CBDC
Experiment report

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In association with

HSBC

BANQUE DE FRANCE

IBM

Content

1. Executive summary

In May 2020, HSBC and IBM partnered to jointly respond to the call for applications organised by Banque de France (BdF - France's central bank), to experiment with the use of a central bank digital currency (CBDC) issued for interbank settlements.

The aim was to explore the potentialities offered by the Distributed Ledger Technology, and to identify concrete cases integrating CBDC in innovative procedures for the settlement of tokenised financial assets.

Three scenarios were put forward to showcase the capabilities and benefits of a wholesale CBDC implementation:

- Issuance and distribution of a CBDC
- Bond subscription in primary and secondary markets followed by coupon redemption
- Execution of cross border and cross network payments

All three scenarios were combined into a single experiment as a proof of concept (PoC), executed in a complex environment which included multiple ledgers, technology stacks and control frameworks.

BdF participated by maintaining overall control of the experiment along with supplying three permissioned distributed ledger technology (DLT) platforms (one for primary market securities transactions and two payment networks, all based on the BdF DL3S platform, an Hyperledger Fabric DLT), while HSBC supplied its Digital Vault (R3 Corda), a securities custody platform also based on Distributed Ledger Technology.

The objective of the experiment was to...
functionally and technically demonstrate that DLT can be used in coexistence with existing networks through interoperability, which had not been achieved in previous CBDC experimentations, by:

1. Using CBDCs on several networks hosted on multiple platforms and technologies, across multiple time zones, leveraging both central and commercial banking ecosystems
2. Ensuring BdF could maintain controllability, traceability and governance of CBDC across multiple networks
3. Using smart contracts to streamline complex business processes such as a coupon payment requiring a multi-currency payment (PvP transaction) across different networks and platforms
4. Enabling cross DLT network atomic transactions in a permissioned, though trust-less, environment using a groundbreaking interoperability protocol (Weaver).

The experiment's use case was to...

- Issue and distribute a EUR CBDC
- Issue and distribute a euro eBond from a fictitious issuer to HSBC paid for in EUR CBDC. HSBC to acknowledge receipt of the eBond and sale and custody of the eBond for its customer
- Pay an eBond coupon in EUR CBDC to HSBC who transferred the coupon payment to its customer in another CBDC via an FX payment (in this proof of concept, a fictitious CBDC XXX was used)
- Have the experiment take place over several business days and BdF reconcile the CBDC balances during the process.

The experiment was successfully completed in just four months and demonstrated the use of a CBDC to enable transactions across borders and technology platforms whilst facilitating the lifecycle of digital assets and currencies in wholesale markets.

The Banque de France proved that each transaction flowed correctly through the network of systems, automatically triggering the required events, whilst retaining visibility and control over the EUR CBDC in circulation.

Aside from the business objectives having been met in full, this experiment showcased partnership and collaboration between a central bank, a commercial bank, and technology providers in a challenging timeframe.

2. Description of the experiment

Banque de France CBDC experiment

In March 2020, Banque de France (BdF) launched a wholesale CBDC experimentation program to "test the integration of a central bank digital currency (CBDC) for the exchange and settlement of tokenised financial assets between financial intermediaries".

A partnership between HSBC and IBM was selected to evaluate the potential of cross networks Payment versus Payment (PvP) and Delivery versus Payment (DvP) operations using CBDCs.

This experiment set out to go beyond previous public experimentations by:

- Exchanging multiple CBDCs across multiple DLT based networks (using different Hyperledger Fabric networks)
- Streamlining complex end-to-end business processes using DLT's automation capabilities (coupon payments in different CBDCs on different networks settled within seconds)
- Using a decentralised bridge component to enable atomic transactions across different types of networks and technologies
- Improving the security of transactions between central banks, commercial banks and their clients whilst accelerating processes and reducing market risks.

Organisation & methodology

The CBDC experiment included participants from:

HSBC

HSBC provided a blockchain service (Digital Vault) to custody the securities alongside expertise in the processing and management of DvP and PvP settlement.

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The Banque de France provided the capability to issue and manage CBDCs during their lifecycle via the DL3S platform, as well as a version of DL3S to manage CBDC payments in the secondary market.

IBM

IBM, technology partner of the working group led by HSBC, brought its know-how of developing blockchain solutions for financial markets to enrich this platform with specific functionality, especially on blockchain protocols interoperability.

The experiment ran over a period of four months, with 1.5 months for experimentation design, 2 months of implementation and a few weeks of indepth testing. User stories were used to document the functional requirements.

Objectives

This experiment set out to demonstrate the capabilities and benefits of a wholesale CBDC.

From a business perspective this included:

- The full lifecycle of a financial instrument (eBonds)
- Cash flows management in CBDC on behalf of a client of HSBC, acting as custodian,for a specific usage (buying eBonds on secondary market)
- Cross-border aspects (a client requests to receive a coupon payment in a non euro CBDC)

A focus on interoperability between networks:

- Systems using different DLTs (Hyperledger Fabric and Corda)
- DLT and non-DLT systems owned either by the central bank or by private sector participants

Leveraging existing assets developed by the three participants:

- DL3S: a DLT-based BdF owned Securities Settlement System with CBDC available only for Banks
- EUR_NET: a BdF owned DLT-based payment system for EUR CBDC (based on DL3S)
- XXX_NET: a simulated DLT-based payment system for a fictitious XXX CBDC (based on DL3S)
- HSBC Digital Vault and FX Everywhere, HSBC Commercial Bank Money (CoBM) platforms
- IBM Relay services (Weaver) – for interoperability between networks

<u>All objectives were successfully met</u> at the end of the experimentation.

Experimentation environments

The experimentation leveraged three different systems:

1. DL3S, a BDF owned DLT-enabled network developed on Hyperledger Fabric, built for the management and the settlement of securities and CBDC. Two additional DL3S networks were deployed: EUR_NET and XXX_NET. EUR_NET is a EUR CBDC payment platform for secondary market. XXX_NET is a non-euro CBDC payment platform for secondary market cash flows in the fictitious XXX CBDC.
2. HSBC Digital Vault, a DLT digital asset custody platform for HSBC Securities Services developed using R3's Corda.
3. HSBC FX Everywhere, a private DLT solution, for the netting and settlement of FX transactions and payments used by HSBC across its affiliates.

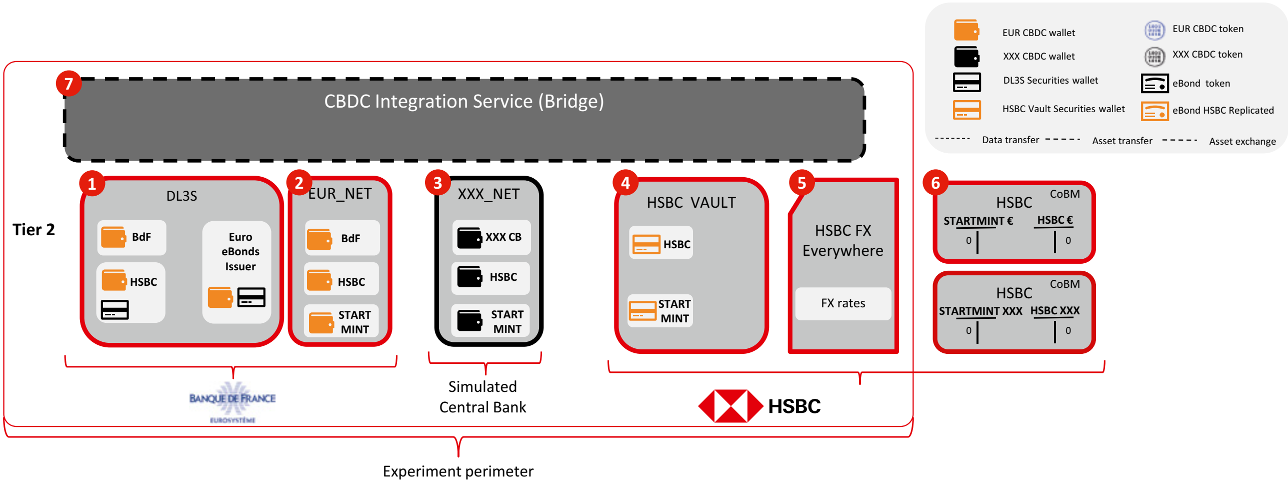
The experimentation used a bridge service to provide inter-operability between the different networks. Built on IBM's Weaver technology, it enabled atomic transactions of data and assets across different networks and technologies in a trust-less manner.

The EUR CBDC distribution process designed for the experimentation followed several steps:

1. For HSBC, as a T2 participant, BdF issued an amount in EUR CBDC in DL3S, equivalent to the amount needed to buy a fictitious digital bond on the primary market, crediting HSBC's wallet with EUR CBDC.
2. It was assumed that HSBC's client pledged commercial bank money (CoBM) on an HSBC account for the secondary market transaction.
3. HSBC, acting as the client's custodian, provided the equivalent amount in EUR CBDC to its client in EUR_NET, which enabled the client to settle the cash leg of the DvP in the secondary market.
4. The interoperability feature of the bridge service allowed CBDC to flow between DL3S and EUR_NET networks.

The experimentation perimeter enables the issuance and the distribution of EUR CBDC to participants, following strict audit rules that framed the actions across the platforms.

The structure is shown on the figure below:



(All environments used were test environments)

1. DL3S, a BdF owned DLT network, initially built for the management and the settlement of securities against CBDC. In this experiment, DL3S was used to settle the cash leg of the Delivery versus Payment (DvP) transaction between a CSD and HSBC on the primary market.
2. EUR_NET, a BdF owned DLT network relying specifically on DL3S set up to hold EUR CBDC. This platform enables T2 participants and their clients to use EUR CBDC to settle specific transactions in a secure way (cash leg for the secondary market DvP and PvP)
3. XXX_NET, a BDF owned DLT network using DL3S technology set up to hold digital non-EUR CBDC. In this network, a central bank was simulated and participants as well as their clients were able to settle in XXX CBDC.
4. Test environment for HSBC's Digital Vault, the DLT digital asset custody platform for HSBC Securities Services.
5. FX Everywhere, an HSBC DLT solution for the netting and settlement of FX transactions and payments used by HSBC and its affiliates.
6. HSBC core banking systems environment for the accounting of non CBDC flows (not connected and used in this PoC).
7. A decentralised bridge, developed by IBM Research for the interoperability and transfer of data and assets across multiple networks and technologies

DLT focus

Several different DLT networks and their associated protocols and technology stacks were used during this experiment to demonstrate their interoperability, while preserving transactions privacy and participants' confidentiality. These were:

1. DL3S, EUR_NET and XXX_NET platforms using Hyperledger Fabric
2. Digital Vault platform using Corda
3. FX Everywhere platform using a private DLT

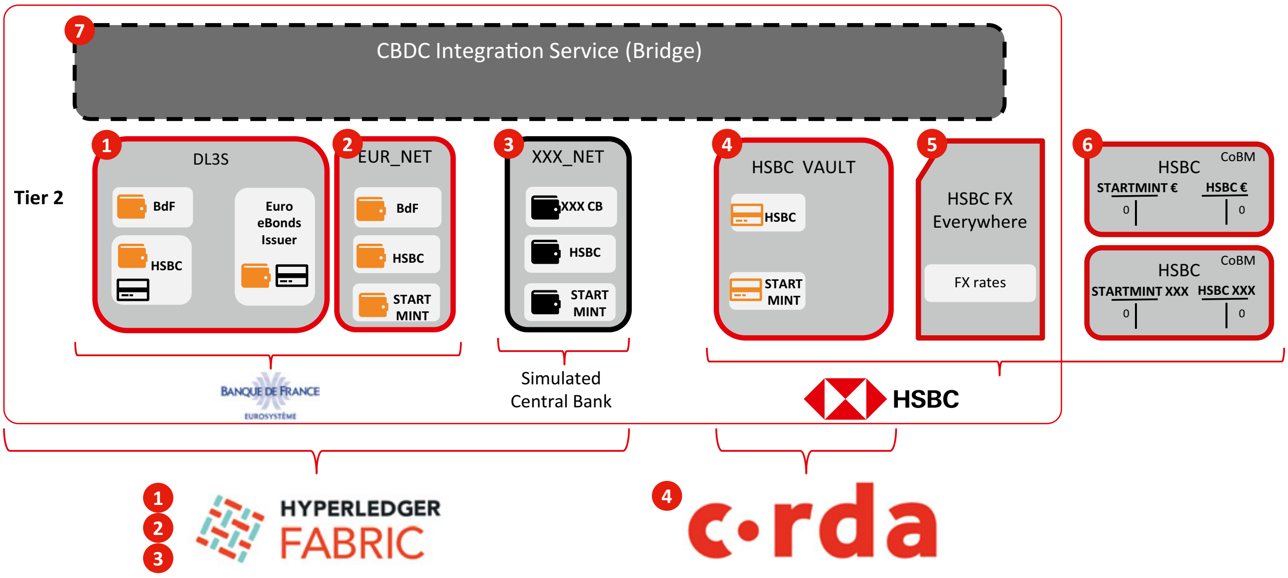


Figure 1: Architecture

All DLTs were permissioned and as such the members are identified and duly authorised by the individual networks. The platforms were deployed and tested in a hybrid-cloud environment, with nodes distributed across several organisations in private (HSBC & BdF) and IBM public clouds.

Use case overview

The following actors were involved in the experiment:

- Banque de France (BdF) as a EUR CBDC issuer
- eBond Issuer (EBI) as an issuer of Euro Bonds for the primary market, and a T2 participant
- Central Bank X (CBX) as a simulated central bank issuing a fictitious CBDC XXX
- HSBC as a commercial bank and securities custodian for its corporate clients
- Startmint as a fictious corporate client of HSBC
- Operator as a fictious auditor role

The use case was designed to run over two business days.

Day 1

- On the first day, every wallet on the different networks is initialised. The eBond is created on DL3S platform by EBI (a fictitious issuer of Euro Bond for the primary market) based on ISIN code and other parameters including coupon payment frequency and currency. The information pertaining to that issuance is updated in HSBC Vault using the interoperability data transfer mechanism. A standing order is defined in Digital Vault to set up an FX payment preference for Startmint. Startmint declares that any coupon payment received by its custodian HSBC in EUR CBDC must be converted into XXX CBDC.
- HSBC requests the issuance of EUR CBDC to its DL3S EUR CBDC Wallet to BdF who issues the corresponding amount. The EBI issues eBonds into its own securities wallet in DL3S. HSBC proceeds to buy the issued eBond with a Delivery versus Payment (DvP) operation within DL3S. The Digital Vault is updated with the amount held by HSBC in DL3S using interoperability data transfer mechanism.
- Startmint transfers EUR to HSBC in CoBM (simulated). In return, HSBC transfers the appropriate amount from DL3S to EUR_NET on behalf of its client Startmint using interoperability asset transfer mechanism.

In Digital Vault, HSBC's back office registers a DvP trade between Startmint and HSBC. Startmint acquires the eBond held by HSBC. A cross-network DvP is executed atomically between Digital Vault and EUR_NET, using interoperability asset exchange mechanism. CBDC EUR is transferred from Startmint's wallet managed by HSBC acting as custodian, to HBSC's proprietary wallet in EUR_NET, and HSBC transfers eBond to Startmint in Digital Vault.

- At the end of Day 1, all CBDCs are redeemed in the DL3S and EUR_NET networks. The operator triggers a corporate action event linked to the eBond previously created. The coupon payment instructions are created on the DL3S network and planned to be executed on Day 2.

Day 2

- At the start of Day 2, the daily rate for EUR to XXX conversion is fixed based on FX Everywhere. EUR CBDC is issued for EBI. HSBC requests the issuance of XXX CBDC to its XXX CBDC Wallet in XXX_NET. CBX issues the corresponding amount.
- The coupon payment is executed in DL3S and EBI pays HSBC in DL3S. Upon reception of the payment, Digital Vault is alerted using interoperability data transfer feature. This alert initiates the transfer of the coupon payment from HSBC to its client Startmint wallet. Digital Vault then computes the EUR CBDC amount to pay to Startmint based on the amount of eBonds its client holdings and the characteristics of the bond. Digital Vault requests a CBDC transfer to DL3S. HSBC's wallet is debited from the correct amount in DL3S and Startmint's wallet is credited in EUR_NET, using an asset transfer interoperability mechanism.
- The reception of the coupon payment by Startmint in EUR_NET triggers the standing order and Digital Vault instructs a PvP operation to EUR_NET. A cross-network atomic PvP is then executed between EUR_NET and XXX_NET. Startmint's wallet is debited in EUR CBDC to the credit of HSBC in EUR_NET, while HSBC transfers XXX CBDC to Startmint's wallet in XXX_NET. The PvP is executed using the interoperability asset exchange feature.
- At the end of Day 2, all CBDC are redeemed in DL3S, EUR_NET and XXX_NET

Below is a simplified diagram that illustrates DvP operation between EUR_NET and Digital Vault (cross-network).

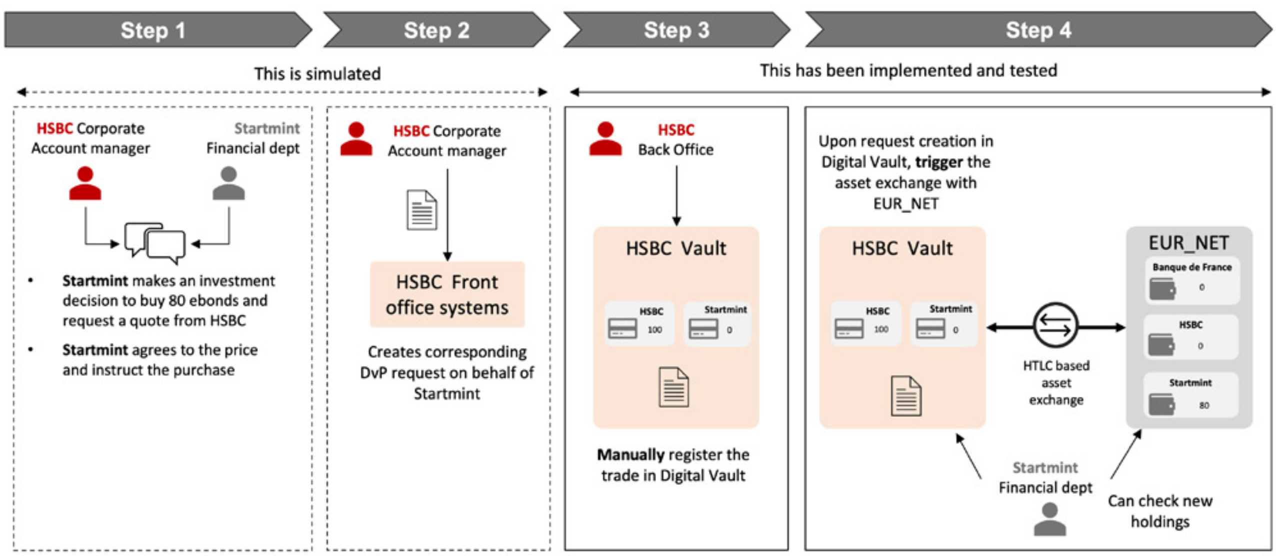


Figure 2: Scope for Secondary Markets DvP

Below is a simplified diagram that illustrates PvP operation between EUR_NET and XXX_NET (cross-network) with interaction from DL3S and Digital Vault (Coupon Payment and standing order execution workflow).

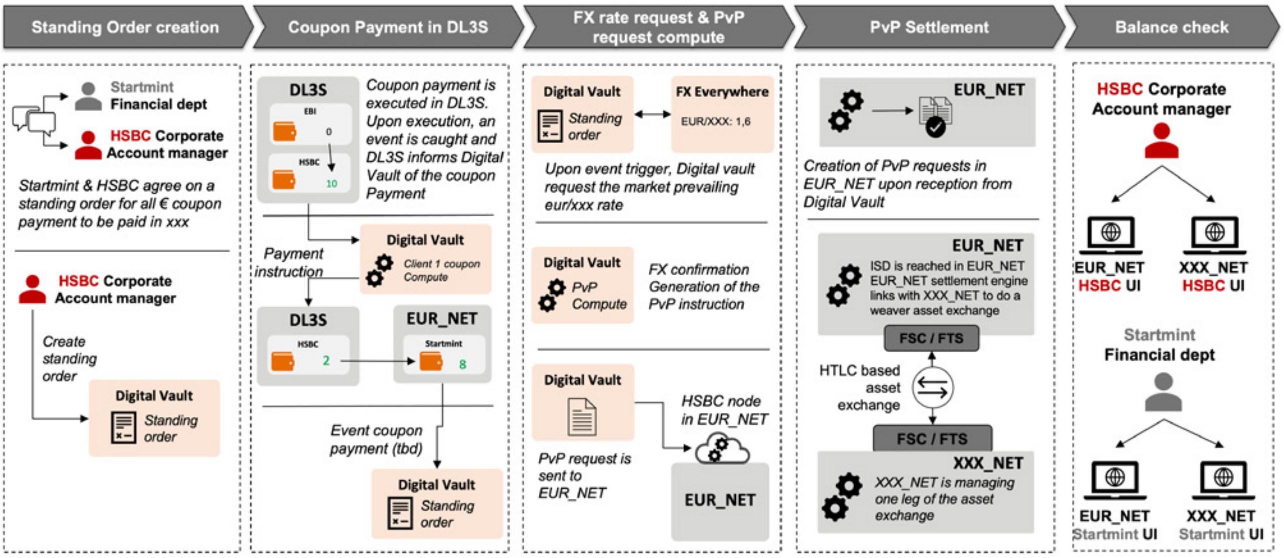


Figure 3: Scope for PvP Workflow

3. Technological environments

Blockchain technology data

1 HSBC's Digital Vault

In the digital world era, most securities are de-materialised but there are still a significant number of paper-based transactions requiring significant manual support from clients and other stakeholders. This ranges from manual reconciliations, wet-ink signing of documents, through to fax/couriering documents.

Digital Vault is a custody blockchain solution that aims to:

- Enhance client experience by ensuring all assets materialised / de-materialised can be accessed on a real-time basis.
- Simplify transfer of ownership, reduce administrative burden, and provide opportunity for greater liquidity.
- Extend the vault services to different types of digital assets on the DLT network and for the safekeeping of private keys.

This platform is enabled by R3's Corda technology to transact directly and privately. Smart contracts reduce transaction and record-keeping costs and streamline business operations. R3's Corda is a scalable, permissioned peer-to-peer (P2P) distributed ledger technology (DLT) platform that enables the building of applications that foster and deliver digital trust between parties in regulated markets.

Blockchain's potential in supporting the custody of future digital asset classes is immense, and we have already seen this in practice with HSBC's Digital Vault service which has been serving Private Placement Customer for several years.

The Digital Vault Network is deployed onto Google's Cloud Platform, accelerating client on-boarding times and reducing costs.

For this experiment, the Digital Vault platform was extended (in an innovation environment) to model the below steps in the eBond issuance lifecycle using CBDCs:

1. Primary market – eBonds issuance & subscription (Cross-Ledger Data Transfer for receiving HSBC's Account Holdings)
2. Secondary market – HSBC selling eBonds to its client (Atomic Cross-Chain Swap to enable Delivery Vs Payment)
3. Coupon payment triggered and paid to HSBC in EUR CBDC (Cross-Ledger Data Transfer for receiving the notification of Coupon Payment)
4. HSBC making coupon payment in a client preferred currency by capturing a Forex Deal on FX Everywhere

The technical stack (Fig.) for Digital Vault leverages technologies such as Kotlin, Corda Token SDK and latest technologies and Angular for UI.

2 Banque de France's DL3S network

DL3S platform (Distributed Ledger Technologies for a Securities Settlement System) a fully distributed, confidential and atomic settlement platform on Hyperledger Fabric, was provided by Banque de France for this experimentation.

DL3S has been used for various experimentations covering several businesses use cases of assets issuance (securities, CBDC) and distribution, cross network settlement and payments.

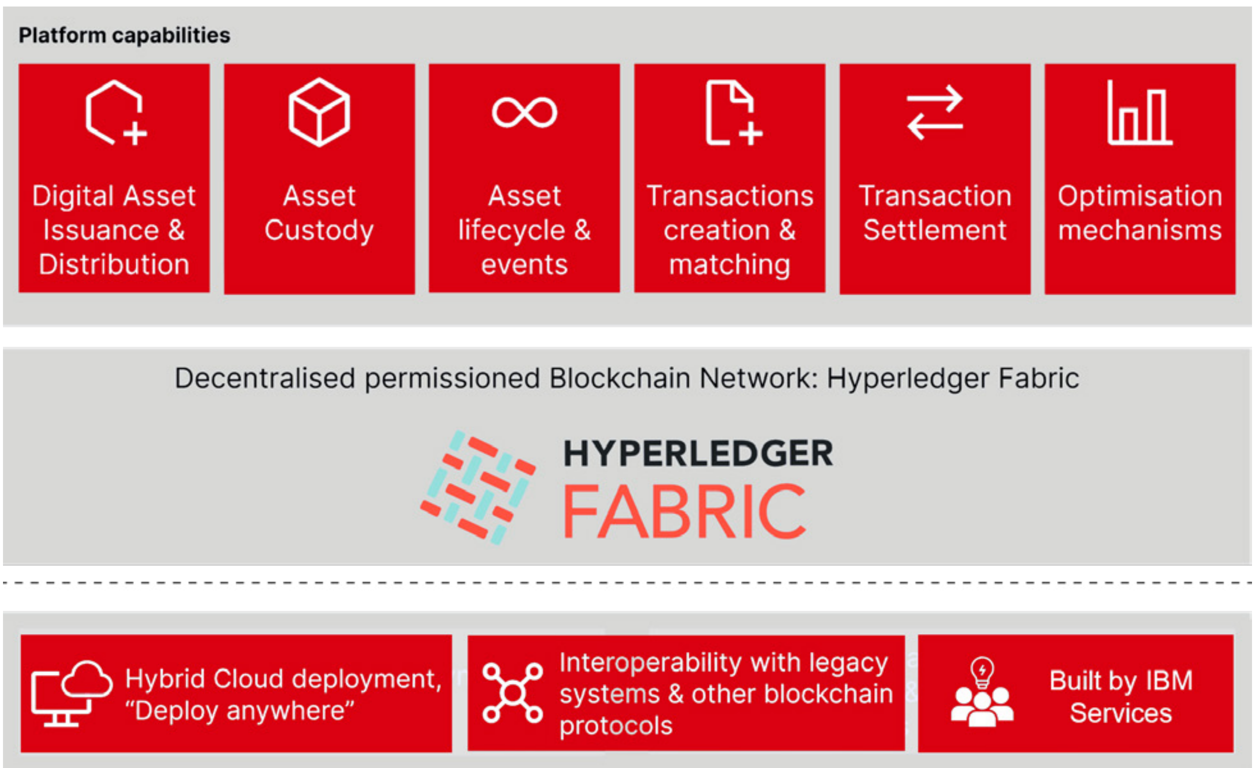


Figure 4: Platform Capabilities Overview

DL3S already supports entire financial assets lifecycle, from securities or CBDC management to a network operating for either the primary market or secondary market. Some optimisation mechanisms have been implemented such as auto-collateralisation (on flow with fixed value), recycling, coupon payment or REPO operation lifecycle to name a few.

Non-functional requirements are at the heart of the development of DL3S. With a strong focus on confidentiality, the DL3S platform leverages privacy and anonymity for its users, with auditability features for designated actor. It also ensures atomicity on an all-or-none basis with reliable performance.

DL3S platform also supports FSC (Fabric Smart Client) and FTS (Fabric Token SDK) technologies which facilitate token and wallet management, ensuring the Unspent Transaction Output (UTXO)[1] model as well as the requirement for privacy.

DL3S target architecture is an integrated platform, flexible and customisable to allow integration with legacy technology and new FSS ecosystems. It can support different token types such as different CBDCs or digital assets (bonds, shares…). Strongly built around connectivity and inter-operability in mind, it leverages connectors for different networks or systems.

3 Privacy management

Each blockchain technology addresses privacy management with specific features.

Hyperledger Fabric provides several mechanisms that ensure confidentiality regarding the content of each transaction and privacy in relation to the counterparties involved. Some of the key mechanism we used – amongst others – were:

- Channels: a virtual blockchain network which sits on top of a physical blockchain network with its own access rules. Channels employ their own transaction ordering mechanism and thus provide scalability, ultimately allowing for effective ordering and the partition of huge amounts of data.
- Private Data Collections: mechanisms allowing the restriction of the visibility of pieces of data, called collections, to properly authorised peers (defined in the collection's access policy), while at the same time maintaining traces of that data (seeded hashes) to the system's ledger.
- Identity Mixer: a Zero-Knowledge Proof based client authentication mechanism allowing for anonymous and non-linkable transaction creator authentication. More specifically, the transaction creator can prove to the network that they are a member of a particular organisation without revealing their identity or being connected to other transactions that they have submitted to the system.

Corda networks are semi-private. To join a network, participants must obtain a certificate from the network operator. This certificate maps the node's identity on Corda to a real-world legal identity and a public key.

The network map service matches each node identity to an IP address. Nodes use these IP addresses to send messages to each other.

Nodes can also generate confidential identities for individual transactions. The certificate chain linking a confidential identity to a node identity or real-world legal identity is only distributed on a need-to-know basis. Nodes can use confidential identities to protect themselves if an attacker gets access to an unencrypted transaction. The attackers cannot identify the participants without additional information.

Based on the above mechanisms, the technical governance was implemented in such a way that roles and permissions could be configured according to the network topology, independently of whether a participant has direct or indirect access to a block chain node. These roles are configurable on each member's nodes, according to their permissions.

[1] UTXO model is a design to register transactions. An UTXO is the technical term for the amount of digital currency that remains after a transaction.

Hybrid-cloud approach to provide flexibility & security

The experiment employed a different set of clouds which would have to interact with each other as well as with on-premise and edge environments.

This was facilitated by the IBM hybrid cloud architecture which enabled HSBC and IBM to build and run with consistency across cloud, on-premises and edge environments.

The various DL3S platforms were deployed using docker & containers to ensure a consistent user experience across multiple platforms.

The HSBC managed Google Cloud Platform was used to deploy the Digital Vault application. Virtual machines with customisable hardware, operating systems, network, firewalls, auto-scaling policies etc. allowed for maximum control over each and every resource.

The IBM hybrid cloud approach enabled a build once deploy anywhere approach which also facilitates interaction with multiple networks and platforms built on different technologies.

The various DL3S platforms were deployed in IBM Cloud in early phases and in BdF Cloud for the final tests.

The diagram below describes the four networks and participants at play during the experimentation with the different Virtual Machines (VMs) deployed in BdF and HSBC environments for the final tests (target architecture).

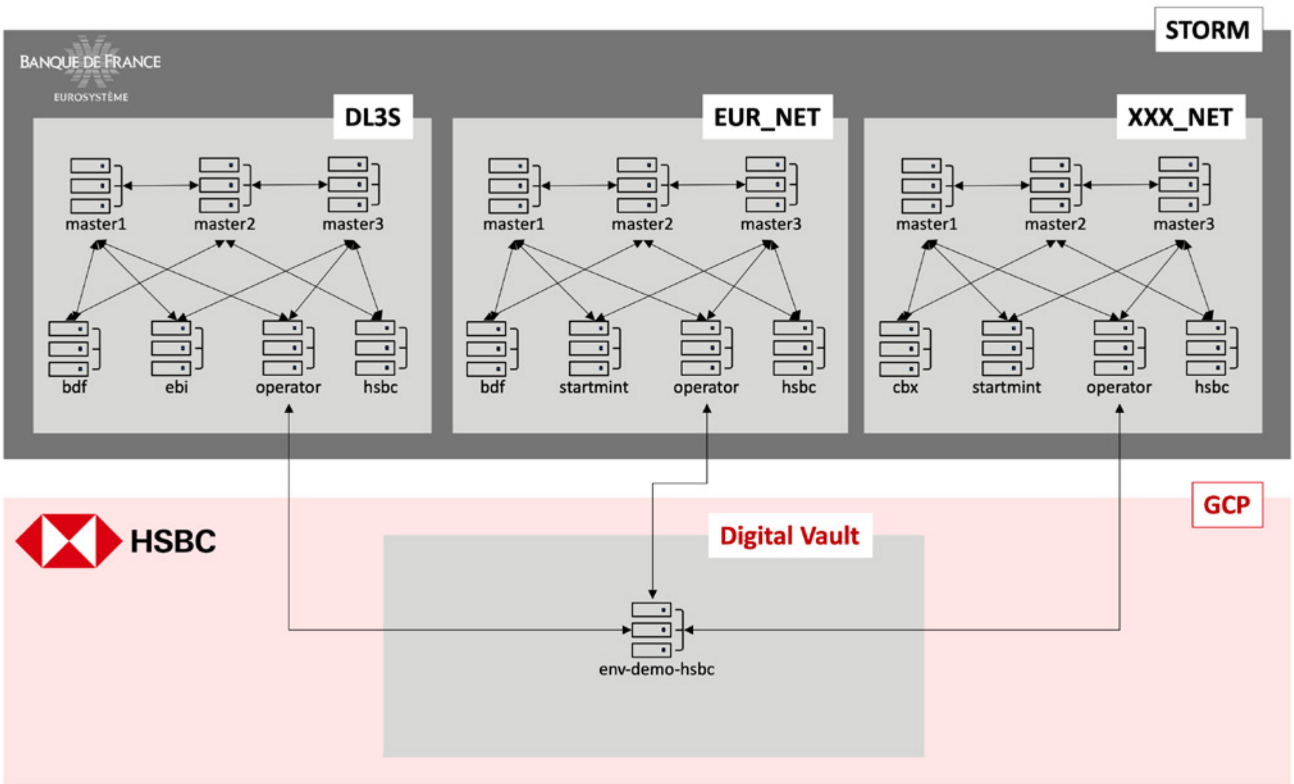


Figure 5: Network Overview

Interoperability

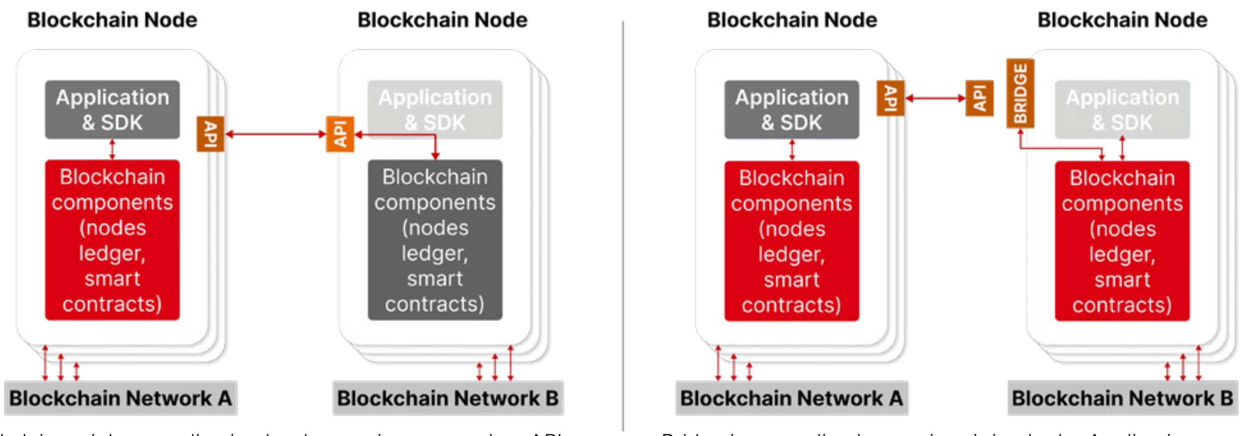
1 Definition

As illustrated below, inter-connectivity and inter-operability are two different notions. To better understand inter-operability, we first need to describe inter-connectivity.

On one hand, inter-connectivity, in a blockchain design, is the implementation and the definition of a set of APIs and APIs calls to ensure appropriate exchange of information and therefore atomicity in the settlement.

Those APIs are mainly located at application level in both networks.

We could also imagine a dedicated service "bridge" with its own API, sitting next at application level but not necessarily linked to it. It could be a way to separate application and bridge service but, in the end, there is no novelty in this approach.



Work is mainly at application level, exposing appropriate APIs and defining exchange format, sequence between APIs calls, etc. to ensure atomicity.

Bridge is an applicative service sitting in the Application or next to it.
No novelty in this approach.

Figure 6: Inter-connectivity design

On the other hand, inter-operability, in a Blockchain design, is the implementation of two (or more) "bridge" components based at protocol level. The bridge service is specific to each network, which are responsible for its integration. Using the bridge, one network can initiate a transaction that creates counterpart transaction in the other ledger at the blockchain level, using smart contracts directly.

This approach is preferred for cross-network transactions as it reduces the trust required in the other transacting party. You have the guarantee and proof that the instruction is created in the other network thanks to the smart contract. With this experimentation, we achieved inter-operability with the following design (fig. 7)

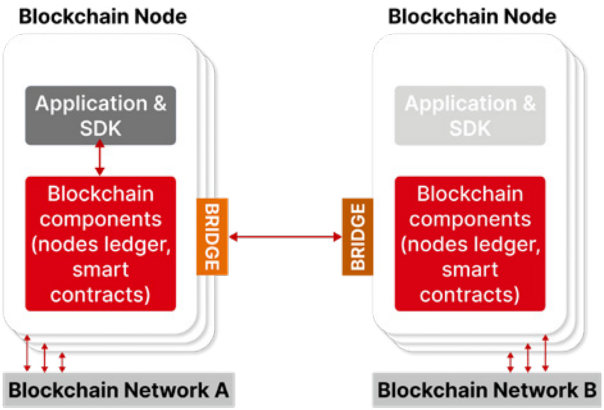


Figure 7: Inter-operability design

- Bridge is a specific component part of each network that is responsible for its implementation
- Using the bridge, one network can initiate a transaction that creates counterpart transaction in other ledger at the blockchain level - i.e. creating one Tx for a DvP leg using the other network smart contracts directly
- This approach is preferred for cross-network transactions as it reduces the trust required in the other transacting party
- Complexity of this approach is to have an implementation able to accomodate different blockchain protocols
- **IBM has an asset that would be reused for this experimentation (Relay Services / Weaver)**

When designing the bridge component, we defined numerous services it could manage such as the capabilities to:

- Manage mint and burn instructions of CBDC on the back of CeBM
- Handle payment and liquidity transfers
- Ensure trust between different services and networks (EUR CBDC, foreign CBDC, securities oriented-networks, etc.)
- Ensure confidentiality and anonymity for all parties
- Expose and share information between parties, ensuring non-reputability and freshness[2].

The main features of the bridge were:

- Ensure communication between DLT-Networks, channels, legacy systems and data providers
- Enablement of Data Transfer
- Ensure Asset Exchange with HTLC orchestration (cross network PvP, cross network DvP)
- Ensure Asset Transfer (cross networks payment)
- Proof analysis and claim checking
- Identity management and privacy management

Additional features were envisioned but not implemented such as: FX Provider, Remuneration Calculation, Limit Evaluation, Global Supervision, AML Features, Intraday Blocking, Liquidity Management.

At the beginning of the project, multiple approaches were described in order to plan for the optimal implementation based on complexity and business requirements (figure 8).

1 Centralised system

The first design was a centralised system, where a single bridge service would act as a service operated by a trusted 3rd party. This design ensures a simpler implementation but has a few limitations such as the requirement for a trusted 3rd party to maintain and operate the bridge, and the introduction of a SPOF (single point of failure) in the ecosystem.

2 Decentralised system

The second design, with moderate complexity, was a decentralised system where the bridge is a component of each network in the ecosystem. It is used as a gateway to the other networks. This implementation reduced the concern of a SPOF, it also enables each network to be responsible of its own integration of the bridge. In such scenario, the bridge would act as a gateway towards other networks and systems, storing minimal data. Data would be stored in the respective ledger of each network. For such an implementation to

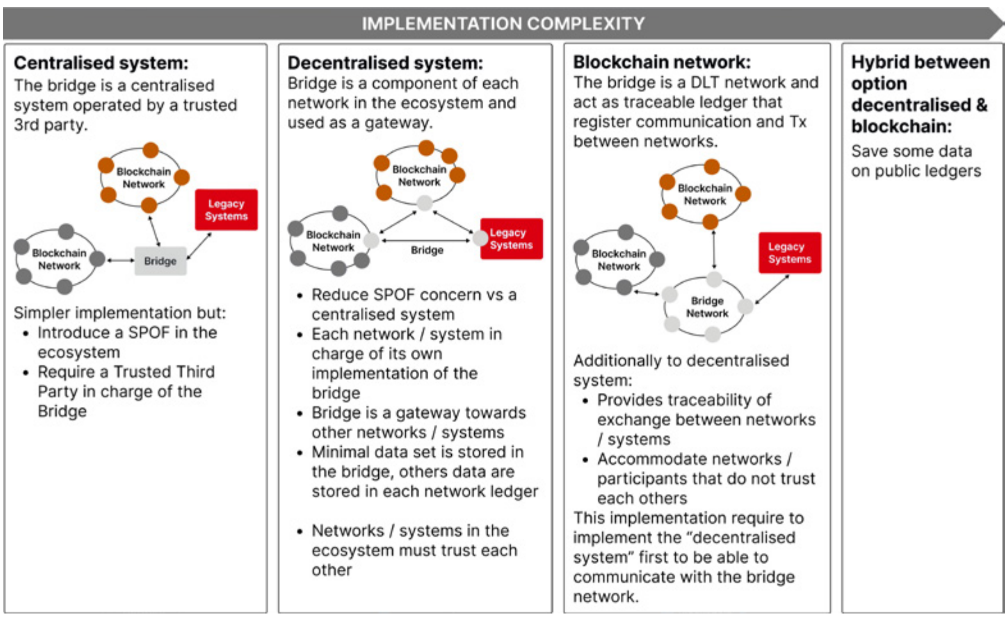


Figure 8: Possible implementation approach to bridge

[2] Information are shared with cryptographic proof that i) the sender cannot deny to have provided them and ii) they represent the current status of the network at time of require

be relevant, networks or systems in the ecosystem need to trust each other. This design was used for the experimentation.

3 Blockchain network

The third design is a complete blockchain network, where the bridge is a DLT network and acts as a traceable ledger that registers communication and transactions between networks. It builds on the advantages of the decentralised system and adds more to it, such as the traceability of exchanges between networks and systems, and leverages on networks or participants that do not trust each other. To design this blockchain network for the bridge, it first requires the decentralised implementation.

The second design option (decentralised bridge) was chosen for the experimentation. The bridge components have been implemented in DL3S network (managing CBDC and Bonds), EUR_NET (for EUR CBDC), XXX_NET (for XXX CBDC) and Digital Vault (Bonds) at a protocol level, achieving inter-operability. To accelerate the implementation, the Weaver Framework was used for this experiment.

Figure 9: Decentralised bridge implemented

2 Weaver framework

The Weaver framework[3] developed by Hyperledger Labs enables scalable interconnectivity between disparate distributed ledgers in a manner that preserves the core tenets of decentralisation and security. The framework's objectives are described as follow:

- Enabling the seamless flow of data and value across disparate blockchain networks in a manner that preserves their trust and security tenets.
- Aims to join up network, data, and value silos
- Increase market sizes, liquidity, and overall efficiency as separate DLT's can communicate, which in turn will have network effects
- Enable orchestration of complex business workflows across networks
- Enable and encourage the growth of networks
- Encourage further adoption of the technology

Bridges, or "relays" as they are called in the Weaver Framework, act as a gateway between different networks. They need to be implemented into each different network. They can be represented as follow:

Based on this model, the experimentation highlighted three different needs for interoperations:

- Data Transfer: The transfer of data from a source ledger to a consuming ledger. The data transfer can either be a result of a transaction in the source network, or an explicit request from a consuming network.
- Asset Exchange: The change of ownership of an asset in a source network and a corresponding change of ownership in another network. No actual value leaves the networks boundaries. Example: atomic cross-chain swap.

[3] For more information on the IBM Weaver framework please go to: https://www.ibm.com/blogs/blockchain/2021/07/making-permissioned-blockchains-interoperable-with-weaver/

- Asset Transfer: The movement of an asset from the source ledger to a consuming ledger. As an asset cannot be double spent, the transfer of an asset should result in the termination/locking of its use in the source ledger, and its creation into the target ledger. Mechanisms that support such capabilities are one-way and two-way pegs

Those three interoperations needed to be implemented in three different typologies of networks:

1. Fabric to Fabric, to achieve interoperability between DL3S and DPS_VB (EUR_NET) and XXX_NET. DPS_VB is a DL3S network designed to manage the cash flows.
2. Fabric to Corda, to achieve interoperability between DL3S and Digital Vault
3. Corda to Fabric to allow communication between Digital Vault and DL3S, as well as Digital Vault and DPS_VB

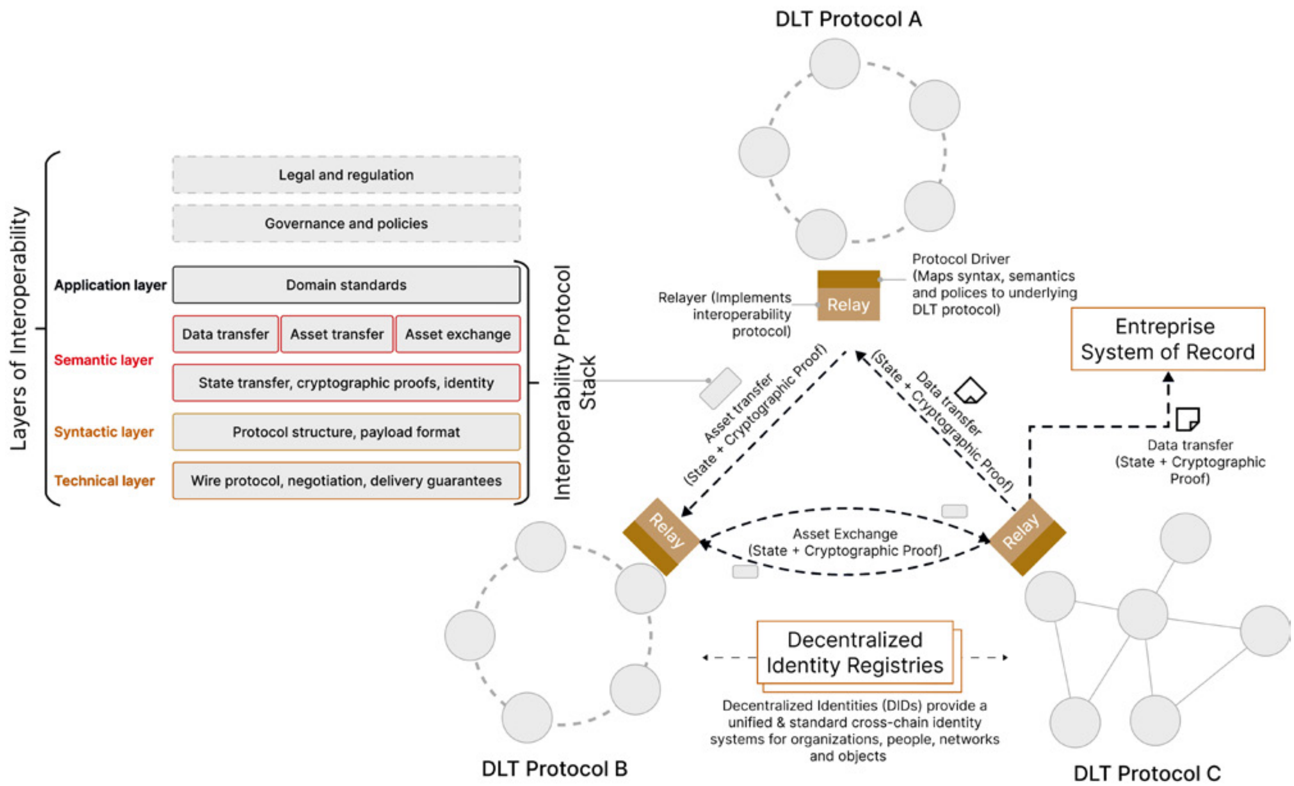


Figure 10: Weaver Framework Overview

During the experiment, we leveraged many different inter-operability capabilities of the Weaver Framework, including:

1. Data Transfer, to transfer information between different networks without the need of a 3rd party or without trust between the networks. This mechanism was used to gather ISIN information, wallet balances, instructions settlement etc. from one network to another
2. Asset Transfer, to transfer ownership over an asset between two networks, locking the asset in the first network and recreating it over in the consuming network. This was used to transfer CBDC from one network to another
3. Asset Exchange, where the ownership over a bond or an amount of CBDC tokens is transferred from one participant to another in an atomic fashion. This was used to settle DvP and PvP operations.

4. Experimentation results

Atomicity through interoperability

The experiment demonstrated genuine benefits brought by interoperability at multiple levels. As explained previously, interoperability was applied across different DLTs, allowing:

- Data transfer: strengthens the exchange of information by creating a unique / golden source for asset characteristics for example, avoiding errors in the transcription of the features of a security arising from manual processes, notably around the corporate actions processes
- Asset transfer: the ability to move assets across different DLTs
- Asset exchange: through an FX transaction and the related PvP, the exchange between 2 different CBDCs and the cash flows connected to that underlying transaction.

Most importantly, atomicity was achieved thanks to this interoperability, for the primary and secondary market DVPs and with a cascade of events happening simultaneously across 4 different platforms for the corporate action, with the following chronology of events:

a. Coupon payment to the custodian
b. Computation of amount to be paid to clients in EUR CBDC
c. Getting the FX rate upon payment to clients with a standing instruction
d. FX conversion
e. Related cash flows across networks.

FX perspectives

The atomic settlement and atomicity achieved in the payment of the coupon in this experimentation could fix many of the existing pain points associated with custody FX execution.

As a matter of fact, custodians and their clients could agree upon a source for the FX rate and the spread to be applied for the FX conversion service.

The time to market issue would be removed as the FX would be executed concomitantly with the underlying securities events:

- Buy / sell of the securities
- Subscriptions / redemptions in funds
- Corporate actions : coupon and dividend payments

Control framework

The experiment allowed Banque de France to test control features for the distribution and usage of EUR CBDC. As such, only T2 participants could instruct transfers of CBDC across chains or within a given chain where they manage wallets.

Clients can have a view on their balances but could not instruct such transfers without appropriate permissions.

5. Conclusions

The experiment was successfully completed in just four months and demonstrated several business advantages of CBDC:

- The use of a CBDC to enable cross border transactions of a DvP and PvP nature
- CBDCs can be integrated with technology platforms to facilitate the lifecycle of digital assets and currencies, in both wholesale and retail markets
- Banque de France monitored and controlled each transaction, which flowed correctly through the network of systems, automatically triggering the required events, whilst retaining visibility and control over the CBDC in circulation.

From a technology perspective it proved that DLT technology is able to accommodate requirements such as privacy, confidentiality, security and atomicity of CBDC transactions. Moreover, the programmability of complex transactions (e.g. coupon payment in a different currency) using smart contracts allowed to settle PvP in seconds across networks.

Interoperability between different blockchain networks was successfully demonstrated with several type of transactions (data transfer, asset transfer and asset exchange based on HTLC) and paves the way to a more decentralised future, with many blockchain networks relying on different technologies needing to atomically exchange data and assets.

From a business perspective this experimentation showcased that a central bank through CBDC can have full control and visibility of its currency in circulation, even when being used across multiple digital networks.

It also opens new opportunities to address one of the painpoints in custody FX which is the time to market between an event requiring an FX conversion and its actual execution. The atomic execution of the FX once the coupon was paid allowed to neutralise the FX exposure which would normally occur in the existing custody FX process. It could apply to FX related to purchases and sales of assets, subscriptions and redemptions in funds, also addressing the need for regular FX hedging adjustments on the asset side of the funds, or on the hedged share classes.

The experimentation encompassed the integration of tokenised DLT networks with existing technologies and market infrastructures that will remain in place for the foreseeable future.

Aside from the business and technology objectives having been met in full, this experimentation showcased partnership and collaboration between a central bank, a commercial bank, and technology providers in a challenging timeframe.

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