



Digital Dollar Project and DTCC: Security Settlement Pilot

Exploring Post-Trade Security Settlement
with a U.S. Central Bank Digital Currency

November 2022

DTCC



**accenture**

Pilot Partners



Pilot participants provided feedback in the DDP and DTCC:
Security Settlement Pilot through a series of workshops

Foreword

DTCC

It's often said that the COVID-19 pandemic condensed a decade of digital innovation into a two-year period – a statement that rings truer every day. In the post-COVID world, the pace of change has further accelerated, and the reality is that we should expect digital transformation to reshape markets and market structure in the coming years.

At the Depository Trust & Clearing Corporation (DTCC), we have a long history of driving digital innovation – beginning with our founding and the creation of the first electronic securities nearly a half-century ago. We've built upon this legacy in each successive decade, and today, our commitment to providing industry leadership on ways to leverage innovative and emerging technologies to make markets safer, more efficient and less costly is stronger than ever before. This is apparent in our research, development and launch of new solutions in recent years that use distributed ledger technology (DLT), artificial intelligence and machine learning, cloud computing and other technologies.

One area of experimentation that has generated significant interest is our work with Digital Dollar Project this year to better understand the implications of a U.S. Central Bank Digital Currency (CBDC) on post-trade settlement. These efforts, which are detailed in this white paper, simulate future settlement functionalities while ensuring optionality for clients as well as the same – or higher – levels of safety and security as DTCC's existing settlement solutions. This new initiative represents the essence of innovation.

I wish to thank our partner, Digital Dollar Project (DDP). The collaboration with DDP enabled a successful pilot and provided us with valuable insights. DDP and DTCC will continue our exploration of this technology to support efforts by the public sector and the industry to examine the benefits and challenges of a wholesale U.S. CBDC.



Jennifer Peve

DTCC Managing Director
Head of Strategy and Business Development

Foreword



The Digital Dollar Project is a non-profit organization devoted to catalyzing research and exploration of the potential advantages and challenges of a U.S. CBDC. It works to convene and incorporate the perspectives of a diverse set of stakeholders, including private sector, academic, and policy thought leaders, to better inform national policy considerations in the development of a U.S. digital dollar. In 2021, the DDP launched a series of exploratory pilot programs to educate the public, market participants, and policymakers on the implications of applying a CBDC to a range of real-world use cases.

DDP and DTCC's Security Settlement Pilot (the pilot), the first private sector-initiated experiment intended to inform a potential U.S. CBDC, is a prime example of how DDP works with industry stakeholders to bring a broad range of viewpoints to the exploration of a digital dollar. As outlined in this report, the pilot tests the ability of a simulated digital dollar, transacted on a DLT-based network, to underpin the settlement of U.S. equity securities. It confirms how a robust, secure and efficient securities settlement process working with a potential U.S. CBDC could provide many benefits to safeguard U.S. financial stability and mitigate operational and counterparty risks. Understanding the impact of CBDC technology on this critical aspect of financial market infrastructure is imperative to the evolution of U.S. markets.

DDP believes that conducting pilot projects of CBDC applications under real-world conditions with industry participants best generates the empirical data necessary to adequately inform the design and potential deployment of CBDC. It is through public-private partnerships that we can most effectively explore and understand the many technical and policy dependencies and implications in the design of a CBDC.

DDP wishes to thank DTCC for their pilot leadership and the pilot participants for their outstanding collaboration and offer this report for public review and analysis as a resource to inform this critical public policy discussion.

The Digital Dollar Project Board of Directors

The Honorable J. Christopher Giancarlo
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Executive Summary

Exploring Post-Trade Security Settlement with a U.S. Central Bank Digital Currency

Capital market infrastructure providers around the world are looking to new technologies to modernize legacy systems and provide the industry access to new offerings. Market participants are looking for solutions to simplify compliance requirements and ease rising capital allocations and liquidity costs. There is evidence that DLT based infrastructures could save the industry billions of dollars a year by simplifying trade confirmations, reconciliation, cash management, asset optimization and other exceptions-based business logic processes[1]. In addition, CBDC could offer a new and alternative payment model that may provide benefits to cash settlement processes in the United States. To further understand the promise and implication of CBDC, DTCC and DDP launched a pilot initiative focused on delivery versus payment (DvP) settlement.

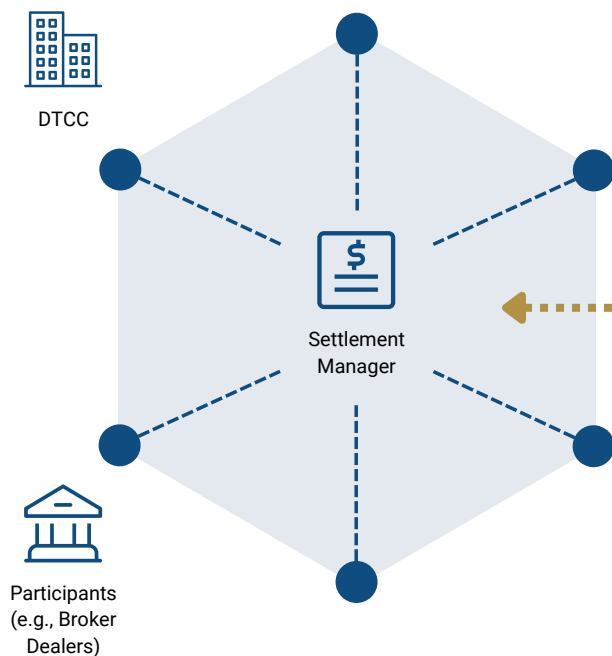
Given the global activity surrounding the potential of CBDC development, the pilot set out to explore CBDC in a U.S. market context and to better understand the potential implications of using CBDC in the DvP settlement process. Post-trade settlement in the U.S. is significantly different from settlement in foreign markets and carries a distinct set of requirements. As digital assets and currencies based on DLT become broadly adopted, it is important for U.S. market participants to explore this technology and understand its implications. Building on the work of global initiatives, this pilot explored CBDC in a distinct U.S. financial market setting.

Leveraging DTCC's experience with and investment in DLT, the pilot focused on exploring the implications of using a U.S. issued CBDC in DTCC's post-trade services. DTCC and DDP experimented with CBDC technology in a research development environment without production implications. The team designed and developed a CBDC network that builds upon the work of previous initiatives coordinated by a range of market participants, including private sector players and central banks, which explored the use of a CBDC in wholesale securities settlements. In the pilot the team designed and implemented a technology solution to demonstrate secure and efficient use of settling tokenized securities on DTCC's Digital Settlement Network prototype against tokenized dollars on a simulated CBDC network, ultimately connecting two distinct asset networks to enable secure, resilient, and efficient security settlement with CBDC. Further, the team assessed network

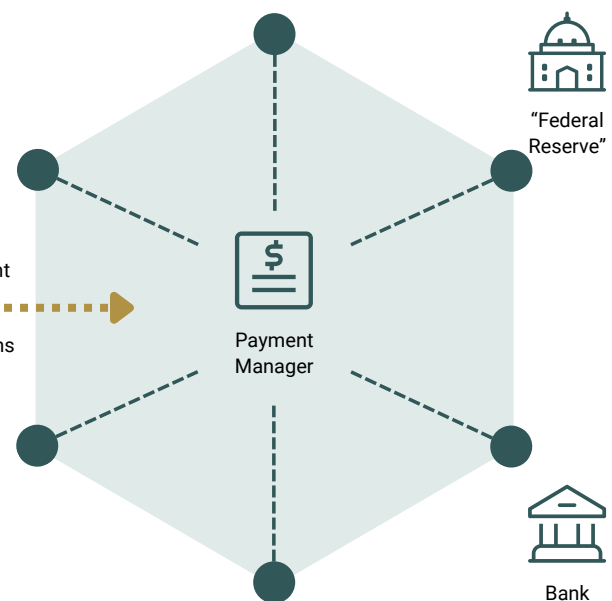
[1] Accenture, ["Banking on Blockchain, A Value Analysis For Investment Banks"](#)

governance and created a mechanism for a network administrator to resolve transactional issues if needed but would otherwise observe while the network automated orchestration. The pilot also solicited feedback from a group of industry experts across nine participating banks to validate the technical and functional designs of the pilot and to evaluate the business implications for wholesale securities settlement.[2] The pilot enhanced the DDP's understanding of CBDC, outlined network connectivity and design choices, identified potential business outcomes, and laid out potential opportunities for further exploration of a CBDC settlement use case.

DTCC's Digital Settlement Network



Digital Dollar Network



Settlement
Instructions

[2] During the pilot, participants completed questionnaires to provide feedback on the project. The responses from the questionnaires have been anonymized and used to inform the perspectives of this report.

Key Outcomes



CBDC Design Approach: Refined the DDP's CBDC Champion Model requirements to support U.S. post-trade settlement.

- A CBDC network's technology decisions and design choices should be driven by functional needs, and as such, multilateral settlement and asset encumbrance mechanisms were identified as core functional requirements to support post-trade settlement.
- Broader access to a digital Federal Reserve payments system could change the existing settlement bank model as well as traditional industry responsibilities. Therefore, the impacts of a potential decision by the Federal Reserve to offer a CBDC should be explored in future initiatives.



Network Connectivity & Design Choices: Implemented certain design considerations based on a logical architecture.

- Minimized transaction confidentiality risks while providing sufficient transparency to DTCC and the Federal Reserve in a simulated environment.
- With the assumption that a Federal Reserve CBDC network and the DTCC's Digital Settlement Network would be separate and distinct networks, orchestration between the two networks was required to provide the guarantee of atomic settlement.
- Implemented a neutral third-party orchestrator to handle all settlement transaction instructions between the networks which ensured that the assets were settled on both networks, minimized dependencies on communication between parties and eliminated counterparty risk at the time of settlement.
- Used an algorithmic encumbrance mechanism to enforce conditions on the release of assets, which leveraged smart contracts to control the asset rather than a third party.



Business Implications: Found operational benefits and tradeoffs of a potential CBDC settlement system.

- A CBDC could enhance operational efficiencies, allowing DTCC to streamline settlement processes.

- A DLT-based cash settlement infrastructure where the Federal Reserve is the owner and operator of the network can provide transparency and reporting benefits as an alternative model that replaces and simplifies reporting to DTCC and the Federal Reserve.
- CBDC settlement supports a flexible settlement architecture that provides additional optionality to industry participants.
- CBDC settlement could provide funding and risk benefits and tradeoffs for the industry.

Future Considerations



Future Exploration: Specified opportunities for further exploration.

- Potential business benefits to CBDC settlement will depend on industry adoption. Accordingly, ecosystem adoption rates and requirements should be studied to better understand the business value proposition.
- The design and implementation of a logical model that could support cross-network settlement was the focus for the pilot. Future experimentation should focus on refining technology requirements for such a model, including scalability and performance, network interoperability and standards, and participant integration.

As the U.S. dollar is an integral part of the U.S. and global economy, a digital dollar should be carefully explored in consultation with key stakeholders in both the public and private sectors. This pilot with DTCC was a practical exploration of the use of simulated CBDC and DLT for DvP settlement in the U.S. wholesale financial markets through direct engagement with market participants. The results of the pilot are intended to inform private sector participants and U.S. policymakers of the advantages, requirements, and implications of this new technology paradigm.

Terminology

An important foundational component of the pilot was using common terminology and aligning on universally consistent definitions during the experiment. This report uses the following terms and abbreviations for ease and convenience.

Application Programming Interface (API)	A mechanism enabling communication between two software systems.
Atomic Settlement	The exchange of two assets that are conditional such that the transfer of one occurs only upon transfer of the other one.
Bilateral Settlement	A transaction in which two firms settle trades directly with one another.
Central Bank Digital Currency (CBDC)	A fiat currency that is digitally issued by the government's central bank, has the same legal status as physical bank notes and is fully fungible with central bank notes (bank notes or cash) and reserves.
Central Securities Depositories (CSD)	Provides a central location in which securities may be immobilized, or through which securities may be dematerialized, and interests in those securities reflected in accounts maintained for members.
Central Counterparty (CCP)	Also known as Central Counterparty Clearing House. A party that interposes itself between the counterparties in financial transactions by acting as the buyer to every seller and the seller to every buyer and provides clearing and settlement services
Delivery vs Payment (DvP)	Delivery versus Payment (DvP) is a settlement method that guarantees the transfer of assets only happens after payment has been made.
Distributed Ledger Technology (DLT)	Distributed Ledger Technology is a decentralized digital system for recording transactions between parties in multiple places at the same time.

Encumbrance	An encumbrance on a DLT transaction, if present, enforces a conditional control over the transaction that must be verified during the execution of the transaction. Transactions are encumbered by smart contracts.
Fed Fund Settlement System (FFS)	The Fed Fund Settlement System manages the communication of cash obligations to the Federal reserve system to update DTCC participant's reserve accounts.
Multilateral Settlement	Multilateral settlement is a payment model where the transactions of multiple parties can be summed and settled in aggregate rather than settled individually.
National Settlement Service (NSS)	The National Settlement Service is a multilateral settlement service owned and operated by the Federal Reserve Banks. The service is offered to depository institutions that settle for participants in clearinghouses, financial exchanges and other clearing and settlement groups.
Notary	Notaries are comparable to traditional Notary Public services that provide reliable witness to events. In simple terms, notaries confirm the validity of transactions and prevent double spending. They need not know the content of transactions.
Real-Time Gross Settlement (RTGS)	Real-time gross settlement is the process of settling payments on an individual order basis.
Settlement Bank	A DTCC settlement bank is a DTCC settlement participant who has access to a federal reserve account and can settle on behalf of other brokers.
Tokenization	Tokenization in this pilot program refers to the act of digitally representing information uniquely on a distributed ledger.

Introduction

Financial markets around the world are experiencing a paradigm shift

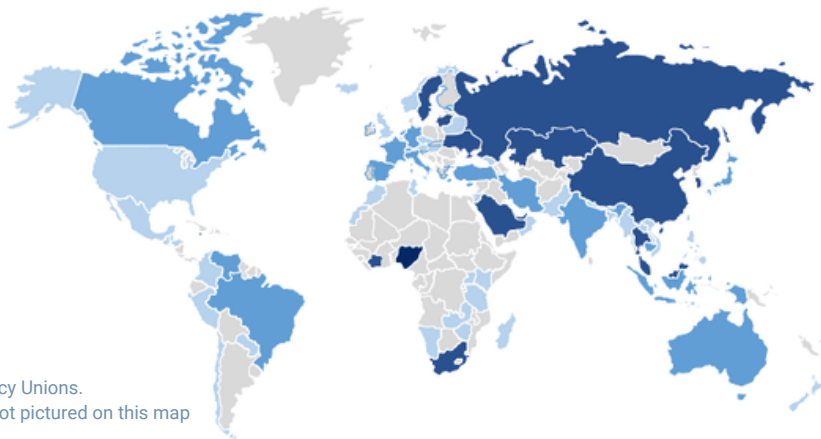
as distributed ledger technology and tokenized assets are challenging traditional business models and market infrastructure providers. As the world progresses towards a digital asset future, private and public institutions are continuing to explore benefits and implications across various digital asset use cases. Digital currencies are being introduced to streamline traditional payment networks and provide greater transparency across retail, wholesale, and cross border transactions.

Around the globe, digital assets of all designs are gaining traction as DLT-based infrastructures are beginning to complement traditional market infrastructures. CBDC has been proposed as a logical advancement and an alternate form of fiat money for central banks. CBDC is garnering significant attention with several initiatives being explored by private and public institutions. Over 105 countries, representing about 95 percent of global GDP and 19 of the G20 countries are exploring CBDC. [3] The European Central Bank (ECB) is currently undertaking a two-year investigation phase of its retail “Digital Euro” project (anticipated to be completed at the end of 2023)[4] and is considering whether new technologies like DLT could improve settlement in central bank money for wholesale transactions.[5] China reports that its digital fiat currency, the eCNY, is held in over 250 million digital wallets and is already responsible for a remarkable 87.5 billion yuan (\$13.78 billion) worth of transactions.[6]

112 Countries Currency Unions Tracked

- Launched 11
- Pilot 15
- Development 26
- Research 46

The Atlantic Council tracks 112 Countries / Currency Unions.
CBDC initiatives that are inactive or canceled are not pictured on this map



[3] Atlantic Council, [Central Bank Digital Currency Tracker](#)

[4] European Central Bank, [Digital Euro: Investigation Phase](#)

[5] European Central Bank, [Digital Euro: Demystifying wholesale central bank digital currency](#)

[6] China Internet Watch, [China's digital currency eCNY reached 261 million digital wallets](#)

In the U.S., private and public sectors are beginning to explore digital assets to understand how the American economy can harness their potential. The Federal Reserve Board of Governors and Reserve Banks have been analyzing a potential U.S. CBDC and fostering dialogue around the issue. Earlier this year, President Joe Biden issued the “[*Executive Order on Ensuring Responsible Development of Digital Assets*](#)” (the Executive Order) directing the Administration to promote development of digital asset and CBDC technologies consistent with American values and legal requirements.[7] Last month, the White House’s Office of Science and Technology Policy (OSTP) released a paper that discusses the many design challenges and opportunities to be examined in consideration of a U.S. CBDC.[8] This month, the Federal Reserve Bank of New York’s Innovation Center, released its Phase One report on Project Cedar, examining wholesale cross-border payments.[9] Additional policymakers, including members of the U.S. Congress, are also considering the potential benefits and risks.

In 2020, Accenture (NYSE: ACN) and the Digital Dollar Foundation partnered to create the DDP to advance exploration of a U.S. CBDC or a “digital dollar”. The purpose of the DDP is to encourage research and public discussion on the potential advantages and challenges of a digital dollar, convene private sector thought leaders on this topic, and propose possible models to support the public sector adoption. In May 2020, the DDP published a white paper describing a champion model of a U.S. CBDC.[10] As the Federal Reserve and other public sector initiatives explore CBDC technology, the DDP strongly believes that the private sector should have a voice in the design of a digital dollar that meets the needs and requirements of the industries that use it. To further their research, the DDP launched a series of pilot programs[11] that, in collaboration with the industry, explore potential uses for a U.S. CBDC or “digital dollar”. The pilots are intended to define requirements, raise questions, and identify potential implications and benefits across various use cases.

Earlier this year, DTCC joined the DDP to launch the first pilot in the program[12]. It is the U.S. capital market industry’s first exploration of U.S. CBDC in post-trade infrastructure by private sector participants. DTCC in collaboration with DDP and support from Accenture, designed and built a prototype to settle tokenized securities with simulated CBDC tokens to understand feasibility, design requirements, and functional challenges, and market opportunities. The findings of this initiative will be used with outputs from other DDP pilots to help inform the design considerations of a digital dollar.

[7] U.S. Department of the Treasury, [Fact Sheet: Framework for International Engagement on Digital Assets](#).

[8] The White House, Office of Science and Technology Policy. [Technical Evaluation for a U.S. Central Bank Digital Currency System](#)

[9] The Federal Reserve Bank of New York, Project Cedar

[10] The Digital Dollar Project, [Exploring a US CBDC](#)

[11] Accenture, [Digital Dollar Project to Launch Pilot Programs to Explore Designs and Uses of a U.S. Central Bank Digital Currency](#).

[12] DTCC, [DTCC building industry’s first prototype to support digital U.S. Currency in the clearing & settlement process as part of Digital Dollar Project effort](#)

The Pilot Experiment

I Scope, Objectives, and Approach

The DDP and DTCC formed a research team to understand how DTCC could utilize a U.S. CBDC network as a cash settlement system for the settlement of security transactions. Over the course of 6 months, the pilot assembled industry experts to design the functional requirements of CBDC settlement and discuss the implications with pilot participants from commercial banks.

The pilot's **objectives** were to:

1

Design a logical architecture that could support connectivity and settlement across DTCC's Digital Settlement Network prototype and a simulated Federal Reserve CBDC network;

2

Deploy and test a prototype to efficiently demonstrate security and CBDC settlement across networks;

3

Refine the functional requirements of the DDP's Champion Model to support post-trade security settlement; and

4

Engage with industry participants to identify the potential business implications of a security-CBDC settlement model.

To conduct the experiment, the team developed a prototype to demonstrate security settlement with CBDC tokens.

This prototype consisted of
3 core components:

1

A **simulated CBDC network** that could support cash settlement for participant banks. While guidance from the Federal Reserve on how a CBDC would be designed is not yet available, the pilot team modeled the simulated CBDC network after the functional requirements of the DDP Champion Model. As the team developed the simulated CBDC network, various technical decisions were made to design an ideal cash settlement model. Assumptions relating to such network are reviewed later in this paper.

2

DTCC's **Digital Settlement Network prototype** which was enhanced to offer CBDC settlement as an option for market participants.

3

An **integration approach** to connect the simulated CBDC network and DTCC's Digital Settlement Network prototype together. The integration layer used a "logical architecture" that supports an orchestration model which instructs settlement and ensures that asset and cash settlement occurs on both networks.

Out-of-Scope Experimentation

There were many questions and considerations that the pilot could have pursued but instead deferred, including exploration of the concepts that have been well studied by other global CBDC initiatives.

Scalability and Performance:

The pilot team chose to focus on designing a logical implementation model as opposed to scalability and performance, as the scalability of DLT-based systems has already received considerable attention. For example, the Federal Reserve Bank of Boston and the Massachusetts Institute of Technology recently explored scalability and resilience in the first phase of their Project Hamilton Experiment[13]. Given the processing volume requirements of DTCC and a potential CBDC network, we expect this to be a critical area of continued exploration.

Issuance and Distribution:

The pilot did not hypothesize how a CBDC would be distributed by a central bank to commercial banks but instead assumed that the pilot participants, as regulated financial institutions, were already using CBDC tokens for cash settlement.

[13] Federal Reserve Bank of Boston, [Project Hamilton Phase 1 Executive Summary](#).

I Operational and Business Requirements

To design the settlement model for security settlement in the pilot, the team started by identifying the operational requirements that the CBDC network and connectivity model would need to ensure sufficient settlement capabilities. Several approaches to connect the networks and execute settlement were considered, and ultimately led to a solution design that offered network security, transaction confidentiality and an efficient model for settlement.

Achieving Settlement Across Two Distinct Networks

The pilot explored atomic settlement of tokenized securities managed on DTCC's Digital Settlement Network in exchange for cash tokens on a distinct and separate simulated Federal Reserve CBDC network. The project assumed that a Federal Reserve CBDC will be solely used as a cash network, and not support other type of asset management, to maintain the jurisdiction model of the Federal Reserve. Some foreign research initiatives have designed DLT networks that support cash and asset tokens on the same network. The decision to use a 'cash-only' network was driven in part by existing directional commentary from the Federal Reserve^[14] as well as practical implications of such an expansion in the Federal Reserve's responsibility.

Maintaining a Trusted Third-Party to Satisfy Settlement

To ensure settlement on both networks and continue to utilize the efficiencies offered by central counterparty clearing (CCP), the team identified that there remained a need to have a neutral third party to manage the risk of a communication failure when trades are being executed. The third party is privy to the transaction on both the CBDC network and DTCC's Digital Settlement Network to resolve any disputes on transfer across networks. While the third party does not necessarily need to be the Federal Reserve or DTCC to manage settlement finality, for the purposes of this pilot, DTCC was the trusted third-party. The team designed a system for recording and managing the movement of assets on both networks through the third party. The paper will further discuss below how the third party was hosted and given visibility into the transactions on each network.

^[14] In [Project Hamilton](#), the Federal Reserve Bank of Boston designed a CBDC network prototype that acts as a payment instrument and does not explore the ability to represent other asset types on the network.

Designing a Settlement Model that can Support Multiple Use Cases

The pilot was developed with the view that industry participants should have the ability to choose settlement models based on their preferences and designed the tokenized settlement prototype with the ability to support multiple types of settlement. Participants can elect their preferred type of settlement if all necessary participants agree to the proposed settlement timing and conditions. The team designed a CBDC network and architecture model that could support requirements across bilateral real-time settlement, intraday netting cycles, and end-of-day netting cycles.

CBDC Requirements

In addition to the functional pillars of the DDP Champion Model, and without direct input from the Federal Reserve, the team made certain design and functionality assumptions of a potential Federal Reserve CBDC network. The pilot assumed:

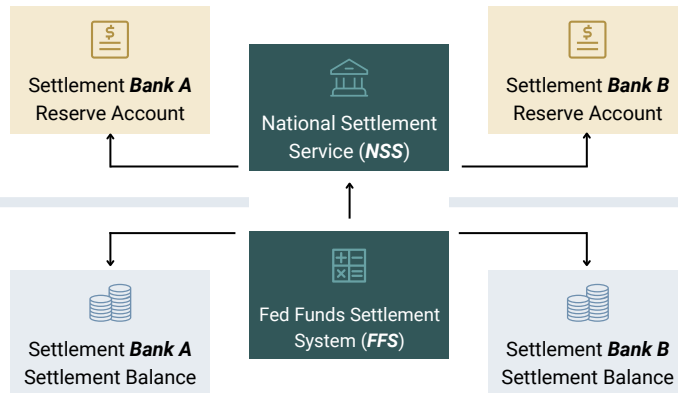
- The Federal Reserve is the sole CBDC issuer and governor of the CBDB network and has its own presence on the network.
- The CBDC network is a permissioned network where only the transaction participants see their transaction information. For the purposes of the prototype, access to the CBDC network is governed by the Federal Reserve and is limited to existing settlement banks and DTCC. While a CBDC network may ultimately provide access to a broader set of financial institutions, the team decided to begin with existing reserve account access.
- All settlement banks have a presence on the network that allows them to receive issued CBDC from the Federal Reserve, transfer it to another settlement bank, and redeem CBDC at the Federal Reserve. Liquidity management on the CBDC network is required but out of scope of the pilot; the pilot assumes that the buyer's settlement bank has sufficient liquidity to successfully complete settlement transactions.
- In addition to this basic CBDC functionality, the CBDC network must support conditional CBDC payments consisting of two phases. The first phase locks, or encumbers, CBDC tokens, while at the same time fixing the conditions for unlocking them. The second phase unlocks these tokens to the recipients, depending on whether all conditions are satisfied. The use of this capability to achieve atomic DvP across DTCC's Digital Settlement Network and the CBDC network is described below.

Federal Reserve Account Model: Cash Settlement

EXISTING MODEL

Federal Reserve

The Federal Reserve credits and debits commercial bank reserve accounts



DTCC

Cash obligations are aggregated and messaged through FFS to the Federal Reserve

Operations

1. Aggregate account balances are debited and credited throughout the day
2. At the end of the day, final fund balances are consolidated by FFS to send to NSS to update participant's commercial bank reserve accounts

Governance

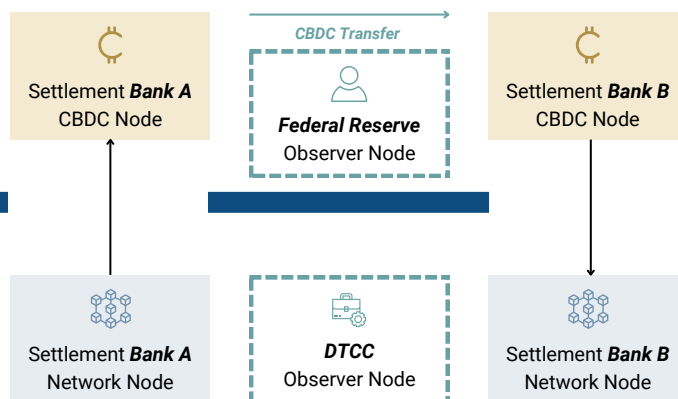
- Follows all SEC regulations & compliance procedures
- Follows all DTCC & NSCC policies & procedures
- Follows identity management requirements (KYC, AML, etc.)
- Standard settlement time is T+2

Tokenized CBDC Model: Cash Settlement

THEORETICAL MODEL

Federal Reserve

CBDC tokens are exchanged between commercial bank CBDC nodes



DTCC

Instructions are automatically sent across participants to instruct the movement of CBDC tokens

Operations

What's Unchanged

- Standard settlement times are unchanged

What's Different

- Reduces the need for multiple messages and reconciliations
- CBDC can be settled at the same time as securities
- Liquidity and risk are improved for buyers and sellers

Governance

What's Unchanged

- Follows all SEC regulations & compliance procedures
- Follows all DTCC & NSCC policies & procedures
- Follows identity management requirements (KYC, AML, etc.)

What's Different

- The Federal Reserve owns & operates wholesale CBDC & its distribution without needing to facilitate the updating of reserve accounts
- The DTCC is an observer of CBDC transactions without needing to instruct end-of-day cash settlement

Achieving Network Connectivity and Settlement Assurance

The encumbrance capability introduced above is used to support the following steps in the transaction workflow:

1. The seller of the securities creates a transaction to encumber the security tokens corresponding to the agreed trade. The key to unencumber the security tokens is shared with the Settlement Manager (an automated transaction orchestrator on DTCC's Digital Settlement Network). The conditions to unlock the tokens are as follows:

- The buyer can take control of the securities upon confirmation that the CBDC assets have been encumbered (or transferred, as transfer can happen as soon as the tokens are encumbered). The key to unencumber the security tokens is provided to the buyer by the Settlement Manager when the confirmation message from the CBDC network is received.
- A DTCC node on DTCC's Digital Settlement Network is granted permission to determine control of the assets after this time-out. That is, if the CBDC transfer does not finalize on time (or at all) then DTCC takes control of resolving the transaction. This gives DTCC the opportunity to determine what went wrong. If the CBDC transaction succeeded (but for some reason this information did not reach DTCC's Digital Settlement Network on time), then DTCC can transfer the security tokens to the buyer. Otherwise, DTCC will return the security tokens to the seller.

2. The buyer of the securities and the Settlement Manager will both have visibility into the encumbrance transaction completion. The Settlement Manager then informs the Payment Manager (an orchestrator on the CBDC network, which is administered by DTCC on the DTCC node) to notify the buyer's settlement bank in the CBDC network to encumber the agreed amount of CBDC tokens and transfer to the seller's settlement bank. Like DTCC's Digital Settlement Network conditions, the conditions to unencumber the CBDC tokens are as follows:

- The seller's settlement bank can take control of the payment if evidence of finalization of the security tokens encumbrance is provided before a given time-out. (In the pilot implementation, this would always be true, as the encumbrance transactions are done serially. For faster throughput, both network encumbrances could be done in parallel, with the tradeoff of additional communication to determine when both assets have been encumbered.)

- In case of time-out, a DTCC node on the CBDC network granted permission to determine control of the assets after the time-out. That is, if there are errors or communication failures preventing cross network communication, then DTCC would assume control to resolve the transaction. This gives DTCC the opportunity to determine what went wrong. If the security tokens transfer succeeded (but for some reason this information did not reach the CBDC network on time), then DTCC can transfer the CBDC to the seller's settlement bank. Otherwise, DTCC will return the CBDC to the buyer's bank. No change of control would happen without clarity of completion on the securities side.

3. The seller's settlement bank (receiver of CBDC tokens) and the Payment Manager will both have visibility to the encumbrance transaction completion. The Payment Manager then informs the Settlement Manager.

4. The Payment Manager then provides the key to unencumber the CBDC assets to the seller's settlement bank. The settlement bank then unlocks the CBDC tokens.

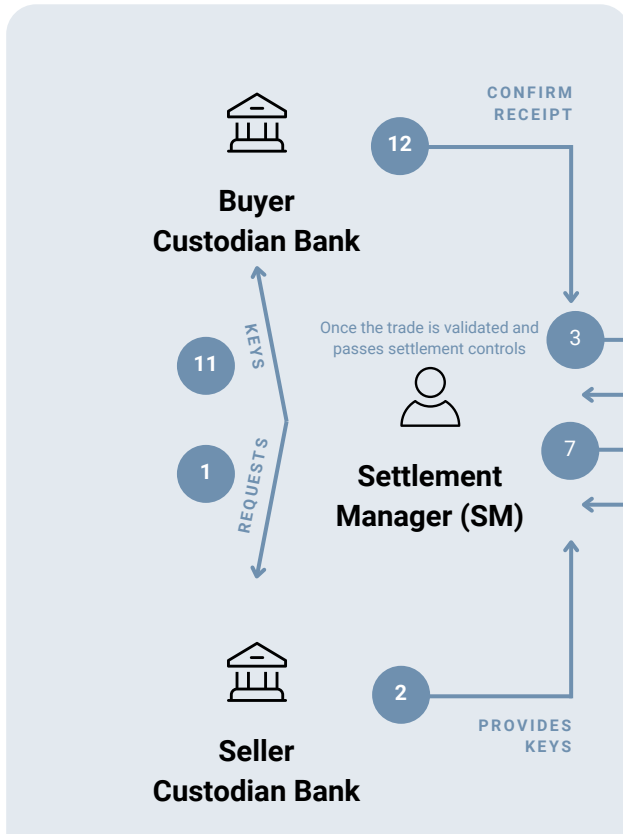
5. The Settlement Manager then provides the key to unencumber the securities assets to the buyer. The buyer then unlocks the security tokens.

In case of failures or time-outs in the process, DTCC can determine the cause based on its presence on both networks and role in the encumbrance, and it can either roll back the transaction by returning the locked assets to the original owners or complete the transaction by unlocking the assets for the recipients.

In summary, normally, both delivery on DTCC's Digital Settlement Network and payment on the CBDC network will complete automatically, without intervention by DTCC. In failure cases (time-outs or technical errors), DTCC can assess the situation and resolve these appropriately. The result is atomic DvP: either both securities and CBDC assets are transferred, or both return to their original states.

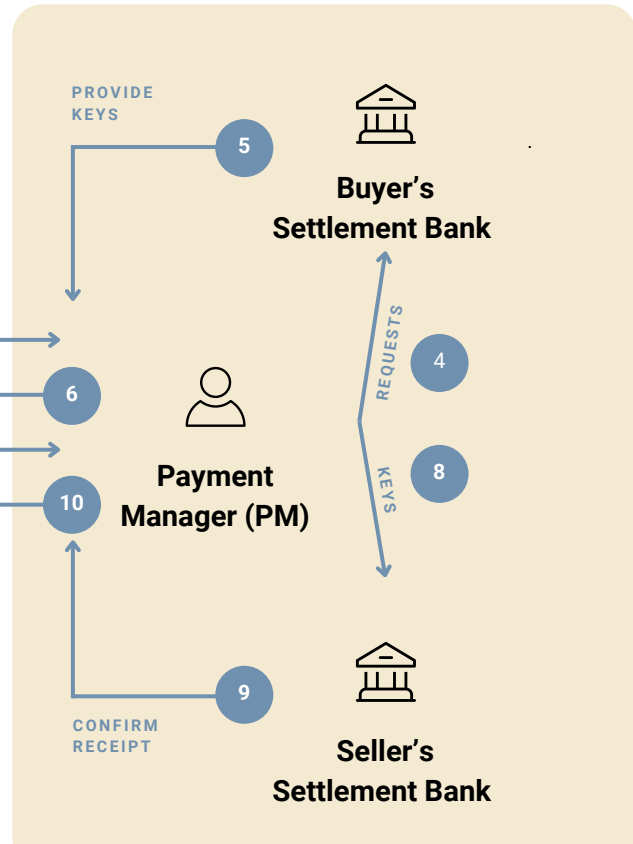
Pilot Architecture Design

DTCC's Digital Settlement Network



- 1 SM requests the security tokens to be encumbered
- 2 The seller provides the keys to the SM to unencumber the security tokens
- 3 SM notifies the Payment Manager (PM) about the security token encumbrance and instructs the PM to initiate the CBDC transaction
- 4 PM requests Buyer Settlement Bank to encumber the CBDC tokens
- 5 Buyer Settlement Bank provides the keys to the PM to unencumber the CBDC tokens
- 6 PM notifies the SM about the encumbrance of the CBDC tokens

Simulated Fed CBDC



- 7 SM instructs the PM to complete payment by unlocking the CBDC tokens
- 8 PM provides the keys to the Seller's settlement bank to unencumber the security tokens
- 9 Seller's settlement bank acknowledges the receipt of the keys and unlocked CBDC tokens
- 10 PM notifies the SM of the fund movement
- 11 SM Delivers the security key to the buyer
- 12 Buyer's custodial bank acknowledges the receipt of the keys and unlocked security tokens

I Pilot Findings

The pilot demonstrated how DTCC could utilize CBDC in post-trade settlement, informed design options for future CBDC settlement models, and provided valuable insights into the benefits that a CBDC model can offer the industry.

Design Decisions and Conclusions

Transparency models

When designing a CBDC model, striking a balance between transaction confidentiality, auditability, trust, and control can result in a variety of CBDC models that can fulfill the use cases with different levels of compromise across the dimensions. The pilot adopted an approach to maximize transaction confidentiality. This meant starting with an assumption that only the parties to the trade would see the details of the transaction. With the Federal Reserve's role in current settlement processes and the pilot's goal of minimizing fundamental changes to the settlement banking system, the CBDC network was set up as a permissioned network for settlement banks, where the Federal Reserve would also have visibility into transactions on the network for auditability through notary nodes, which sign every transaction on the network to prevent double spending of assets.

To confirm that the cash portion of a transaction has been settled, DTCC also needs to have evidence of the cash token exchange. If the only parties with visibility into the transaction are the buyer's settlement bank, the seller's settlement bank, and the Federal Reserve, there are several options:

1. Have transaction participants provide status confirmation. This means that the two parties would need to agree on the status and would require the adoption of mechanisms to address a situation where there is a disagreement on status between the parties. Additionally, in the case of a bad actor, status delays or erroneous status confirmations would be detrimental to the settlement process.
2. Balance transparency versus transaction confidentiality. Making transactions visible to the entire network enhances transparency but at the expense of transaction confidentiality.
3. Have the Federal Reserve confirm status. This means the Federal Reserve would be an active party in transactions and responsible for confirming every settlement transaction on the network which may not be the most efficient approach.
4. Include a third party on the transaction to manage unforeseen operational challenges between parties. Given that DTCC already has visibility into the parties to and amounts of a transaction, DTCC could be added as a party to the CBDC transaction without any additional impact to transaction confidentiality. This requires DTCC to be a participant on the CBDC network but does not require DTCC to have any special permissions, if the

CBDC network supports multi-party transactions. This was the approach taken by the pilot.

Cross-Network Connection

Multiple approaches were considered to enable transacting across two separate DLT networks. The pilot focused on a set of capabilities to address the functional use cases, while non-functional requirements remained out-of-scope. Because the networks are separate, transacting at the DLT protocol layer used by nodes within a network was not feasible. Consequently, a higher connectivity layer is required, and for simplicity, REST APIs were used to connect to services hosted on both the securities and CBDC networks, using services connecting over HTTPS. This effectively enabled network-specific logic (in the form of off-chain services and on-chain smart contracts) to be created for each network. Unlike a transaction within a single DLT network, however, the existence of two networks resulted in a distributed transaction that required orchestration across the networks to provide guarantees of atomic settlement. Alternative approaches could potentially enable connectivity with differing tradeoffs.

Orchestration Model

Orchestration between DTCC's Digital Settlement Network and the CBDC network has the unusual characteristic that the delivering and receiving parties on each network are not necessarily the same. The buyer and sellers on DTCC's Digital Settlement Network may have distinct settlement banks, and therefore none of the participants on the networks would have visibility into both networks. (There are cases where a buyer or seller is also a settlement bank, but because it won't always be true, the process does not assume shared visibility to both networks by any party). The two main approaches explored for managing communication across networks were:

1. Require and depend on each party to communicate with its settlement bank in real-time throughout the transaction. While the buyer and seller would each have established communication channels with their settlement banks, relying on communications between the parties and their settlement banks to facilitate transaction workflows timely and accurately places a burden on every participant in DTCC's Digital Settlement Network and every settlement bank to build systems that support this specific communication and transaction flow.
2. Set up an orchestrator to handle all settlement transaction communication between the networks – in the settlement scenarios being analyzed in the pilot, since DTCC has visibility to both the securities transactions and the CBDC transactions, DTCC can orchestrate the transactions and facilitate communication across the networks. This minimizes the dependencies on communication between parties, at the expense of increasing dependence on DTCC.

DTCC's Responsibilities

In a model where both security and cash positions are settled on two different DLT-based networks, it is possible that a transaction completes on one network, but fails or times out on the other network, and one party ends up with both assets. In the case of a failure, some form of remediation is required to ensure all parties' positions are settled properly.

If only a buyer and seller (and their settlement banks) have access and control over a transaction, they may not be incentivized to remediate failures in the transactions in a timely fashion (and in fact may benefit from delays in the transactions). Accountability for delays in transaction completion would also be difficult to maintain. As a trusted third party that would already have visibility into these transactions, DTCC is uniquely positioned to address transaction failures without creating additional network security risk.

The model employed in the pilot defines DTCC's role in the settlement transactions as follows:

- Manages access to and governs the DTCC Digital Settlement Network
- Initiates settlement transactions on DTCC's Digital Settlement Network based on incoming trades,
- Is party to every securities settlement transaction for visibility and potential remediation,
- Is privy to CBDC transactions to ensure that DTCC settlement instructions are satisfied for visibility and potential remediation,
- Manages the automated orchestration of settlement transactions across the two networks,
- Stores the keys used to lock / encumber tokens and transfers the keys (or directly unencumber the tokens) at the point when the assets on both networks have been encumbered, and
- Determines and implements the appropriate course of action to either complete or rollback the transaction in case of a transaction failure or time-out on either the securities or CBDC networks. More details about how this is accomplished are provided in the following section.

Encumbering Assets

In distributed transactions, there are two common approaches to maintaining data consistency across independent services – using two-phase commits or using compensating reversal transactions to undo initial transactions in case of rollback. In scenarios where assets can be consumed or spent in the time between an initial transaction and a reversal, the use of

compensating transactions cannot guarantee that the original state will be restored. Also, in a DLT scenario, there is no way to force a compensating transaction to happen. As a result, the approach used in the pilot focused on a two-phase commit.

A significant downside to two-phase commits is that resources can be locked and unavailable for extended periods of time if transactions take too long. This can cause bottlenecks and significantly limit throughput or activity of the system. This type of transaction across networks therefore needs to be completely automated, with expected completion times (and transaction time-outs) within a manageable period for participating parties. The pilot did not try to define an optimal time-out window or measure system throughput at scale but assumes that it would need to be measured in seconds to accommodate multiple individual DLT transactions and complete in under a minute to not tie up assets for an extended period. Given that the velocity of assets on these networks will be directly impacted by system performance, it was critical to set time frames based on expected performance of the network.

The pilot implemented two-phase commits by encumbering tokens and preventing them from being spent, and by putting conditions on their release for use by the receiving party. This is like an escrow model, but in this case, the smart contract, rather than a third party, controls access to the assets.

The encumbrances are established via smart contracts on each network, which lock the assets to be transferred, and then define the conditions under which they can be unlocked and transferred to the receiver. Unlocking the assets requires the key used to encumber the assets initially, and that key is managed by the orchestrator from the time of locking, and then used to unencumber the tokens when assets on both networks have been confirmed to be locked. So, the first phase of the transaction involves encumbering the tokens on each network so they cannot be spent elsewhere, and the second phase of the commit involves unlocking the tokens to release them for use by the receiving parties.

Throughout this process, technical failures^[14] are possible at any point. If a failure is encountered before assets on either network have been encumbered, the transaction will time out and no assets will be transferred. Once assets on either network have been encumbered though, remediating a failure depends on whether the assets on either network have been unlocked already. It is critical that a rollback is not performed on one network when the assets on the other network have been

^[14] Technical failures could be due to several unanticipated problems such as a lack of cash at the time of asset movement, a communication failure, or general infrastructure failure.

unlocked already. It is critical that a rollback is not performed on one network when the assets on the other network have been successfully transferred. Consequently, in these failure or time-out scenarios, assets cannot be automatically returned to the original owner. Only with knowledge of what happened on the other network can an appropriate decision for remediating the situation be made. DTCC, as the only party with visibility into both transactions, is the logical party to make this decision without relying on timely communication between the parties to the transaction. To enable DTCC to manage a rollback of the entire transaction, or even complete the transaction in case of failure, DTCC would need to be given permissions on the transaction to take these actions. This permission can be granted via the encumbrance mechanism. As such, DTCC was given the ability to unlock the tokens and transfer to the recipient or return assets to the original owner after a time-out had been reached. There were two ways for tokens to be unencumbered – one with a successful transaction using the keys to unlock the assets, and one where the time-out is reached, at which point control of unencumbering the tokens is passed to DTCC.

While the model that the pilot utilized involved encumbering assets on both networks, other approaches involving different tradeoffs were considered and determined to be viable. For the settlement scenarios, DTCC's Digital Settlement Network is modeled as a DLT network where encumbrances are possible. There are many situations where an encumbrance may not be possible on one side of the transaction, though. For example, in a CBDC payment for a physical asset, an encumbrance on the CBDC network could be used, and the physical asset would be transferred after the encumbrance is confirmed on the CBDC network. A third party would again be needed to manage rollback in case the physical transfer is not made successfully. In the case where payment is confirmed on the CBDC network before a transfer is made elsewhere (analogous to merchant payment transactions), then an encumbrance is not needed on the CBDC network. In the pilot, the settlement model would be very similar if there were only an encumbrance on DTCC's Digital Settlement Network (and not on the CBDC network). The major difference would be that the unlocking of security tokens could only occur after payment had been confirmed, rather than allowing security tokens to be unlocked after the encumbrance of CBDC tokens had been confirmed.



Business Opportunities and Tradeoffs Identified from CBDC Settlement

The pilot focused on designing a logical model and building a prototype that could support CBDC settlement and identified the opportunities and tradeoffs presented by such prototype.

Funding and Risk Tradeoffs: From the pilot, the team learned that the expected benefits for the industry varied based on the settlement model type. Due to the complete settlement finality expressed above, deliverers and receivers must have the assets and cash available to settle at the agreed upon time. This is different than today's settlement model where participants settle securities throughout the day free-of-payment while cash is settled at the end of the day to fulfill delivery of the assets. Each of the settlement models presents different levels of settlement risk and carries different asset and cash liquidity requirements. The value derived from each model will also depend on the level of industry adoption by participants. Below are summaries of the various models:

- ***Today's End-of-Day Netting Cycles and Settlement Model:***

Today's industry standard of T2 End of Day settlement moves the securities at the time of settlement but moves cash at the end of the day through the Federal Reserve. The netting model provides transaction efficiencies by distilling down transactions to only move an aggregate debit or credit. NSCC's multilateral netting model guarantees settlement, where NSCC becomes the CCP to, and therefore guarantees the settlement of, trades. This allows brokers to offset buy and sell positions executed against multiple counterparties into a single counterparty and reduces payment/security obligations and provides a guaranty of settlement for those obligations – thus also reducing credit and financial exposure[16]. This model separates the "settlement" of a transaction and the actual "delivery" of the assets. This also allows industry participants to go into an intraday deficit throughout the day if they can acquire the assets by the end of the day.

- ***End-of-Day Netting Cycles and Settlement with CBDC (T2, T1, or T0 EOD):***

End-of-day netting cycles and settlement with CBDC is like today's model where transactions are settled throughout the day, but cash is moved, and assets are unencumbered at the end of the day. The current standard is T2, but the industry is planning to move to T1 and is exploring T0 as a potential option. CBDC and tokenized assets may make asset management more efficient but would not provide greater liquidity and risk benefits compared to existing reserve account settlement.

[16] DTCC, [Building the Settlement System of the Future](#)

- ***Intraday Netting Cycles and Settlement (T0 Intraday):***

Intraday Netting Cycles with CBDC as the cash settlement medium begins to provide benefits to participants. The industry does not yet have a multilateral cash settlement mechanism that can support intraday trading. This could be achieved with a traditional payment mechanism, but CBDC may provide the additional transparency and automation needed to increase industry appetite and encourage adoption. T0 settlement with tokenized securities and cash would ensure that deliverers and receivers have sufficient assets at the time of settlement.

- ***Real-time Gross Settlement or “Bilateral Settlement” (T0 RTGS):***

Real-time Gross Settlement is when trades are initiated and settled between two participants without the settlement assurance of netting. The U.S. does not currently provide a RTGS settlement option, which is available in global markets. RTGS has been touted by digital currency advocates as an ideal use case for CBDC settlement. Crypto markets predominately use RTGS settlement models to settle digital assets in real time. RTGS would require that both participants have the cash and securities available at the time of settlement and could atomically settle the transaction. Tokenized cash and securities provide an efficient RTGS model.

DTCC Operational Efficiencies: The CBDC settlement prototype demonstrated that settlement of tokenized assets and cash can effectively be automated. This automation can enable settlement without the need for DTCC or the Federal Reserve to manually send settlement instructions, update files, and confirm that settlement has occurred. It should be noted that, although not currently available, the existing cash settlement system through FFS and NSS could be enhanced to provide an automated settlement mechanism. A CBDC however could provide greater transparency, resiliency, and flexibility to the industry.

Transparency and Reporting Benefits: In today’s system, DTCC sends a batch file to the Federal Reserve to update settlement banks’ accounts held at the Federal Reserve based on participant settlement activity. The Federal Reserve uses the received files to record settlement activity. In a DLT-based settlement future, settlement transactions can include tags to identify those specific settlement types for which the Federal Reserve would have real-time visibility to. DLT-based settlement won’t require the manual process of sending report files because the Federal Reserve would be able to determine DTCC settlement activity at any point in time. The elimination of manual reporting could facilitate the industry’s adoption of accelerated settlement options.

Settlement Finality: The pilot settlement prototype supported the ability to guarantee settlement of security tokens and CBDC tokens, ensuring that cash and assets are either both transferred, or nothing is transferred (in which case the settlement transaction could be retried). The settlement finality of cash and assets promises that the transaction will always complete or be reverted and will never leave a participant in a situation where the assets move without the cash. This level of settlement finality offers a resilient settlement model where participants can be confident at the time of settlement that the assets and cash are settled.

Varied Benefits Across Use Cases: DTCC supports flexible optionality for industry participants and found that a CBDC payment infrastructure can facilitate a range of settlement use cases including intraday and end-of-day netted settlement cycles or real-time bilateral transactions.



I Refining the DDP Champion Model

Throughout the pilot, the team explored the DDP's Champion Model to assess how the functional assumptions hold up in real-world scenarios. The pilot was able to add context to pillars of the DDP Champion Model that can be tested in future pilots DDP will administer with other organizations that hold financial service responsibilities in US markets.

Privacy, Transactional Confidentiality, and Data Distribution

A core principle of the DDP's Champion Model is individual privacy in the use of CBDC. In a wholesale settlement model, the transaction is executed at an organizational level, not an individual one. Instead of preserving an individual's privacy, a CBDC network will need to ensure the confidentiality of data relating to the transactions of participating organizations. Only the participants of a transaction, the clearing house, and the Federal Reserve would have access to the transaction data. This is of course different from public DLT models where the whole ledger is visible to all participants.

Technology decisions and design choices driven by functional needs

Another core DDP tenet is that the technology decisions and design choices should be driven by functional needs. Accordingly, the pilot was able to identify functional needs for a post-trade use case. Future DDP pilots should consider additional functional needs and understand how the technology can satisfy diverse needs across use cases.

- **Multilateral Settlement:** To enable DTCC to know the status of a transaction, the CBDC network would need to allow multiple participants to be party to such transaction
- **Asset Encumbrance Mechanisms:** To guarantee the completion of a transaction across two networks, an encumbrance mechanism is necessary to provide confidence that tokens would not be re-spent or reclaimed before the transaction completes

CBDC Access Implications:

The decision to issue a wholesale or retail CBDC will have varying implications on the existing settlement model in the U.S. Currently, only certain banks, who have access to Federal Reserve accounts can settle cash through the Federal Reserve. This restriction of access is one reason why brokers use settlement banks to settle cash obligations. There is already an ongoing discussion in the U.S. to simplify and potentially broaden Federal Reserve account access to non-traditional banking institutions.^[17] The implications of issuing a CBDC with broad industry access will share many of the tradeoffs of extending access of the existing Federal Reserve payment system. DTCC participants with access to a digital dollar could settle for securities without having to rely on a bank which holds an account with the Federal Reserve. As a result, reducing the industry's dependence on the settlement bank model, which in turn could reduce systemic risk by distributing cash settlement responsibilities across additional organizations. This expanded access to the Federal Reserve payment system could also change the role of existing settlement banks, shifting their focus to lines of credit and point solutions for market participants.

[17] Board of Governors of the Federal Reserve System, [The Federal Reserve Board announced guidelines to establish a transparent, risk-based, and consistent set of factors when reviewing requests to access Federal Reserve accounts and payment services](#).

Future Exploration

The pilot demonstrated how a CBDC could be used by industry participants and DTCC in the context of securities settlement. It also identified important questions and helped establish future areas of exploration for a U.S. CBDC.

Further Measure Business Value for Industry Participants

During the pilot, participant feedback indicated there could be commercial benefits to settling securities transactions with CBDC. Future exploration should seek to quantify the benefits of incorporating a CBDC into the settlement process. Such studies should compare CBDC settlement models against existing settlement models to accurately measure risk and funding impacts on participants. They should also explore margin requirements, impacts to risk controls, or the ability to go into intraday deficits. Finally, experimentation should seek to measure how shock resistant a CBDC network would be under periods of high volatility or liquidation.

Identify Digital Ecosystem Impacts

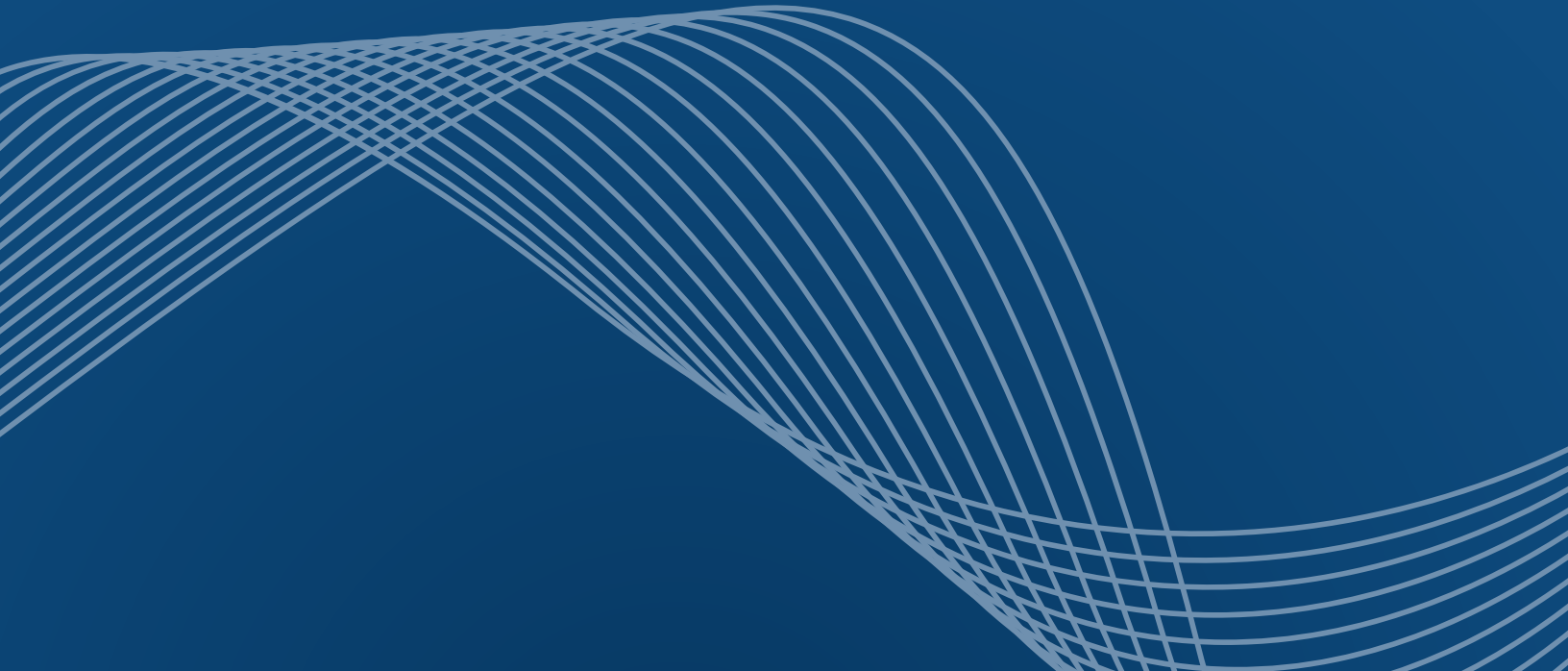
It should be assumed that, if developed, a CBDC network will exist alongside traditional networks as well as private industry digital asset networks. Future research should explore integration requirements for co-existing networks. The pilot identified that different degrees of Federal Reserve account access would have varying effects on the application of CBDC within the existing ecosystem. Further initiatives should explore how a CBDC network could change the relationship between industry participants and their settlement banks.

Explore Ecosystem Adoption Requirements

Many pilot participants shared that their own adoption of CBDC would depend on the degree of industry adoption. Further consideration should be given to the number of DTCC members and industry participants needed to adopt CBDC technology in order to realize meaningful operational efficiencies.

Refine Technology Requirements

The team strove to design a prototype that satisfied the functional requirements of the DDP's Champion Model and could support the business requirements of DTCC's settlement system. It also identified several technology questions that will require further thought.

- **Scalability and Performance:** Future exploration into performance requirements and scalability capabilities would provide greater insights into network impacts and technology requirements.
 - **Network Interoperability and Standards:** Further exploration is required to understand how various DLT networks would harmonize and fragment data or liquidity.
 - **Participant Integration Requirements:** Additional work to understand the requirements more fully for participants to integrate with a CBDC network and DTCC's Digital Settlement Network is needed.
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Conclusion

In keeping with the tradition of technological innovation, this pilot is the first post-trade securities settlement exploration of CBDC, of any denomination, fully initiated by the private sector.

The team designed and deployed a prototype to support the application of tokenized securities and CBDC for wholesale security settlement. The pilot provided a better understanding of the implications and requirements of a CBDC securities settlement network. Bolstered by the expertise of knowledgeable industry participants in analyzing its findings and assumptions, the pilot was an important first step into exploring CBDC technology and should serve as a baseline for future post-trade CBDC exploration.

The U.S. dollar is the financial cornerstone of the U.S. and global economy. DTCC and DDP believe that a digital dollar should be carefully explored in consultation with key stakeholders in both the public and private sectors. Future initiatives should challenge and refine the findings of the pilot to design a CBDC network that can support a variety of nuanced use cases. While the decision regarding whether to implement a U.S. CBDC rests with U.S. policymakers, the DDP and DTCC will continue their exploration of this technology to support efforts by the Federal Reserve Board of Governors and Federal Reserve Banks, Congress, other policymakers, and the broader industry as part of ongoing activity to examine the benefits and challenges of a wholesale U.S. CBDC.

Appendix

Post Trade Settlement Introduction

The Role of DTCC

In capital markets, post trade infrastructure plays a critical role in ensuring that securities and cash are safely settled between trading partners. DTCC supports the U.S. financial markets by providing post-trade clearing and settlement services. DTCC, through its clearing agency subsidiaries, settles securities transactions on behalf of buyers and sellers and functions as a central securities depository by providing central custody of securities. In the context of a securities transaction, settlement is generally the term applied to completion of the transfer of payment to the seller and ownership to the buyer. It is the final step in the lifecycle of a trade.

DTCC's role in the U.S. markets is to automate, centralize, and standardize the processing of securities transactions to mitigate risk, increase transparency and drive efficiencies for industry participants. Broker-dealers, custodian banks and asset managers use DTCC to settle securities obligations and the resulting cash payments efficiently and securely.

DTCC, through its central securities depository subsidiary, provides settlement services for virtually all equity, corporate and municipal debt trades, and money market instruments in the U.S. In 2021, approximately 643 million securities valued at \$152 trillion were settled by DTCC.

DTCC's Digital Settlement Network

DTCC is owned and governed by the industry and is aligned with its clients to explore technology and capabilities that can further support their needs. DTCC developed the DTCC Digital Settlement Network prototype as part of its innovation research and development (R&D) to reimagine how new technologies can serve as a foundation for a future financial infrastructure ecosystem across various use cases. This prototype seeks to enable new functionalities such as accelerated settlement cycles, true continuous netting and opportunistic security settlement, pre-positioning benefits, prefunded bilateral trades, partial bilateral trades, and limited fail tracking.

A core feature of DTCC's Digital Settlement Network prototype was the representation of traditional assets as "tokenized" securities that live on a distributed ledger. In the United States today, the "movement" of financial securities is managed by DTCC subsidiaries. DTCC debits and credits

various account records to keep track of participants' security ownership. In the DTCC's Digital Settlement Network prototype, rather than maintaining a record of security ownership, the securities are represented as "tokens" on a distributed ledger which can be moved between participants directly. In a digital token-based system, the token contains all the information necessary for the recipient to verify the legitimacy, authenticity, validity, and finality of the object transferred (i.e., the token).

DTCC's Current Cash Settlement Model

In today's model, when a settlement transaction is processed by DTCC, DTCC debits and credits the securities from participants' accounts and creates a cash obligation based on the value of the agreed upon transaction. At the end of the settlement day, the cash obligations are aggregated and sent to the National Settlement Service (NSS) to update the participants' reserve account. NSS is a multilateral settlement service owned and operated by the Federal Reserve Banks. The service is offered to depository institutions with Federal Reserve Bank master accounts that settle for participants in clearinghouses, financial exchanges and other clearing and settlement arrangements.[20]

[18] DTCC, [Evolution to an Accelerated Settlement Cycle](#)

[19] DTCC, [DTCC to Launch Platform to Digitalize and Modernize Private Markets](#)

[20] The Federal Reserve Services, [The National Settlement Service \(NSS\)](#)

DTCC's Digital Journey

In addition to DTCC's Digital Settlement Network prototype, DTCC is actively exploring the value of DLT technology with industry participants through various initiatives aimed at modernizing the capital markets infrastructure across the entire post-trade lifecycle while providing further settlement optionality for industry participants. DTCC's Digital Settlement Network prototype, which the pilot leveraged, incorporates novel settlement functionalities and builds on DTCC's modernization efforts.

- **Accelerated Settlement:** DTCC has worked with the industry to continually review the impacts, systems, and processes of securities settlement today, and the merits of further acceleration, including T+1 and netted T+0.[18]
- **Digital Securities Management (DSM):** DTCC has announced the Digital Securities Management infrastructure to transform the private market ecosystem and enable the tokenization of securities to streamline the issuance, transfer, and servicing of private market securities [19]
- **Project Ion:** DTCC launched Project Ion to develop a settlement platform that leverages DLT and provides a resilient, secure, and scalable alternative settlement service. This platform became operational in the pilot as an MVP (minimum viable product), providing a parallel record and infrastructure for over 100,000 bilateral transactions settling daily in the DTC classic settlement system.

DTCC participants that do not have reserve accounts with the Federal Reserve use a “settlement bank” to settle cash obligations with Federal Reserve accounts on their behalf. These settlement banks are responsible for reconciling the cash movements that occurred within their reserve account with the trading activity of their participants.

DTCC has continued to explore how new technologies, including DLT-enabled digital currencies, can help the industry achieve greater transparency, efficiency, and resiliency in the settlement of securities transactions.


The Pilot’s Simulated CBDC Network

CBDC Overview

CBDC is a new digital currency and payment network model that is being explored by institutions and central banks around the world. The DDP believes that if designed appropriately, CBDC could be the next major innovation in U.S. money and could provide a modernized currency for a token-based future. In the DDP’s Champion Model, a U.S. CBDC, issued by the Federal Reserve System, would enjoy the full faith and credit of the U.S. government to have the same legal status as physical bank notes and reserves. CBDC has the potential to be a natively digital solution that integrates efficiently with other DLT-based assets and infrastructures to support a Web 3.0 future.

Digital Dollar Project’s Champion Model

The DDP has studied findings from global CBDC initiatives to develop a “Champion Model” that can be tested and refined through hands-on testing. The DDP recognizes that there are many unanswered questions regarding a U.S. CBDC. As global experimentation produces new findings and requirements, the DDP intends to refine its champion model to incorporate the needs of various use cases.



The DDP Champion Model is made up of the following functional tenets:

Tokenization:

A digital dollar would be a tokenized form of the U.S. dollar. Tokenization is the act of creating a digital representation of the information, rights, and ownership of an asset, good, right, or currency and using that digital representation to attest to facilitate transactions and ownership.

Third format of currency:

A digital dollar would operate alongside existing fiat currency and commercial bank money. It will mirror many properties of physical money, including its ability to work alongside existing account-based systems. Existing money supply could be converted on a 1:1 basis into CBDC to ensure there is no new money creation.

Maintenance of the two-tiered banking system:

A digital dollar would be distributed through the existing two-tiered architecture of commercial banks and regulated financial technology intermediaries.

Privacy:

The digital dollar would support a balance between individual privacy rights, data confidentiality, and necessary compliance and regulatory processes, in accordance with democratic norms, and ultimately reflecting the jurisprudence around the Fourth Amendment of the U.S. Constitution.

Monetary policy-neutral:

The introduction of a digital dollar would be a new representation of the U.S. dollar and would not change the money supply. The technology that underpins it, such as programmability, may open more opportunities for the Federal Reserve to transmit monetary policy but is subject to how a digital dollar is ultimately designed and implemented.

Technology decisions and design choices driven by functional needs:

The policy and economic requirements, such as scalability, throughput, and data privacy, of a digital dollar would inform both the underlying technology and ultimate design choices.

Future-proofing the architecture through flexibility:

The chosen technological architecture would offer the flexibility to adapt based on policy and economic considerations. A CBDC would be designed with the ability to be updated as technology advances.

Continued private sector innovation:

A digital dollar would act as a catalyst for innovation and will not be antithetical to the development of private sector initiatives.

[21] For a full explanation of the Digital Dollar Project's Champion Model, please refer to the DDP's 2020 White Paper, [Exploring a US CBDC](#)

Using CBDC for U.S. Post-Trade Securities Settlement

Around the globe, it has been theorized that CBDC, combined with digital asset networks, has the potential to streamline asset management, settlement, and reporting. Capital market institutions have started to explore the potential of CBDC technology to unlock efficiencies and streamline post-trade settlement activity. Global projects outside of the U.S., such as Helvetia,[22] Jasper Phase 3, [23] and Ubin Phase 3,[24] were collaborative initiatives to examine the implications of post-trade settlement with tokenized assets and CBDC. Each of these projects evaluated use cases in their respective jurisdictions and economies with varying requirements. These initiatives moved the needle on global CBDC explorations and raised important findings and questions about CBDC settlement.

Project	Publishing Organizations	Jurisdiction/Region	Scope
Helvetia	BIS, Swiss National Bank, SIX Group	Switzerland	<ul style="list-style-type: none"> Settlement of digital securities and a simulated CBDC that both exist on a single network Exploration was performed from the perspective of the central bank
Jasper Phase 3	Bank of Canada, Payments Canada, TMX	Canada	<ul style="list-style-type: none"> Details a full lifecycle from issuance to redemption of digital securities and cash Exploration was performed from the perspective of the central bank
Ubin Phase 3	MAS, SGX, The Association of Banks in Singapore	Singapore	<ul style="list-style-type: none"> Settlement of securities and cash on separate and distinct networks Exploration was performed from the perspective of the central bank
DDP & DTCC: Security Settlement Pilot	The Digital Dollar Project (DDP) and The Depository Trust & Clearing Corporation (DTCC)	USA	<ul style="list-style-type: none"> Settlement of securities and cash on separate and distinct networks Exploration was initiated and run by the private sector to explore how CBDC would impact industry participants

[22] Project Helvetia was a multi-phase investigation by the BIS Innovation Hub, the Swiss National Bank (SNB) and the financial infrastructure operator SIX to explore how central banks could offer CBDC settlement in a future with DLT-enabled tokenized financial assets, focusing on operational, legal and policy questions. BIS, [Project Helvetia: A multi-phase investigation on the settlement of tokenised assets in central bank money](#).

[23] Phase 3 of Project Jasper was a collaborative research initiative between Payments Canada, the Bank of Canada, TMX Group, Accenture and R3, to understand how DLT could transform the future of payments and securities settlement in Canada. Bank of Canada, [Digital currencies and fintech: projects](#)

[24] Project Ubin Phase 3: Delivery versus Payment (DvP) was a collaboration between MAS and Singapore Exchange (SGX) to develop DvP capabilities for settlement of tokenized assets across different blockchain platforms resulting in the atomic settlement of digital currencies and securities. Monetary Authority of Singapore, [Project Ubin Phase 3: Delivery versus Payment \(DvP\)](#).

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