Retail CBDC can serve high transaction volume, low transaction value, in the production-like-pilot environment for up to 2,000-2,500 transaction per second (TPS), (equivalent to existing payment system) and in the laboratory experiment for up to 10,000-12,000 TPS, as summarized in Figure 7.

FIGURE 7 : Capability of Retail CBDC in the pilot

Note: These are based on pilot testing and subject to further exploration.



Source: Bank of Thailand

4 – Challenges

Challenges uncovered during the pilot testing

Business & Regulatory

1. Non-bank business model

Despite having direct access to the CBDC system during the pilot, non-banks still had to rely on banks and were faced with transaction fees for exchanging Thai baht with Retail CBDC, for transactions between non-banks and the BOT (i.e., request/redeem) as well transactions between non-banks and users (i.e., top-up/withdrawal). These transaction fees occur since the testing design set bank and non-banks (as FSPs) to take both wallet provider and Retail CBDC distributor roles. Given this, Retail CBDC management by non-banks would need to be considered further to explore sustainable business models for non-banks in the future.

Technology

2. In-progress transactions and double payment handling

Given the BOT's important role as a validator, the BOT may need to be involved in retail transaction management if transactions are found pending (with an in-progress transaction status), which in some instances could lead to failed transactions or double payments (via CBDC and/or other payment channels). However, it is important to note that no CBDC was lost and no double-spending of CBDC occurred during the pilot. Therefore, the design level of CBDC should be further explored to overcome such technical challenges to ensure the irrevocability of transactions, as well as to **consider an appropriate role of the central bank in the double payment handling process.**

Technology

3. Offline CBDC for specific use cases and reliance on physical devices

Despite the revealed capability of Offline Retail CBDC from the pilot, the instability in the connectivity between offline devices remains challenging (e.g., physical card) through Bluetooth and NFC, leading to the possibility of multiple retries.¹² Therefore, Retail CBDC design should take such technical challenges into account to enhance confidence in transacting with CBDC in offline settings. Additionally, the global ongoing development of security for offline CBDC functionality may pose cyberthreats to Retail CBDC kept in the offline device for a long period of time due to the compatibility and application issues. Subsequently, certain usage rules, e.g., limited offline periods for holding Retail CBDC, might be set for the users to mitigate these risks.

¹² This is the result based on as-is offline solution during test period, which has been further improved with more stable connectivity options afterward (though those new options have not been tested during our pilot). In addition, there is zero failed retry throughout the test period, so it is just a matter of user experience only.

Challenges for future exploration

Business & Regulatory

1. Positioning of Retail CBDC for public use

From a user standpoint, the basic functions of Retail CBDC provides a user experience that is no different from other existing electronic payments. Thus, the design and positioning of Retail CBDC in the long term should take into account public needs beyond the capabilities of the existing payment infrastructure e.g., programmable payment features. This appears to be the same challenge for countries that have already launched Retail CBDC and are facing challenges with adoption.

Business & Regulatory

2. Governance for common functionality

Based on the result of the POC from the Innovation Track, CBDC presents substantial benefits for financial innovation within the payment system. Nonetheless, in practice, there is the challenge of establishing appropriate governance models to onboard innovative features for common CBDC functionality that would be open for both small and large FSP players in the market to compete and develop use cases.

Business & Regulatory

3. Alignment of future regulatory framework

Relevant laws and regulations must be considered if Retail CBDC is to be launched in the future, and such actions require a great deal of coordination with relevant government agencies. Laws such as Thailand's Currency Act, Payment System Act (under the BOT's supervision) and Digital Asset Laws (under the supervision of Thailand's Securities and Exchange Commission) would need to be aligned.

Business & Regulatory

4. Business rules

Retail CBDC, as a public infrastructure for businesses and the general public, should consider the format of business and services together with conditions for their business models. That said, such forethought should be done based on the concept that Retail CBDC will support a variety of players and foster competition in terms of financial innovations so that business and individuals will have access to financial services that serve their needs and are at reasonable cost.

Technology

5. Technology solutions

The BOT chose certain technologies for the pilot test e.g., token-based instead of account-based, or centralized-based rather than DLT-based, etc. Nonetheless, these technologies will continue to evolve due to technological advancements. Therefore, the technology solution and CBC design would need to be re-evaluated in the future before making it available for general public use, by taking into account the adaptability the underlying technologies, as well as their ability to respond to cyber risks and threats. For instance, potential technology choices could be a hybrid model of centralized and decentralized systems, or the development of interfaces to be compatible with seamless smart contract connectivity, etc.

5 – Conclusion

FIGURE 8 : The Journey of Thailand Retail CBDC Pilot Program



Source: Bank of Thailand

Retail CBDC

The Retail CBDC Pilot Program, focused on the real-value CBDC testing, involved an end-to-end cycle of CBDC operations. This included the BOT minting and melting CBDC and verifying CBDC transaction, as well as FSPs distributing CBDC and providing CBDC wallets to designated individuals, merchants and businesses for transfer and payment transactions. Throughout this process, the BOT and FSPs gained firsthand experience with Retail CBDC operations and also addressed considerations related to business, regulation, accounting, risk management and technology. The pilot showcased the potential of CBDC especially from a financial innovation perspective e.g., programmable payments and common functionality features. Nonetheless, the pilot revealed key findings and challenges across multiple considerations including policy, business, legal aspects which may serve as a pivotal reference for future initiatives in payment system

development, potentially enabling the people in Thailand to have greater access to a range of innovative services at a reasonable cost.

In a nutshell, the successful Retail CBDC Pilot Program was part of a long-term project of CBDC study and development, aimed at assessing the suitability of CBDC technology and CBDC design to drive financial innovation in the future.

Next steps

The insights gained from the Retail CBDC Pilot Program, particularly regarding CBDC design and technology, have yielded significant lessons for further development in other projects, especially in the areas of architecture design and common functionality. The BOT will leverage insights from the pilot to support future payment initiatives and projects, which will be on a separate track from the Retail CBDC Pilot Program. For instance, this could include programmable payments by the private sector and the tokenization of assets. These separate tracks will be further explored by the BOT, in close collaboration with the private sector, through an upcoming sandbox scheme that will soon be open for applications.



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7 – Contributors

Authors



ธนาคารแห่งประเทศไทย
BANK OF THAILAND

Digital Currency Policy and Development Unit Bank of Thailand

Kasidit Tansuguan Project Owner/Director	Naphongthawat Phothikit Director	Peerapong Thonnagith Deputy Director
Witit Symsatayakul Deputy Director	Nuntapun Bhensook Assistant Director	Thanaporn Rattanakul Senior Specialist
Pontakorn Mekintarangkoon Senior Specialist		

Acknowledgements



ธนาคารแห่งประเทศไทย
BANK OF THAILAND

Bank of Thailand

Sethaput Suthiwartnarueput Governor	Alisara Mahasandana Deputy Governor	Titanun Mallikamas Assistant Governor
Chayawadee Chal-anant Assistant Governor	Dej Titivanich Assistant Governor	Amporn Sangmanee Assistant Governor
Vachira Arromdee Executive Advisor	Buncha Manoonkunchai Senior Director	Yuphin Ruangrit Senior Director
Chiranut Tanyacharoen Senior Director	Wijitlaka Marome Director	Tuangporn Khawcharoenpom Director
Pisak Kurusathian Deputy Director	Uraipun Borriruktungkul Deputy Director	Korakod Pattanakun Deputy Director
Sarun Puttikajom Deputy Director	Chonkana Noppakunsomboon Assistant Director	Tanathom Mahapomprajuck Assistant Director
Pimpatra Kayansumruaj Assistant Director	Premmanat Kanchanawila Senior Specialist	Tunyathon Koonprasert Senior Specialist
Krittidech Wongpool Senior Specialist	Purinut Kittichaiwat Senior Specialist	

Technology vendor



Giesecke+Devrient
Creating Confidence

Giesecke + Devrient advance52 GmbH

Martin RÖnnebeck Project Manager	Youssef Benghazouani Project Manager	Tom Bruls Head of Professional Services
Dr. Klaus Alfert Senior Architect	Dr. Lars Hupel CBDC Expert	Jie Hou DevOps
Teresa Riedl Head of Product	Youjin Kim Senior Product Manager	Peter Zeller Performance Expert

Acknowledgements



Financial Service Providers

Siam Commercial Bank Public Company Limited

Chalee Asavathiratham SEVP, Chief Digital Banking Officer	Pompen Rungruangpattana Lead, Project Manager, E-Integration Innovation Delivery	Pichaya Pejarononda SVP, Retail Payment Acquiring Product Management
Arparat Vatanasirisuk Senior Professional, Strategy & Business Development	Varin Ployangoonsri Head of Payment Eco	Tikamporn Plapiriyakit Project Manager, Digital Platforms
Salaya Kasetkansakun Project Lead, Card Acquiring	Krich Kanadern Head of Payment Integration Platform	



2C2P (Thailand) Company Limited

Varin Achariyakulporn Executive Director and Team	Wutthisart Yingdon Director Application and Team	Sirinee Delokcharoen Director Marketing and Team
Adam Rivera Director Projects and Team	Raden Trevisure Director Business Development and Team	Siripom Chongpratheep Senior Manager Product Support and Team
Krit Tanamartayarat Senior Manager Product and Team	Chanapol Chumpoo Manager DevSecOps and Team	Noontalee Konghachan Manager Card Operations and Team



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Bank of Ayudhya Public Company Limited

Sayam Prasitsirigul Chief Information and Digital Officer	Patcharin Boonlumsun EVP, Head of Commercial Digital Solution Division	Pongsit Vilalert SPV, Head of Domestic Cheque Operations Department
Manisa Meeanim SVP, Head of Debit Card Payment and Western Union Products Department	Sumalee Noparat SVP, Executive Relationship Manager	Vichai Kolsonvoravattanakul VP, P2P Accounting SSC/COE Department
Boonthep Techarungrangkit SVP, Digital Strategy and Planning Section	Samatcha Thanangthanakij System Architect, Innovation and Business Solution	Patcharin Khaoriang SVP, Head of SME Digital Banking Department

Appendix 1 – Innovation Track Use Cases

Programmability tested in Innovation Track via Grow Up Wallet use case demonstrated that the Common Functionality feature facilitates the scaling of innovation across FSPs with less adoption time.

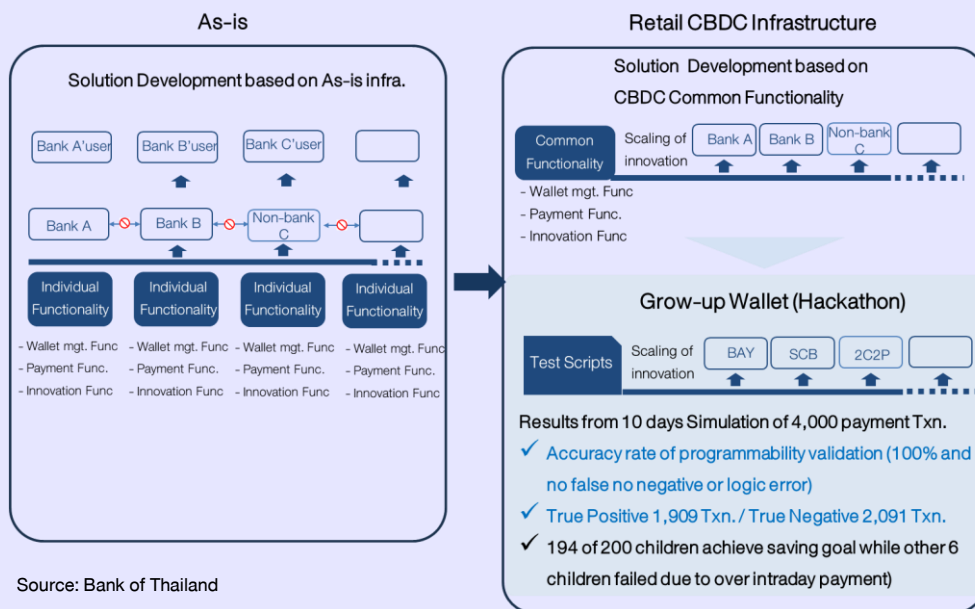
Figure 8: Innovation Track – Use case

Category	Pilot Participant(s)
Innovation Track	
(1) Experiment – Grow Up Wallet	BOT x First prize winner of CBDC Hackathon 2022 x 3 FSPs
(1) Conceptual Feasibility – Universal Escrow	BOT x Bank of Ayudhya Public Company Limited
(2) Conceptual Feasibility – Fraud Handling	BOT x Siam Commercial Bank Public Company Limited

Experiment – Programmable Payment

Grow Up Wallet

Figure 9: Experiment – Grow Up Wallet



Problem Statement:

As financial literacy is an essential skill, it is necessary for parents and schools to infuse key concepts into school curricula and everyday life. To further promote disciplined financial habits by leveraging the benefits of technological solutions, Grow Up Wallet aims to

explore how programmability might equip parents to set conditional payments in their child's wallet in which these payment conditions can be scalable to any merchants. This would help shape payment behavior for children under their care.

Potential of Retail CBDC Solution:

The success of the programmability experiment, which identified no logic errors, indicates that the CBDC system's common functionality can expedite use case development with shorter adoption times for financial intermediaries.

Nonetheless, to further enhance financial innovation, the expansion of features under the common functionality is essential to support a broader range of use cases.

Testing:

The experiment was designed to run for 10 days, involving 200 testers who executed 4,000 transactions. It included three distinct test scripts tailored for parents, children, and merchants. This set up aimed to test the interactions among these parties to ascertain whether the Retail CBDC infrastructure could effectively set conditions for payments and validate programmability across the service providers correctly.

Universal Escrow

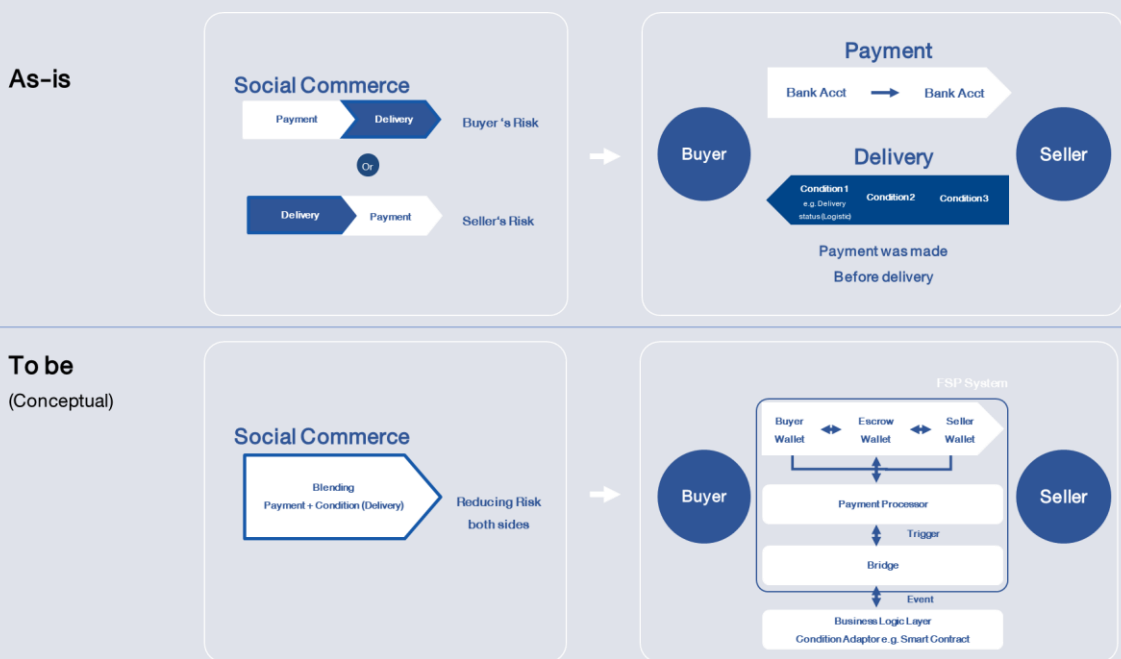
Problem Statement:

Nowadays, the purchasing of goods and services online without an intermediary platform can introduce risks such as the non-delivery or unsatisfactory delivery of goods and services, particularly when payment is made up front. This issue has led to significant disputes and losses in the retail payment system. Many products and services lack an intermediary platform, and where such platforms exist, sellers often incur service fees as a cost of doing business.

Potential of Retail CBDC Solution:

The potential of the escrow use case, proposed by Bank of Ayudhya Public Company Limited, lies in its ability to scale across financial intermediaries through a common functionality feature of the CBDC System, regardless of the diversity in the legacy systems among them. If programmable payments is established as a common feature of CBDC, it could enable the widespread use of such features across all financial intermediaries. However, it is important to note that further exploration into interface solutions, such as APIs and smart contracts, is essential for successful implementation

Figure 10: Conceptual Feasibility - Universal Escrow



Source: Bank of Thailand

Fraud Handling

Problem Statement:

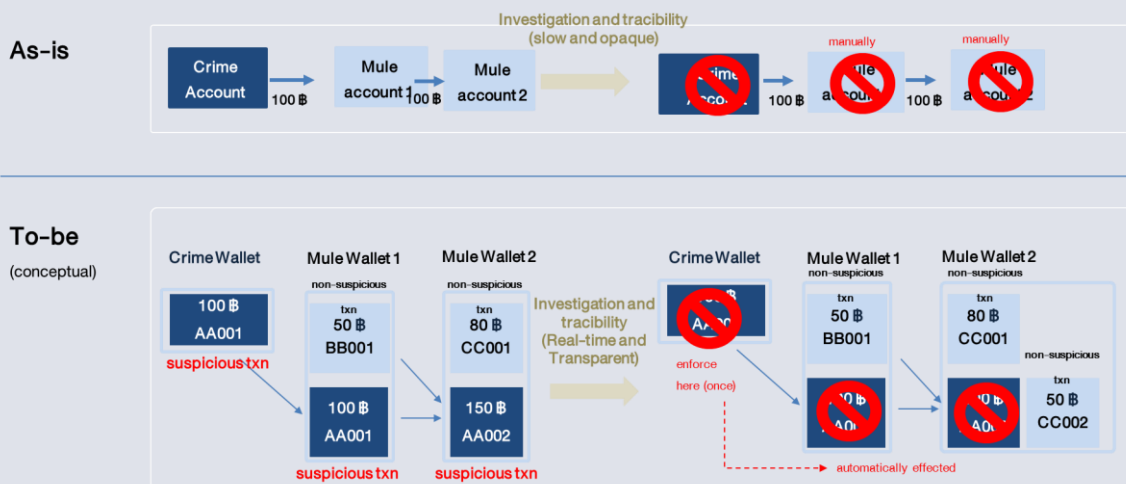
In Thailand, tracing the financial pathways of financial crimes is time-consuming due to redundant processes and inefficiencies, as well as a lack of data connectivity in the current financial system. This delay causes drawbacks to the public and consumes extensive government resources. Even when financial trails are detected, entire bank accounts must be frozen, as it is challenging to distinguish between legitimate funds and illicit money within the same account.

Potential of Retail CBDC Solution:

As initiated by Siam Commercial Bank Public Company Limited, a token-based CBDC, equipped with a unique serial number (like token identifier) has the potential to significantly aid in addressing fraud-related use cases. It allows for the direct identification of the specific Retail CBDC units that were in the possession of criminals, enabling tracking at individual token level. This approach contrasts with current procedures, which necessitate tracing and freezing funds at the account level to address illicit financial flows.

However, it is crucial to note that while this use case is technically feasible, it has not yet been tested in a real-world scenario. Further exploration into governance, operations, legal implications, and the roles of relevant parties is essential to fully realize this concept.

Figure 11: Conceptual Feasibility – Fraud Handling



Source: Bank of Thailand

Appendix 2 –Technical Terminology

<p>A. Project stages</p>	<p>C. Tokens vs Account Balances</p>
<ul style="list-style-type: none"> • Ideation: The initial phase of product development, which involves coming up with ideas for issues that need to be resolved or opportunities to be seized. • Proof of Concept (POC): An early stage lab-test for validating a specific technology or assessing product feasibility. • Prototype: A workable model of multiple product features that is designed to test a product's design, usability, and frequently functioning. It is comparable to an early draft of the finished product. • Pilot: The phase of product testing with real end-users, to determine if carrying out the project at full scale is feasible. • Minimum viable product (MVP): An upgraded version of the product based on findings from the pilot stage. MVP can typically be deemed as a product that is good-enough to be launched at a minimal scale. • Production: The completed version of the product, launched for usage by the targeted users. 	<p>Digital money issued by the central bank has long existed in the form of reserves deposited in commercial banks' current accounts with the central bank. This means it is held in accounts and the balances are controlled by the central banks in the central systems. The existing digital money is thus managed under account balances basis.</p> <p>In contrast, tokens issued by the central bank represent data stored on the servers containing its serial number. They are similar to banknotes as a form of physical token issued by the central banks, stored in the safety vaults at commercial banks. Tokens can be passed from one owner to another as transfers without instructing a central service to debit and credit accounts. This is called token balances basis.</p>
<p>B. DLT vs Non-DLT</p>	
<ul style="list-style-type: none"> • Decentralized ledger technology (DLT): The technological protocol infrastructure that enable synchronization of record update, validation, and access across decentralized nodes of database, without the need for central administrator. • Non-DLT: Other technology solutions that do not hold the characteristics of DLT. 	



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