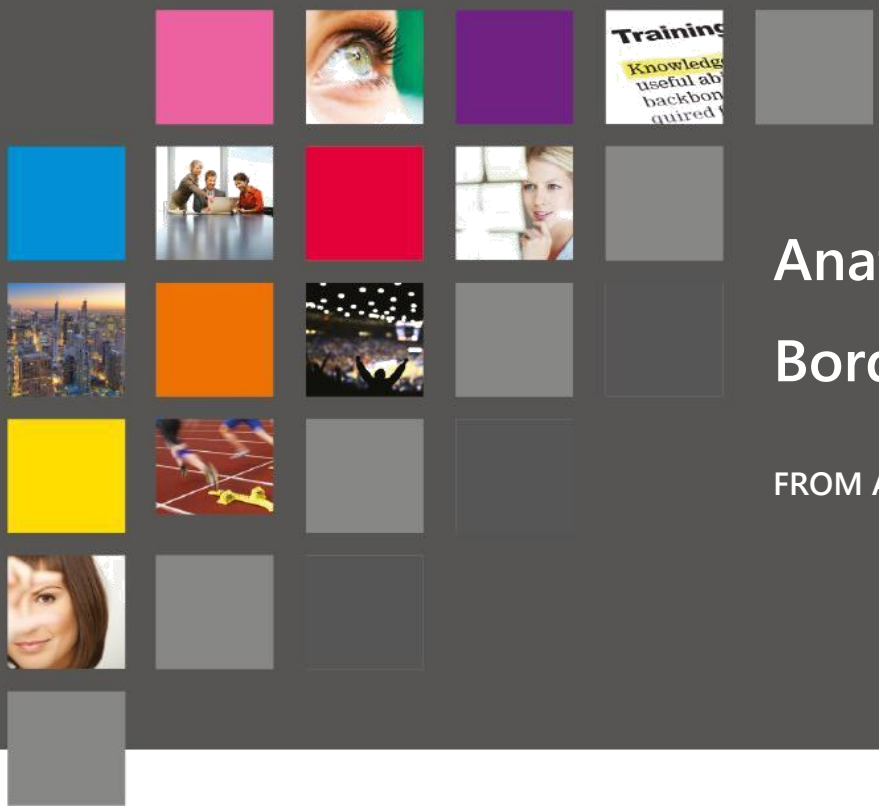


Anatomy of CBDC Cross Border Payment

FROM A TECHNICAL PERSPECTIVE

A CLPS Incorporation TECHNICAL WHITEPAPER

What is CBDC?

Central bank digital currencies (CBDCs) are digital tokens issued by central banks. In a sense, they are the digital version of cash; their value is guaranteed by a central bank and they can be used by households and businesses to make payments. The key difference with reserves (which have been electronic and issued by central banks for decades) is that CBDCs are universally accepted by all households. In contrast to banknotes, they are completed digital.

Compare CBDC to cash and others:

Source: International Monetary Fund (IMF)

- *Central bank-issued*
- *Legal tender*
- *Backed by central bank*
- *Fiat-pegged*
- *Allows for peer-to-peer transfers*
- *Can be programmed*

CBDC: The Holy Grail of Cross-Border Payments

Cross-border payments are transactions in which the payer and the payee (as well as their financial institutions) are located in different jurisdictions. Due to the involvement of different national legal and regulatory frameworks, multiple currencies, different time zones and often numerous intermediaries and financial market infrastructures, they are more complex than domestic payments.

Today, cross-border payments are expensive (compared to domestic payments), can take several days and lack transparency, both in terms of costs and delivery times. This is mainly due to the complexity of the cross-border payment and settlement process, which includes the involvement of multiple entities in the execution of a cross-border transaction, the level of regulation - for example, anti-money laundering (AML), counter-terrorist financing (CTF) and know-your-customer (KYC) requirements - as well as capital requirements, differences in technical and operational standards across jurisdictions, and the prevalence of legacy systems and infrastructure.

On the retail side, international remittances pose a number of well-known problems, some of which could be addressed by appropriate CBDC solutions. Firstly, charges for international remittances are generally high. Second, in some circumstances, senders may be

unable to guarantee that all funds reach the intended recipient. Finally, international remittances are often hampered by a lack of interoperability between the payment systems of different countries.

On the wholesale side, the correspondent banking network, which can be costly and slow, especially in the case of long correspondent banking chains, mitigates these inefficiencies resulting from the lack of interoperability of payment systems. Many obstacles to cross-border payments stem from differences in national legislation. These include differences in the implementation of anti-money laundering rules, rules on finality of payments, criteria for participation in payment systems with central bank settlement and conflict-of-law rules.

Many central banks are looking to the CBDC to streamline and improve the performance of cross-border payments, making them available 24/7, even outside closed solutions or under the control of remittance providers that monitor the end-to-end payment chain. The potential exists to simplify intermediary chains, increase transaction speed and reduce costs by issuing and using a CBDC for cross-border payments.

There is a strong case to be made that CBDCs can address cross-border payment difficulties. Central banks, in partnership with commercial banks and technology companies, are in a unique position to drive this innovation and thereby create significant value for the real economy.

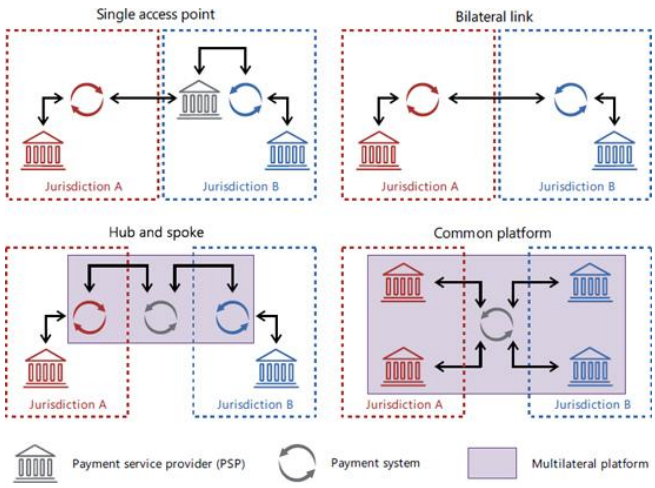
CBDC System Interoperability Solutions

Interoperability reduces reliance on intermediaries and simplifies the process of transferring funds across different CBDC systems. Multilateral platforms are payment systems primarily used for cross-border transactions, although they can also be used for domestic payments. Their multi-jurisdictional nature is the main feature that distinguishes them from other payment systems. They provide a faster and more efficient way for businesses in different jurisdictions to make cross-border payments to their customers, suppliers or entities in other countries, alongside traditional correspondent banking relationships or domestic

payment infrastructures. Multilateral platforms are typically grouped into four stylized models (IMF):

1. ***Single Access Point Model:*** In this model participants in one domestic payment system gain access to a foreign system

   through a single entity that directly engages with the foreign system.
2. ***Bilateral Link Model:*** In the bilateral link model, participants in the domestic system can directly reach all participants in the foreign system via the link instead of only through the single gateway entity.
3. ***Hub and Spoke Model:*** Within the hub and spoke model, bilateral links between two or more payment systems (the spokes) are replaced by links to a common intermediary (the hub).
4. ***Common Platform Model:*** In the common platform model, participants can reach each other directly across borders on a single, integrated technical platform.



Source: IMF

Options for access to CBDCs

Source: Bank for International Settlements (BIS)

Closed access – domestic PSPs/ residents only: only domestic institutions can access, hold and use the CBDC
Direct/Indirect access – foreign PSPs/ non-residents can directly hold and transact in CBDC issued by a central bank without/with an intermediary participant.

Any multilateral scheme will need to coordinate between many public and private sector stakeholders in different countries to agree how to design, manage, operate and monitor the scheme. The Hub/Spoke platform can use the existing relationships between the Spoke and its participating PSP for domestic transactions, while the parties can focus on cross-border transactions through the Hub.

On the other hand, almost every aspect of the platform's activities would have to be agreed by the stakeholders for a new common platform. A common platform is typically built on a single technical

infrastructure, whereas hub-and-spoke systems may be based on completely different technical platforms. In addition, compared to a hub-and-spoke approach, a common platform may offer more consistency to participants.

Choice of currency arrangement

Source: IMF
The multilateral platform should be a single currency, multicurrency or cross-currency platform:
Single currency platform – single currency platform, which can be a common currency of a currency union between the connected jurisdictions
Multicurrency platform – transactions are processed in multiple currencies using account structures that are segregated by currency. Currency conversion happens outside the platform.
Cross-currency platform – the conversion from one currency to another takes place on the platform, allowing one connected PSP to be debited in one currency and another connected PSP to be credited in the other currency.

Technical Platform Selections

It is widely believed that CBDCs could also be implemented using blockchain or DLT, as many privately issued digital currencies such as Libra (now

known as Diem) or Bitcoin use blockchain or distributed ledger technology (DLT) to ensure the immutability of transactions. Given the unique requirements of CBDCs, consortium chains or private chains are evaluated as the core of technology selection.

Alternative platforms should have the following basic capabilities:

1. Support for smart contracts;
2. Built-in support for permission and privacy within the DLT platform;
3. Support for consensus with finality properties;
4. Well-established recognition in financial industry.

Enterprise blockchains like Hyperledger Fabric, Corda, and Quorum have demonstrated their strengths and have been selected by various CBDC pilot programs.

Hyperledger Fabric, an open-source blockchain infrastructure managed by the Linux Foundation, provides support for a multichannel global broadcast infrastructure. Hyperledger Fabric is a

modular blockchain framework that allows the creation of blockchain-based products, services, and applications tailored for use by private businesses with the help of plug-and-play components.

R3 Corda Distributed Ledger Technology platform uses a point-to-point data broadcast system. Corda enterprise is an open-source enterprise-based blockchain developed to facilitate interoperability. It serves as a system for managing, synchronizing, recording agreements, and transferring assets.

Quorum is an open-source enterprise-focused Ethereum blockchain protocol explicitly created for use in private blockchain networks. A single member owns all the nodes or consortium blockchain networks in which multiple members hold a part of the network. Quorum's layer is designed to establish the permissioned structure and privacy protections required for enterprise use, primarily in the financial industry.

Multilateral Platforms in Detail

Hub and Spoke

The hub-and-spoke solution is simpler than other single common platform models. In this model, each CBDC system only needs to integrate with one external system (the hub), rather than integrating with each individual CBDC system. The advantage of this model is that it can scale to support many participating systems without increasing the complexity of the design, given the total number of inter-CBDC system connections that will need to be configured as the network expands. With n CBDC systems, n links are sufficient in the hub-and-spoke model, whereas solutions without a central hub require at least n(n-1)/2 such links. The most popular hub implementation today uses the Hash Time Length Contract (HTLC) protocol.

HTLCs initially emerged as an alternative to centralized exchanges because they allow cross-chain atomic operations. HTLCs techniques use hashlocks and timelocks to enforce the atomicity of operations, typically between two parties. In this

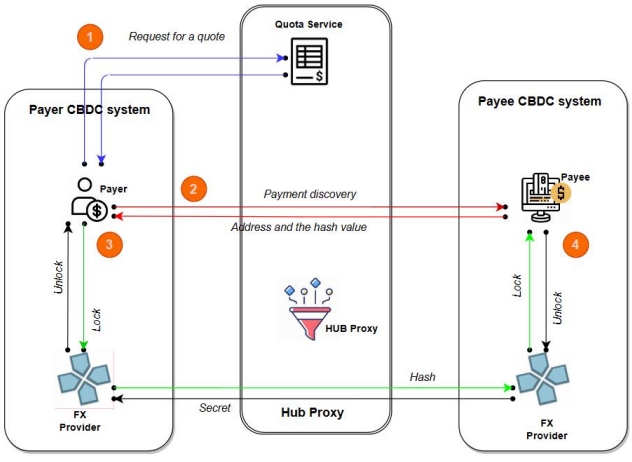
process, a trader commits to complete the transaction by providing a cryptographic proof to the other party before a predefined timeout. Different projects

implement HTLCs differently, providing different guarantees of correctness. However, the general algorithm is quite similar in most solutions.

A cross-border payment is divided into two parts Domestic payments. The originator makes the payment to the FX provider in the currency of the originator (the currency within the originator CBDC system), while the FX provider makes the payment to the beneficiary in the currency of the beneficiary (the currency within the beneficiary CBDC system). Importantly, no CBDC leaves its respective jurisdiction. This means that the beneficiary must provide the foreign exchange company with the necessary information to claim the funds from the sender.

There are four steps in this whole payment process:

1. The payer initiates a request for a quote and selects the best quote, including the identity of the chosen FX provider.
2. The payer requests the payer wallet via the hub and obtains the payee's address and the hash value. Additionally, the payee generates a secret derived from this hash value).



3. The payer creates a locked (domestic) payment to the payer's FX provider, and the payer's FX provider transmits the payment information and the hash value to the payee's FX provider via the hub. Subsequently, the payee's FX provider generates a locked (domestic) payment in the payee's currency to the payee.
4. The payee verifies that the secret matches the hash value used to lock the payment. Once the match is confirmed, the funds are released to the payee. Subsequently, the payee's FX provider sends the secret, via the hub, to payer's FX provider, which then uses it to unlock the incoming payment from the payer.

The Hub maintains a database of FX rates uploaded by FX providers. Within the multilateral framework, direct quotes may be unavailable or uncompetitive for certain currency pairs. In such cases, the hub will use an alternative currency to fulfil the FX requirement. For instance, if a foreign exchange provider does not offer a service for the currency pair A / B, but does offer a service for A / C and C / B, the hub fills the gap and creates an alternative payment channel using C as an intermediate currency. By ensuring that the FX rate quoted to the payer is the cheapest payment route between the payer and payee countries, the hub calculates the most favorable effective rate.

The hub-and-spoke solution implies that a hub could become a single point of failure. This implies specific requirements for disaster recovery and business continuity. These include the provision of a secondary site, redundancy in power and communications, contingency plans and back-up procedures.

FX service providers are private profit-maximizing entities that hold liquidity in the currencies they deal in. In the event of insufficient liquidity in one or more currencies, certain payments may be delayed or not executed.

Pilot Projects

Features	
Project name	***Icebreaker/Jasper-Ubin***

CBDC Type	***rCBDC/wCBDC***
Currency arrangement	***Multicurrency***
Access for CBDC	***For FX: Direct*** ***For Resident: Close***
Platform	

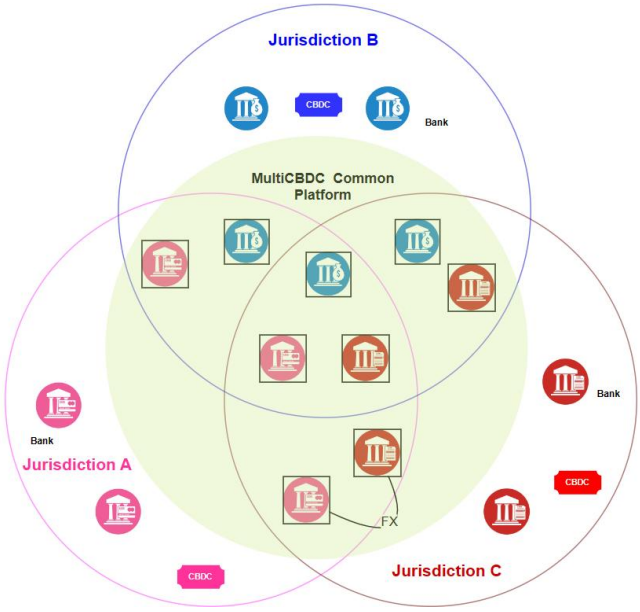
Common Platform

CBDCs using a single shared technical infrastructure, possibly coupled with a common rulebook, are referred to as a common platform model. While the platform rulebook is common to all participants, the rulebook for each CBDC may still vary from jurisdiction to jurisdiction. These differences could relate to aspects such as holding and transaction limits, requirements for participation, and the issuance and redemption of CBDCs. As a result, this model is not an interconnection of different CBDC systems, but rather the creation of a common platform for interoperability between CBDCs (BIS).

This allows participating commercial banks to have direct access to foreign currencies without having to maintain accounts with correspondent banks. Since all participating banks could potentially hold the different CBDCs directly, participating banks will be able to transact directly with each other in the participating currencies.

The common platform is designed to eliminate the need for foreign currency accounts with correspondent banks by allowing participating banks to transact directly with each other using different CBDCs. Instead, CBDCs can be transferred directly from the sending bank to the receiving bank.

Although all participants may hold CBDCs, central banks are likely to issue CBDCs only to banks licensed in their jurisdiction. The issuance of CBDCs is conditional on central banks providing an appropriate amount of collateral through national payment systems. In the context of foreign exchange transactions, non-resident banks may acquire and hold CBDCs by purchasing them from other banks.



There are three key building blocks to facilitate the process within the common multiple CBDCs platform:

1. Mint and Redemption Functionality
2. Liquidity Provisioning and Market Making
3. FX Trade Settlement (PVP and Netting)

A shared platform implies a level of universality, with features and capabilities that are common and available to all participants. Platform rules and policies are applied universally and fairly across all participants.

While the common platform challenges the traditional correspondent banking system, it also presents opportunities for the banks and FX /liquidity providers to enhance their capabilities and welcomes new third-party service providers, such as liquidity providers and automated market makers (AMMs).

The provision of liquidity in the currency of origin or destination remains a key component in facilitating cross-currency transactions. Participants could consider two options: (i) relying on conventional, centralized

liquidity provision by traditional commercial banks/foreign exchange
providers, or (ii) exploring newer models of liquidity provision involving decentralized smart contracts.

The first option is in line with current traditional bank/foreign exchange business models, while the second option offers advantages in speed and transparency by integrating the foreign exchange pricing and settlement processes into smart contracts on the common platform. Therefore, until a full transition to decentralization takes place, the common platform should be able to support both the traditional liquidity provision model and the decentralized smart contract model.

Pilot Projects

Features	
Project name	***Dunbar***
CBDC Type	***wCBDC***
Currency arrangement	***Multicurrency***
Access for CBDC	***Direct***
Platform	***Corda/Quorum***

XC's Architecture

In early November 2022, the IMF published a working paper on a multi-currency exchange and contracting platform (known as XC) that the authors said could reduce the cost of FX transactions. One of the key features of the XC platform is the use of tokenized assets, including deposits and potentially CBDCs. This revolutionary approach to conducting financial transactions promises to make doing business globally more seamless and efficient. Through the tokenization of assets, the XC platform removes traditional barriers and offers increased liquidity, enhanced security and improved speed of transaction.

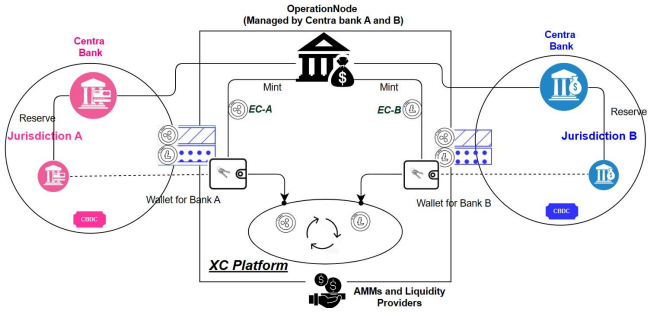
XC operates on a "centralized" model that incorporates multiple currencies. Participants from different jurisdictions within the platform have accounts in the multilateral platform. As such, XC does not require modifications to domestic systems.

There are three key technological features in XC, each serving different roles in various use cases:

1. A common and unique ledger with participants' accounts
2. Programmability
3. Encryption techniques.

XC's first key technological feature is the unique state of the common ledger. This ensures that all participants interact with the same dataset, determining who has ownership of what.

The design of the platform involves the issuance by the central bank of an end-of-day asset, the so-called CEs, for each participating country. These CEs are safe and homogeneous, with no intermediary risk, as they are issued on a one-to-one basis against central bank reserves. There are no interoperability issues as CEs are native to the platform and are only issued and exchanged
within the platform. Settlement takes place through the transfer of value on the platform's ledger by moving CEs between agents' accounts. This promotes competition in market making for each currency pair, as all participants from participating countries can hold both domestic and foreign CEs in any of their platform accounts. A notable feature is that CEs will always be convertible at par value for central bank-regulated entities authorized to hold reserves.



This diagram illustrates how participants' accounts are funded with reserves. A bank in jurisdiction A (PSPA) funds its account using reserves in the form of CBDCs or physical fiat from jurisdiction A. In the same way, a commercial bank in jurisdiction B (BankB) performs the equivalent operation to fund the account of jurisdiction B (CE-B). PSPA and BankB exchange their CEs at an agreed foreign exchange rate. In principle, this transaction could be executed by relying on a quote from a third party (the 'Oracle'), through a bilateral agreement, as is typical in the OTC market, or through a AMM offered by liquid vendors. The final results are (-CE-A, +CE-B/FX) in PSPA's wallet and (-CE-B, +CE-A/FX) in BankB's wallet.

XC platforms also adhere to common rules, governance and standards, and use technology to reduce risks and exchange costs (see CPMI-IMF-WB 20222). Taken together, these elements can be holistically referred to as part of the "infrastructure", as they involve the provision of public goods from which all participants benefit. Since the procedures are clearly specified, must be followed and are enforceable, this common infrastructure also contributes to greater transparency in cross-border payments.

Pilot Projects

Features	
Project name	***Inthanon-LionRock***
CBDC Type	***wCBDC***
Currency arrangement	***Multicurrency***
Access for CBDC	***Close***
Platform	***Corda/Quorum***

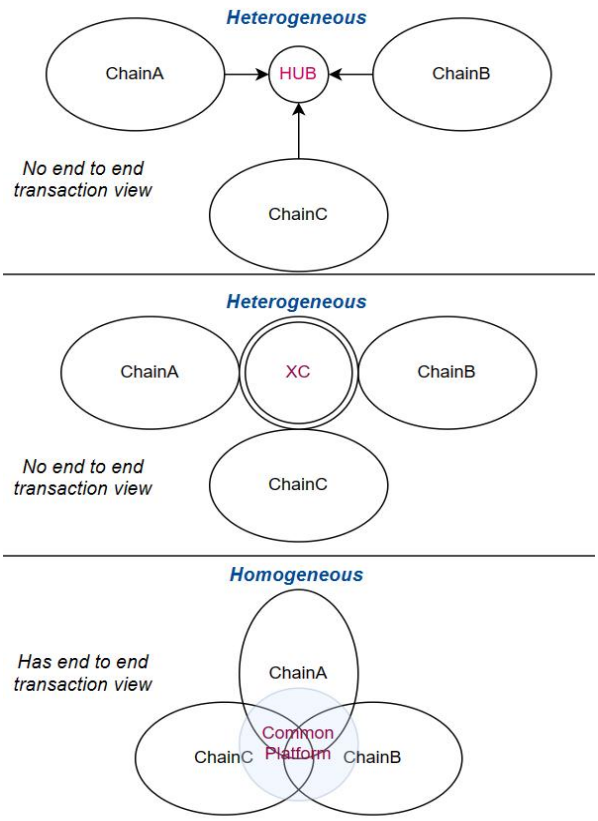
Technical Discussion

The technical implementations of CBDC cross-border interoperability that we have discussed so far are based on the three major platforms (HyperLedger, Corda and Quorum). Now, let us approach this from a more generalized perspective.

A technical report from the National Institute of Standards and Technology (NIST) defines blockchain interoperability as "a composition of distinguishable blockchain systems, each representing a unique distributed data ledger, where atomic transaction execution may span multiple heterogeneous blockchain systems, and where data recorded in one blockchain are reachable, verifiable, and referable by another possibly foreign transaction in a semantically compatible manner". In reality, there are two main categories:

1. A transaction between different chains, belonging to the same blockchain system (homogeneous blockchains).
2. A cross-blockchain transaction, which is a transaction between different blockchains (heterogeneous blockchains).

The previously discussed common platform would support category 1, while Hub and XC would support both.



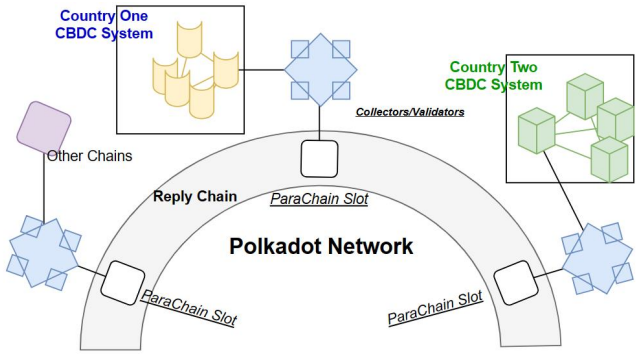
Through state transition validation performed by chain relay validators, Polkadot facilitates interoperability. The parachains communicate using the Cross-Chain Message Passing (XCMP) protocol, which is a queueing communication mechanism based on a Merkle tree. The transfer of proofs of state transitions from the parachain to the relay chain is achieved by means of an erasure coding scheme. Polkadot's scalability includes connecting up to 100 parachains directly to the relay chain in the short to medium term, with a long-term solution under investigation to add second and third level parachains in parallel.

Mao▼ introduces a CBDC cross-border payment model based on consortium blockchain ctechnology, referencing Polkadot's parachain, relay chain, and cross-chain technologies. This model envisions a scalable, high-efficiency, high-security, and privacy-protecting CBDC cross-border payment system.

In this model, each country acts as a parachain, and each parachain acts as a consortium blockchain. The consortium blockchain is a permissioned blockchain, which means that internally only a specific set of designated nodes are allowed to upload, record and read data. These nodes act as bookkeepers and collectively make decisions to create blocks. Using a consortium blockchain can significantly improve the operational efficiency of the blockchain and reduce network latency, while also ensuring the privacy of each transaction's data. Thus, the implementation of a national blockchain in the form of a consortium blockchain can meet the dual goals of improving efficiency and protecting privacy.

▼*Mao Hanyu : Central Bank Digital Currency Cross-Border Payment Model Based on Blockchain Technology, Conference paper, Open Access First Online: 25 July 2023, IFFMFT 2021: Proceedings of the Second International Forum on Financial Mathematics and Financial Technology*

Polkadot-based solution aligns with the trend of future-oriented BOB and solves the homogeneous chain issue associated with the common platform at a certain level. However, the specific implementation requires further testing and analysis.



As CBDCs emerge as a major disruptor to the existing infrastructure, interoperability remains one of the key barriers to their functionality. Although most financial institutions have been cautious about cryptocurrency, the likes of Visa, MasterCard and PayPal have not only embraced the concept of cryptocurrency and CBDC, but have continued to innovate on both fronts. In the future, they could carve out a new niche for themselves - as the interoperability layer for the emerging CBDC world.

Mastercard has launched its CBDC partner program to encourage collaboration on blockchain-based money. Initial partners include Ripple, ConsenSys, Fluency,

Idemia, Consult Hyperion, Giesecke+Devrient and Fireblocks. Mastercard aims to be the Cosmos or Polkadot of CBDCs. We will continue to pay attention to the development and trends in this field.

Conclusion

As the cross-border payment technology of the CBDCs continues to evolve and the technology of the entire chain matures, we can expect to see a regional polycentric pattern emerge in the future. This represents a new economic development model in which "different currencies within the same system" is used within a region, and "different currencies within different systems" is used between regions in the future. Today, CBDC cross-border payments have attracted international research attention. However, the security and scalability of the chain have yet to be fully established, although some countries are experimenting with CBDC cross-border payments.

Further research can focus on the following two levels:

1. At the technical level: Research into more secure and efficient cross-chain technology is a focal point for future investigations. CBDC cross-border payments are particularly dependent I on cross-chain technology, making it a critical area of research. At the same time, exploring new consensus algorithms applicable to blockchain cross-chain operations can significantly improve the efficiency of CBDC cross-border payments.

2. At the legal regulatory level: Strengthening supervision of CBDC cross-border payment is essential. It is not only important to identify the regulatory body responsible for overseeing CBDC cross-border payments but also imperative to improve the legal framework surrounding CBDC cross-border payment.

About CLPS Incorporation

CLPS Incorporation is a NASDAQ-listed company (Nasdaq: CLPS) and a global information technology, consulting and solutions service provider focused on delivering services to global institutions in banking, insurance and the financial sectors, both in China and globally. For more than fifteen years as an IT, business know-how and talent solutions provider for such clients, CLPS has expanded its service network to clients in the global financial industry, including large financial institutions from the US, Europe, Australia and Hong Kong and their PRC-based IT centers. CLPS has created and developed a particular market niche by providing turn-key financial solutions as well as supplying its clients' needs for talent creation and development. We maintain 19 delivery and R&D centers, of which ten are located in China and nine globally, to serve different customers in various geographic locations. By combining onsite and onshore support and consulting with scalable and high-efficiency offsite and offshore services and processing, we are able to meet client demands in a cost-effective manner while retaining significant operational flexibility.