Connecting digital islands: CBDCs

Results of Swift experiments interlinking CBDC networks and existing payments systems to achieve global interoperability

Results report:
Phase 2 experiments
October 2022

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Executive Summary

There is a growing momentum towards exploring Central Bank Digital Currencies (CBDCs) amongst central banks globally. A recent report from the Bank for International Settlements (BIS) observed that nine out of 10 central banks are now exploring CBDCs – covering economies that account for more than 90% of global GDP. An increasing number of these central banks are in the advanced stages of exploration, with nine countries already live with their own digital currency, most notably Nigeria and The Bahamas. Others meanwhile are researching, developing and experimenting as they seek to understand and make design choices for future CBDCs.

Swift's strategy is to achieve instant and frictionless cross-border transactions and, in that context, we have been researching CBDCs for a number of years. In 2020, we set up an innovation project to understand the impact of CBDCs and digital currencies on Swift and our members, with a focus on the cross-border payments use case. This work sought to understand, for instance, how a business in a country with a CBDC might make a transaction with another business in a country with a currency that is not a CBDC. CBDCs raise a number of questions for these types of transactions, bringing various challenges and opportunities. Our view is that these questions need to be addressed in the context of ensuring economic interoperability between payments systems, now and in the future – which is key to a vision of frictionless payments, account to account, anywhere in the world.

About our experiments

In May 2021, we published the white paper 'Exploring central bank digital currencies: How they could work for international payments,' which set out the results of our first round of experiments. These demonstrated, for the first time, how interoperability could be achieved between a CBDC network and a non-CBDC payments network, and between two CBDC networks on different technologies. These experiments reused existing messaging and banking structures to achieve interoperability, solving for BIS mCBDC Model 1.

Based on subsequent feedback from the financial community, and working in collaboration with Capgemini, we have now gone much further. These new experiments have successfully demonstrated a ground-breaking solution capable of interlinking CBDC networks and existing payments systems for cross-border transactions. Interlinking is a solution to achieve interoperability, through a technical connection between networks. Our teams were able to build a simulation of Swift's enhanced platform and a Connector Gateway that combined are capable of linking these networks together at the technical level. As such, this solution can solve for BIS mCBDC Model 2.

> We believe our solution can offer a seamless transaction flow on a highly scalable model, with no manual intermediary message initiation required.

We believe our solution can offer a seamless transaction flow on a highly scalable model, with no manual intermediary message initiation required. This solution can provide CBDC network operators at central banks with simple enablement and integration of domestic CBDC networks into cross-border payments, through the introduction of a Connector Gateway.

These experiments were able to demonstrate transactions flowing across the networks as expected, proving the merits of our proposed solution and validating its technical feasibility to seamlessly link a co-existing world of CBDCs and non-CBDCs. We also leveraged the ISO 20022 standard and use of PKI signatures to ensure interoperability in the experiments. The scenarios were selected both to address normal and exception flows.

What's next?

Based on the success of these experiments, Swift has already deployed the technical infrastructure into a CBDC sandbox that is now being used by over 10 institutions – including central banks, market infrastructures and commercial banks from across the globe. This provides the ability for bilateral testing, and facilitates real-time feedback opportunities for our customers to share their challenges with Swift and contribute to the next generation of CBDC solutions. The sandbox will enable further iteration of the solution as part of our commitment to open innovation.

Furthermore, we plan to use the outcomes of this work to shape our strategic approach for digital currencies moving forward, providing valuable solutions for the entire Swift community.

In a rapidly evolving world, nobody knows for certain what payment models will become dominant in the future. However, we're confident that, with this solution and others, we will be able to deliver on enabling instant and frictionless cross-border payments, regardless of the form they take.

Introduction: A growing momentum

Interest in Central Bank Digital Currencies (CBDCs) is gathering speed. Over 100 countries, representing 95% of the world's economic output, are exploring CBDCs, through research, experimentation, and/or development. Extensive work, driven by BIS Innovation Hubs and central banks, has helped understand and inform the design choices for CBDCs at a domestic level: single vs. two tier models; the role of commercial banks in a CBDC environment; retail vs. wholesale use cases, etc.

Whilst much of the current focus on CBDCs is on how they could help achieve domestic policy goals, their use cross-border has received much less attention. However, facilitating interoperability and interlinking between different CBDCs being developed around the world will be critical if we are to fully realise their potential. Today, the global CBDC ecosystem risks becoming fragmented with numerous central banks developing their own digital currencies based on different technologies, standards and protocols. If left unaddressed, this fragmentation could lead to 'digital islands' springing up across the globe. Different systems and different CBDCs will need to be able to efficiently work together, or it will hamper the ability of businesses and consumers to make frictionless cross-border payments using CBDCs. Given our strategy to achieve instant and frictionless cross-border transactions, this is a challenge that Swift is well placed to address.

Barriers to success

While central banks across the world have deployed a variety of platforms for their pilots, it's increasingly evident that no one platform or solution will win out. Consequently, the ability to enable transactions to take place between different platforms will be critical.

Conceptually, moving CBDCs across borders is complex. It's technically possible using various emerging technologies, but the definition and usage of a CBDC outside its native jurisdiction is unclear. In order to be practicable, some form of interchange mechanism with local currency must exist. A bilateral solution between two countries would work, but such a system would not be scalable, and would be unmanageable if applied globally. Nevertheless, enabling two CBDC systems to interoperate would still require intermediary institutions. What will be required instead is a multilateral interchange mechanism which enables payments to be made end-to-end, in a frictionless way.

The BIS multi-CBDC arrangements

The BIS has been closely examining the role and potential of CBDCs via its Innovation Hub (BISIH) and it is actively engaged in a number of Proofs of Concept (POCs). The BIS has proposed three models for payments between multiple CBDC networks:

- **mCBDC Model 1** describes an interoperability model of enhanced compatibility of CBDC systems, with compatible regulatory and technical standards and co-ordinated identification schemes.
- **mCBDC Model 2** describes an interlinking model through shared technical interfaces or the use of a common clearing mechanism.
- **mCBDC Model 3** describes a model of multiple CBDCs on a single platform or system.

Figure 1:
The BIS multi-CBDC arrangements

Source: R Auer, P Haene and H Holden, "Multi-CBDC arrangements and the future of cross-border payments", BIS Papers, no 115, March 2021

Model 1 –
mCBDC arrangement based on compatible CBDC systems

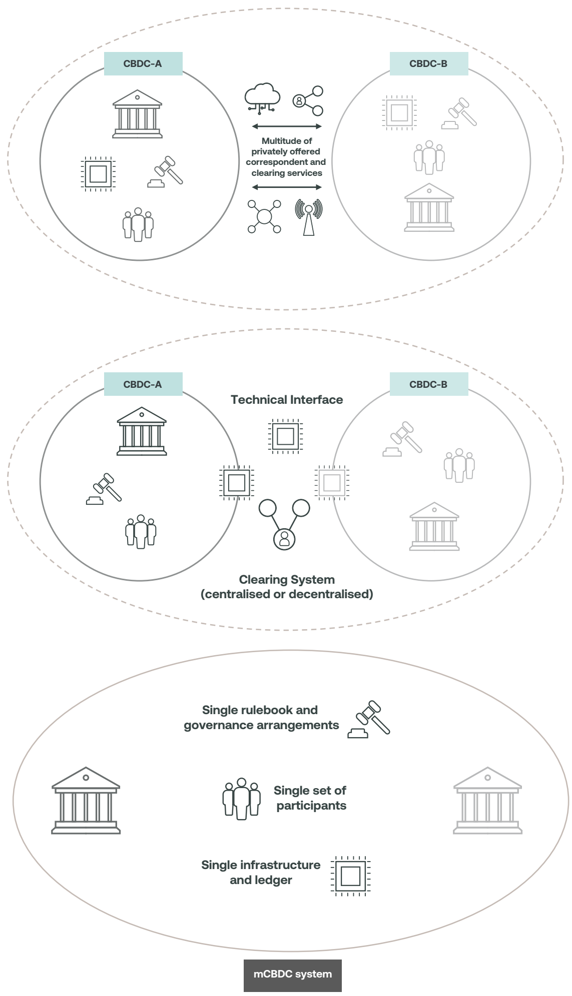
- Transfers between CBDCs offered by a multitude of competing private companies benefiting from compatibility measures and broadly similar participation requirements
- CBDC systems separately determine rulebook and governance, participation criteria, and infrastructure

Model 2 –
mCBDC arrangement based on interlinked CBDC systems

- Three options to establish:
  - Technical interface
  - Centralised clearing process
  - Decentralised clearing proces
- Joint contractual underpinning of interlinking system
- Separate rulebook and governance, participation criteria and infrastructure

Model 3 –
single mCBDC multi-currency system

- Single system with multiple CBDCs
- Central banks to agree on single rulebook, single set of participation requirements, and supporting infastructure



Ongoing efforts to join up CBDCs

Valuable work has been undertaken on developing these models. For example, on Model 3, Project Dunbar and other projects have explored issues such as access, jurisdictional boundaries and governance. Also in this context, Swift continues to advise the collaborative Regulatory Liability Network (RLN) initiative which involves many global banks.

Nevertheless, there are also many challenges to a model involving a single global system, something which was acknowledged in the Project Dunbar report published in March 2022. It said: "Given the complexity of having multiple central banks sharing critical financial infrastructures and the unique requirements of each jurisdiction, a common multi-CBDC platform may be more likely to be implemented as a series of regional platforms rather than as a single global platform. This naturally leads to considerations around how it may be possible to connect these individual regional platforms to realise synergies such that participants transact directly across jurisdictions."

Swift's Phase 1 experiments (2021)

Given these challenges, we have focused our own experimentation on solving for Models 1 and 2. As we are constantly exploring innovations and finding new ways to support our members, we initiated and executed a CBDC and digital asset innovation project in November 2020. Our 2021 Whitepaper outlined a solution to Model 1, supported by experimental results. In 2021, we completed two experiments:

1. **Experiment A1: Value transfer between traditional payments system to CBDC system:** The objective of this was to test and showcase Swift's ability to use innovative DLT features to orchestrate a cross-border transaction between two entities on two different networks: a traditional payment system (e.g. an RTGS system) and a DLT-based CBDC system. Using a settler on the DLT network, funds were locked until settlement was on the DLT. Transaction settlement was triggered by a successful transfer of funds on the traditional payment system. In doing so, the technology eliminates counterparty risk, exposure of default by the involved parties, and a third-party escrow.
2. **Experiment A2: Value transfer between two CBDC systems, orchestrated by Swift**
   The objective of this was to test and showcase how a cross-border transaction between two parties on different DLT networks could rely on Swift's ability to orchestrate a cross-border, multi-currency transaction through the correspondent banking system, by using an HTLC model to execute value transfer between two DLT networks (Corda and Quorum)

These experiments enabled us to:

- Reflect the existing correspondent banking systems and its associated relationships.
- Enable the creation of a conditional transaction by the Swift platform instructing the relevant parties to act in the correct sequence.
- Leverage unique DLT features, such as tokenisation of value, smart and conditional contracts, distributed ledgers, and a settler.

While the 2021 experiments were successful in achieving interoperability, we also found in Experiment A2 that the use of escrow transactions using an HTLC model resulted in a high number of messages between intermediaries (as the conditional transactions were set up, the hash of the secret shared and the secret then shared to released). In addition, the release of the transactions occurred 'right to left' (beneficiary first) which is different from the familiar 'left to right' release of established cross-border payments – which could be a challenge for commercial banks operating in this space.

Building on these learnings, our 2022 experimentation demonstrates an interlinking solution to BIS's Model 2

Building on these learnings, our 2022 experimentation demonstrates an interlinking solution to BIS's Model 2 – agnostic to the specifics of CBDC implementations and technologies – by providing a bridge for cross-border payments. This enables a payment flow more similar to established cross-border payments. The solution also gives the CBDC network operator the flexibility to implement their own flows and rule book on the domestic CBDC network, while enabling cross-border payments through the use of a connector gateway that sits on that network, and communicates with many other CBDC networks and payments systems through the Swift platform.

Swift's Phase 2 experiments (2022)

Following the first phase of experiments, it was confirmed that there is significant demand for Swift services to enable transaction orchestration in a cross-border CBDC context, and there were additional characteristics that we wanted to explore, namely:

- **Rich data and standards** — The ability to carry data about the payment in a standardised form, which can be readily understood and reported is crucial, and ISO 20022, especially, will be essential.
- **Digital identity** — If fraud is to be combated, then secure identity is crucial.
- **Core payment system requirements** — The core requirements (fraud prevention, Know Your Customer (KYC), Anti-Money Laundering (AML), security, integrity, transparency, data privacy, and, internationally at least, Financial Action Task Force (FATF) recommendations and sanctions screening of a payment will need to apply.
- **Interoperability and integration within domestic infrastructure** — CBDC-based systems must co-exist and be integrated with other payment systems. This is a vital part of making different forms of money useful in practice.
- **Implementation generality** — Ensuring simplicity in effort for various network providers regardless of technology choices.

For this reason, we scoped the second phase of experiments to demonstrate the ability to perform cross-border transactions using the Swift suite of solutions – including a simulation of the Swift platform and Connector Gateway – and facilitate cross-border payments between financial networks of various types, including CBDC, in a seamless and frictionless way. The solution is to be agnostic to technology and processing rules. As part of these experiments, we wanted to ensure the following:

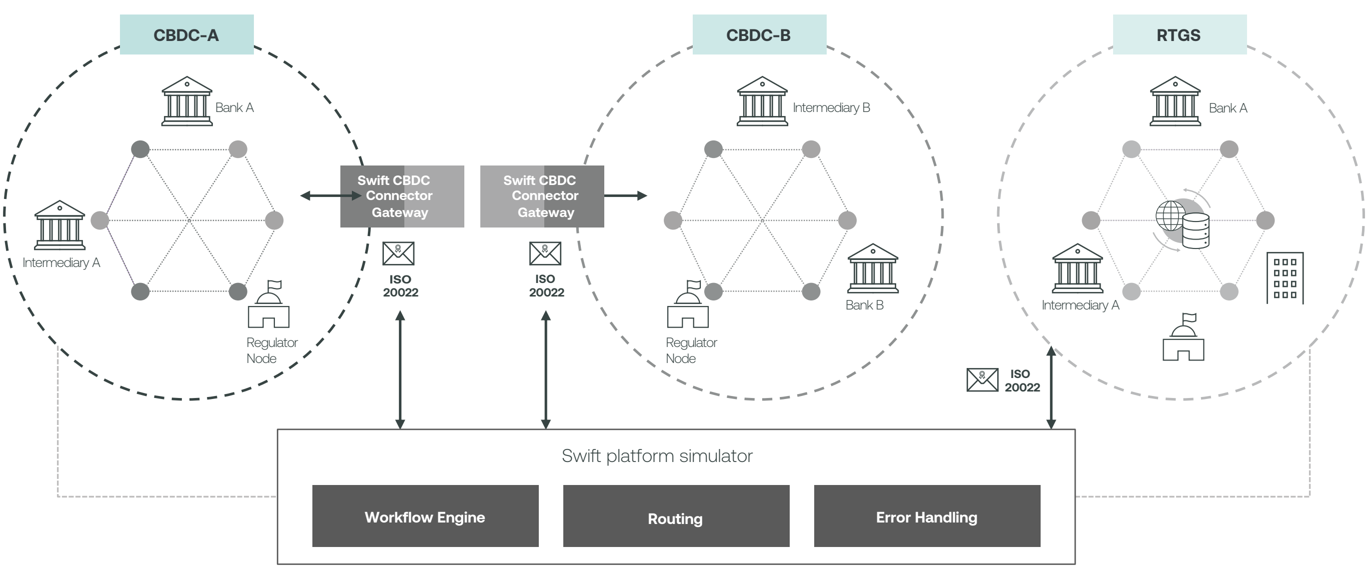
- Use of ISO 20022 standards to communicate between gateway connectors attached to the CBDC network. The gateway will convert to protocol required by the local CBDC network.
- Use of Swift PKI to enable interoperability trust between networks.
- Network operators to implement the rulebook/policy and adaptors to communicate with their network; and provide that implementation as a pluggable module to the gateway to conduct the local orchestration.
- The Connector Gateway is run and operated by the network operator. Network operators can implement the message processing rules per the policy of their network, thus keeping the knowledge of processing cross-border payment messages local to their network and in their control within the network. This approach encapsulates how a cross-border payment needs to be initiated from the sender of the payment.
- Smart contracts developed by the network operators will be used for payment execution, as defined by the rulebook implementation, thus hiding the local intricacies from the initiator of the payment.
- Payment orchestration within a CBDC network will be executed using innovative technology chosen by the CBDC network. Swift will play no role in intra-CBDC orchestration.

Solving the interlinking challenge

The goal of this solution is to highlight the potential for seamless cross-border interlinking between various CBDC and RTGS networks. While CBDC networks will be implemented by each CBDC network operator, to demonstrate the concept, we built a reference implementation based on the following components:

- **CBDC Networks:** The solution consists of two simulated CBDC networks, one implemented on R3 Corda, and another on Quorum. CBDC network regulators will run and govern a “trusted DLT node” created as part of Swift’s solution.
- **RTGS Simulator:** As the adoption of CBDCs will be gradual, we assume that it will be necessary to transact between a traditional RTGS and CBDC network – and thus simulated an RTGS environment for this case.
- **Swift CBDC Connector Gateway:** A CBDC Connector Gateway was built to facilitate seamless interactions between various networks via the Swift platform simulator. This gateway acts as a standardised interface for all traffic between the CBDC network and the Swift platform simulator, a single entry and exit point for cross-border payments to and from the CBDC network. The gateway is run on a regulator node, and provides the flexibility for network operators to implement their connection to the gateway, based on their specific network design,- including flexibility around smart contract protocols, conditional payment protocols, messaging formats, etc. While the network operators would be required to implement this adaptor, the gateway would provide a seamless linking with the rest of the Swift ecosystem, including the Swift platform simulator and its associated value-added services, such as the use of the Unique End-to-end Transaction Reference (UETR) to track an entire transaction. Note that in addition to the DLT-based CBDC networks connected here, the Connector Gateway could also be implemented in non-DLT technology based CBDC solutions.
- **Swift platform simulator:** The fundamental premise of Swift’s transaction management vision is that it allows interoperability between different standards, channels, protocols and across currencies, while embedding adjacent services to make the payment safe, secure and complete. In order to leverage these capabilities, a simulator of the platform was used, which adds the potential for extensibility of value-added services, such as KYC, AML, security, integrity, transparency, sanctions screening, etc.

Figure 2: The Swift solution



In addition, the solution was built with the following principles:

- **Use of ISO 20022:** Cross-border payments have an inherently complex process and require good coordination among many participants to be successful. ISO 20022 is data rich and supports many different characters, unlike MT format and other native formats. Being in the XML format makes it easier for the IT system to use this data message for processes like AML, fraud checks, etc. The following are some of the benefits:
- **Easier adoption for banks:** Already having invested in ISO messaging, banks are keen to scale its use in CBDCs, thus making the case for adoption.
  - **Lower TCO:** Using ISO 20022 will address the challenge of the cost of investing in and continued maintenance of multiple native CBDC protocols.
  - **Cross-border usability:** ISO 20022 messaging will improve interaction, especially in cross-border and inter-DLT transfers.
- **PKI:** This solution leverages PKI-based identity. The identity is used by participating banks to sign ISO 20022 messages sent over the DLT network.
- **Management simplicity:** The gateway connector approach simplifies the maintenance of identity management and connectivity to different networks, since each CBDC only has to connect to Swift. CBDC processing intricacies are localised on the gateway and not exposed to the sender or Swift.
- **Transaction transparency:** The gateway will propagate the status of transactions within the network which will provide transaction transparency across networks.

The Phase 2 results

There are many possible design choices currently being explored by various central banks for the purpose of creating CBDCs. As such, in our experiments, we implemented two different DLT networks, Corda and Quorum, to show the interlinking between different networks. In addition to these simulated CBDC DLT networks, a third mock-RTGS network was also created to demonstrate a hybrid cross-border flow. This experiment showcases two high-level use cases: CBDC to CBDC (both Corda to Quorum, and Quorum to Corda) and RTGS to CBDC (RTGS to Corda). In addition to these standard flows, exception scenarios were implemented.

Experiment Scenario 1: CBDC-to-CBDC

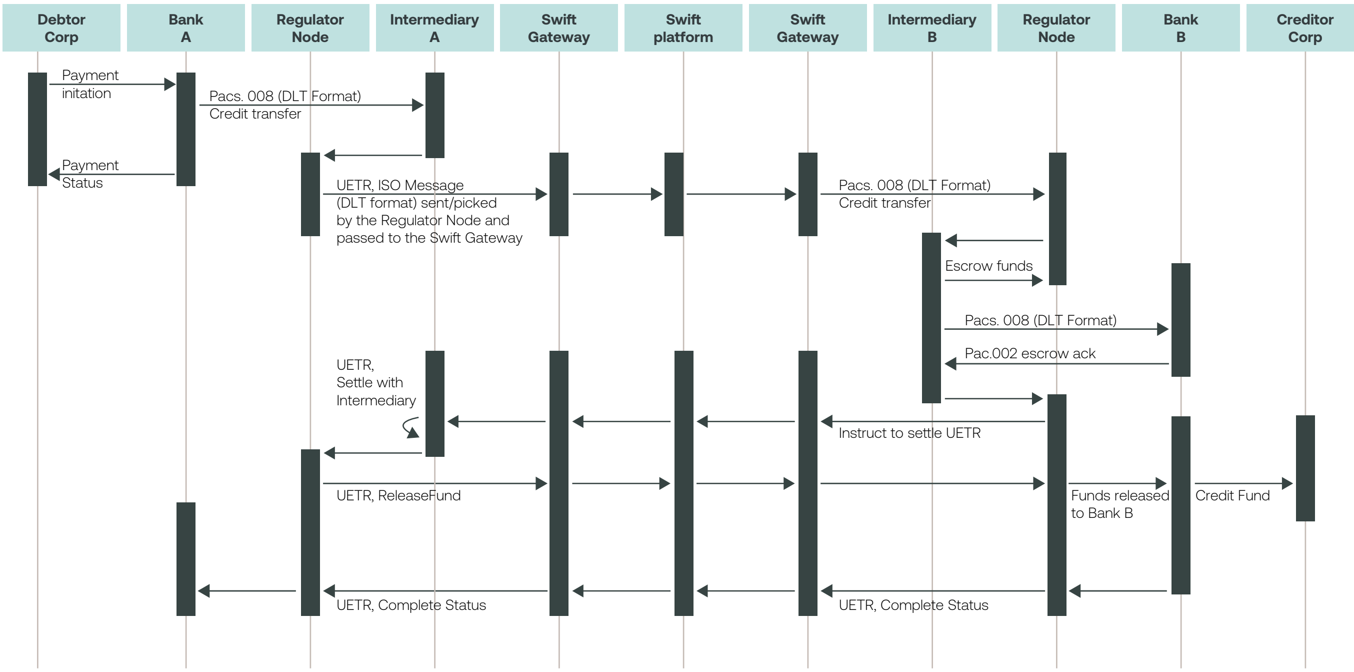
This experiment took advantage of the innovative capability of DLT networks for intra-DLT transactions, in which the Swift platform simulator and Swift Gateway are leveraged to enable interlinking. To achieve this, we implemented a standard escrow mechanism to prevent double spend. Note, this is a reference implementation flow for demonstration purposes. However, each CBDC can define its own flow and have that logic implemented in the gateway and the network.

The experiment flow is depicted here in 10 steps:

1. Debtor Corp submits a credit transfer request to Bank A
2. Bank A initiates the credit transfer by creating a payment message, and makes a call to the Swift platform to identify the cross-border payment route. The message follows the ISO 20022 format and is signed using Swift's PKI-based encryption. The signed message is then sent to Intermediary A using a messaging smart contract.
3. Intermediary A then sends a payment message to Intermediary B by using the messaging smart contract. The Regulator Node of Country A intercepts the message and forwards it to Country A's Swift CBDC Connector Gateway (Swift Gateway).
4. Country A's Swift Gateway then sends the message to the Swift platform which identifies the corresponding Swift Gateway in Country B to receive the payment instruction.
5. Country B's Swift Gateway then converts the ISO 20022 message into the local DLT format and executes the messaging smart contract with Intermediary B.
6. Now Intermediary B creates a conditional payment for Bank B by escrowing the tokens with the Regulator Node. The funds will not be released until the Regulator Node in Country B receives a release funds notification from Intermediary A
7. Next, Intermediary B sends the payment message to Bank B using the messaging smart contract
8. Bank B then sends the message acknowledgement to Intermediary B using the messaging smart contract. Intermediary B performs the same action to inform Intermediary A via the Regulator Node.
9. Intermediary A then receives the notification of the creation of a conditional payment smart contract via the Swift Gateway, and the Swift platform. Intermediary A then settles by updating the nostro account for Intermediary B. Intermediary A sends a release funds notification using the messaging smart contract to the Regulator Node.
10. Country A's Regulator Node then sends the release funds notification to the Regulator Node in Country B via the Swift Gateway and Swift platform. The conditional payment smart contract is executed and the funds are released to Bank B, and ultimately sent to Creditor Corp.

N.B. Swift Gateway in each country updates the Swift platform of the transaction status, enabling participants to view the status of the transaction.

Figure 3: Experiment flow – CBDC-to-CBDC



N.B. We also experimented with changes in payment flow direction and made the implementation bi-directional. The experiment includes reversing the role of sender entities with receiving entities, making Bank B the sender and Bank A the receiver entity.

This experiment shows the following:

1 **Payment path:** Sender Bank made a call to the Swift platform simulator, which was able to identify the cross-border payment path.

2 **Payment execution:** The CBDC network was able to transfer messages from one node to another with the help of the node address.

3 **Messaging:** The ISO 20022 message format can be used for communication.

4 **Transaction status:** The Swift Gateway has the capability to propagate the transaction status within the DLT to the tracker so that the global status of the transaction can be ascertained at any time. The network should provide the cross-border transaction message and status to the gateway.

In addition, many exception use cases were tested. For example, exception at creditor agent; exception at debtor agent; exception when payment initiated by Creditor Corp; Credit reversal (crediting back to debtor), etc.

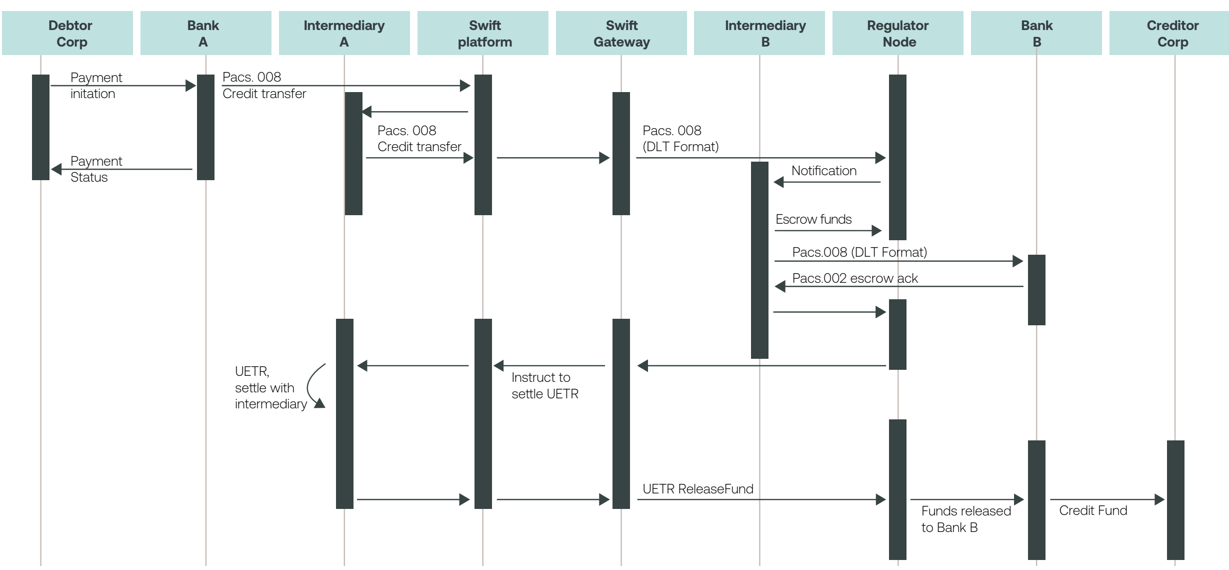
Experiment Scenario 2: Fiat-to-CBDC

This experiment explored fiat to CBDC payment transactions, in which a regulator node was used to validate payment notifications from fiat to CBDC. This experiment took advantage of the innovative capability of DLT networks for intra-DLT transactions, leveraging the Swift platform simulator and Swift Gateway. Note, this is a reference implementation flow to demonstrate. However, each CBDC can define its own flow and have that logic implemented in the gateway and the network.

The experiment flow is depicted here:

1. Debtor Corp submits a credit transfer request to Bank A.
2. Bank A initiates the credit transfer by creating a payment message and makes a call to the Swift platform to identify the cross-border payment route. The message follows the ISO 20022 format and is signed following PKI- based encryption.
3. The signed message is then sent to Intermediary A via the Swift platform. The Swift platform provides payment orchestration within the RTGS side.
4. Intermediary A then sends the message to Intermediary B via the Swift platform.
5. The Swift platform identifies the corresponding Swift Gateway in Country B to receive the payment instruction.
6. Country B's Swift Gateway then converts the ISO 20022 message into the local DLT format and executes the messaging smart contract with Intermediary B.
7. Now Intermediary B creates a conditional payment for Bank B by escrowing the tokens with the Regulator Node. The funds will not be released until the Regulator Node in Country B receives a release funds notification from Intermediary A
8. Next, Intermediary B sends the payment message to Bank B using the messaging smart contract.
9. Bank B sends the message acknowledgement to the Intermediary B using the messaging smart contract. Intermediary B will perform the same to inform Intermediary A via the Regulator Node.
10. Intermediary A receives the notification of the conditional payment smart contract creation via the Swift Gateway and Swift platform. Intermediary A settles by updating the nostro account for Intermediary B. Intermediary A then sends a release funds notification via the Swift platform
11. The release funds notification is received by the Regulator Node in Country B via the Swift Gateway. The conditional payment smart contract is executed and the funds are released to Bank B, and ultimately sent to Creditor Corp.

Figure 4: Experiment flow – Fiat-to-CBDC



This experiment shows the following:

1 Payment path: Sender Bank made a call to the Swift platform simulator to identify cross-border payment path.

2 Smart-contract execution: Once the Regulator Node receives payment confirmation from the fiat side, a smart contract was auto-executed to move the fund.

3 Messaging: The ISO 20022 message format can be used for communication.

4 Transaction status: The Swift platform simulator continues pulling the current payment status. This payment status is made available to all banks through the Swift platform simulator API calls.

Conclusion and next steps

With the Phase 2 experiments proving to be successful, we have demonstrated the technical feasibility of our CBDC interlinking solution – using standards and using a gateway in each network, which greatly simplifies interlinking CBDCs with other financial networks. It provides a highly scalable solution that solves the 'one-to-many' challenge not addressed by bilateral connectivity, while more closely replicating the flows familiar to commercial banks from established cross-border payments.

For a central bank CBDC network operator, it can offer simple enablement and integration of domestic CBDC networks into cross-border payments, while giving flexibility to the CBDC network operator to:

a. Implement the rulebook of its network.
b. Provide a CBDC adaptor to the gateway to interface with the network. This paves the way to integrate with any technology.
c. Use standards and protocols that eliminate the need to know the messaging processing details (smart contract, etc..) on the sender and receiver networks.
d. Simplify the administration and management of the network, as the only connection between the networks is through Swift as a trusted entity.

As part of our ongoing CBDC experiments and exploration, we identified the need for an environment that allows us to engage, test and, collaborate with our customers in an open and innovative way. As a result, we have built a CBDC sandbox and visual interface that is now being used by more than 10 institutions – including central banks, market infrastructures and commercial banks from across the globe – to assess potential use cases and wider CBDC operability. We started welcoming our banks into the sandbox in September and will seek feedback through to late 2022.

Incorporating multiple blockchain technologies, the sandbox not only provides the ability for bilateral testing, but also facilitates real-time feedback opportunities for our customers to share their challenges with Swift and contribute to the next generation of CBDC solutions.

We plan to use this feedback to shape our strategic approach for digital currencies moving forward, providing valuable solutions for the entire Swift community.

Want to learn more?
If you would like to learn more about our CBDC experiments and solutions, please reach out to your Swift account manager or contact innovate@swift.com.

Abbreviations

BIC	Bank Identification Code
BIS	Bank for International Settlement
CBDC	Central Bank Digital Currency
Direct Account relationship	Sender and receiver are in nostro-vostro relationship
DLT	Distributed Ledger Technology
FI	Financial Institution
HTLC	Hash Time Locked Contract – This is a smart contract bound in time and in secret
IBAN	International Bank Account Number – Internationally agreed format for identification of bank accounts held by various parties
Intermediary	This is an FI involved in the transfer of funds between sender and receiver, when sender and receiver don’t have a direct relationship
PSP	Payment Service Provider
Receiver	Receiver is a financial institute who receives a message / fund from another party
Sender	Sender is a financial institute who transmits a message / fund to another party

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About Swift

Swift is a global member-owned cooperative and the world's leading provider of secure financial messaging services. We provide our community with a platform for messaging, standards for communicating and we offer products and services to facilitate access and integration; identification, analysis and financial crime compliance. Our messaging platform, products and services connect more than 11,000 banking and securities organisations, market infrastructures and corporate customers in more than 200 countries and territories, enabling them to communicate securely and exchange standardised financial messages in a reliable way.

As their trusted provider, we facilitate global and local financial flows, support trade and commerce all around the world; we relentlessly pursue operational excellence and continually seek ways to lower costs, reduce risks and eliminate operational inefficiencies. Headquartered in Belgium, Swift's international governance and oversight reinforces the neutral, global character of its cooperative structure. Swift's global office network ensures an active presence in all the major financial centres.

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