The University of Hong Kong

FITE4801 Final Year Project

CBDC Interoperability Analysis Under Finternet Framework

Detailed Project Plan

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1 Introduction

Motivated by the recent publication of the Bank for International Settlements regarding the conceptual framework of Finternet, this project aims to explore the technical architecture underlying Finternet. In particular, this paper focuses on the “Unified Ledger” technology of Finternet, which involves analyzing the interoperability between Central Bank Digital Currencies (CBDCs).

1.1 Project Overview

Central Bank Digital Currencies (CBDCs) have emerged as a focal point for central banks worldwide, driven by the potential to revolutionize the financial landscape. As over 100 central banks representing 95% of global financial output explore CBDCs, these digital currencies promise safe, efficient, and cost-effective cross-border payments.

Introduced by the Bank for International Settlements (BIS) in April 2024, the Finternet concept envisions an interconnected network of financial systems, prioritizing seamless global finance interoperability. Under such context, CBDCs which offer programmability, instant settlement, and enhanced traceability must be a crucial part to achieve a Finternet ecosystem and even serve as the foundational layer for a new era.

However, cross-border interoperability of CBDCs remains a critical challenge. Currently, many CBDC systems lack compatibility, impeding the realization of the Finternet's full potential and the benefits of a truly globalized digital financial system. Additionally, there is a notable absence of analysis regarding CBDC interoperability within the context of the Finternet.

This project aims to bridge the knowledge gap between conceptual discussions and the technical implementation of CBDCs within the Finternet ecosystem. By conducting a comprehensive study, we will explore various interoperability models and their practical applications

1.2 Project Objective

Our project aimed to analyze and evaluate Central Bank Digital Currency (CBDC) interoperability models within the Finternet framework, identifying the most promising approach for practical implementation, and demonstrating its feasibility through a proof-of-concept.

By providing both in-depth research and hands-on demonstration, this project hopes to contribute valuable insights to the development of the Finternet ecosystem, potentially paving the way for future directions in cross-border financial transactions and accelerating the adoption of more efficient, interconnected financial systems.

1.3 Project Key Concepts Explanation

1.3.1 Finternet

Finternet is a new concept first introduced by BIS in April 2024. It envisions an interconnected financial ecosystem, similar to the internet [1]. This is also how the name is derived. Finternet aims to address the shortcomings of the current financial system, including low speed, high cost and lack of availability, through leveraging tokenization and unified ledgers technology. In Finternet, all assets could be tokenized and recorded in the unified ledgers. When a transaction happens, instead of going through multiple time-consuming intermediate steps, synchronous movement of tokens would be triggered automatically through programed applications. Thus, assets transfer can happen instantly regardless of its nature and dominate currency.

To achieve such a system, BIS proposed eight design principles of Finternet:

- Users at the center
- Interoperability
- Evolvability
- Modularity
- Scalability
- Division of labour
- Inclusiveness and accessibility
- Security and privacy

We will elaborate these principles in detail in the later section since they serve as the key evaluation criteria for our analysis.

1.3.2 Blockchain

Blockchain is a decentralized public ledger that securely records transactions, making them nearly impossible to alter. Initially developed for cryptocurrencies like Bitcoin, the technology allows for transparent and direct exchanges of value—such as money, property, contracts, and identity—without intermediaries like banks or governments [2].

Key characteristics of blockchain include:

- Decentralization: Unlike centralized databases, blockchain is maintained by a distributed network of computers, enhancing security and preventing manipulation.
- Transparency: All participants in the network can access transaction records, fostering trust.
- Immutability: Once a transaction is verified, it is permanently linked in a chain, preventing any alterations to the history.

One of the most popular blockchain technology is Bitcoin which hosts a digital ledger. However, nowadays, beyond cryptocurrencies, blockchain has potential applications in various fields, including cybersecurity, supply chain management, governance, and financial services, indicating its transformative impact on how transactions and data are managed [3].

1.3.3 CBDCs

Central Bank Digital Currencies (CBDCs) represent a significant innovation in the financial sector, building upon blockchain technology to revolutionize payment systems for both businesses and individuals. CBDCs are digital versions of a nation's fiat currency, issued and regulated by the central bank. Unlike decentralized cryptocurrencies such as Bitcoin or Ethereum, CBDCs are recognized as legal tenders and operate under central bank oversight [4].

The primary goal of CBDCs is to merge the advantages of digital transactions, such as speed and efficiency, with the stability and trust associated with traditional government-backed currencies. Technologically, CBDCs utilize blockchain or similar distributed ledger technologies to enhance security, transparency, and efficiency in financial transactions, while maintaining centralized control by monetary authorities [5].

Key features of CBDCs include [6]:

- Digital Transactions: CBDCs enable instant and secure transactions, reducing the need for intermediaries.
- Decentralization: While controlled by central banks, the underlying blockchain infrastructure can provide a decentralized framework for recording and verifying transactions.
- Enhanced Security: Blockchain’s immutable ledger makes it difficult to alter transaction records, increasing trust in the system.
- Financial Inclusion: CBDCs can provide access to banking services for unbanked populations by enabling digital wallets and transactions via mobile devices.

1.3.4 Blockchain Interoperability and Proposed Models for CBDCs Interoperability

To realize the vision of Finternet, blockchain interoperability is essential. Blockchain interoperability refers to the ability for different blockchain networks to interact and exchange data with each other [7]. This is a key research area in blockchain given that most existing blockchain solutions work in silos. Currently, different blockchains cannot effectively cooperate with each other to achieve a common goal, and thus, greatly hinder the growth and the development of the blockchain technology.

Revisiting the topic of CBDCs, there are currently five CBDC interoperability models proposed by BIS [8].

- The compatible model – refers to the adoption common standards for each individual CBDC system without direct linkage
- The interlinked model with a single access point – refers to the scenario in which one CBDC system have access to another CBDC system through a single gateway
- The interlinked model with a bilateral link – refers to the scenario in which there are direct linkage between two CBDC systems
- The interlinked model with a hub and spoke solution – refers to the scenario in which a common hub is used to connect to multiple CBDC systems
- The single system model – refers to CBDCs that use a single common technical infrastructure

We would evaluate these models later in the paper according to the Finternet framework.

1.4 Project Scope

As elaborated in previous sections, Unified Ledger and Tokenization are key technologies that underpin the architecture of Finternet. Through literature reviews on these two topics, we identified that the Tokenization technology envisioned by BIS exerts strong similarity with the current research trends in tokenization and is widely investigated by scholars, while Unified Ledger is less explored. While blockchain interoperability or cross-chain blockchain solutions remain one of the key research trends in recent years, few papers have investigated such interoperability in the grand level as ideated by Finternet. Therefore, our project will have a primary focus in the technical architecture of Unified Ledger in Finternet.

Within the scope of blockchain interoperability in Unified Ledger, we deliberately selected the CBDC interoperability as our focus due to its relatively abundant resources and its significance in establishing the Finternet. Between CBDC-to-CBDC interoperability and CBDC-to-non-CBDC interoperability, we concentrate in the former one as CBDC-to-CBDC transaction is under the category of cross-border transaction, which has significant cost and slow settlement speed in the current financial system as identified by BIS [1]. Since addressing CBDC-to-CBDC interoperability is essential to the develop of Finternet, our research anchors the discussion predominantly about CBDC-to-CBDC interoperability, with minor discussion about CBDC-to-non-CBDC interoperability in between.

To conclude, this project focuses on the CBDC-to-CBDC interoperability under the vision of Unified Ledger in Finternet.

1.5 Project Deliverables

1.5.1 Fundamental Analysis of CBDC Interoperability Models

Our project will deliver a detailed analysis of Central Bank Digital Currency (CBDC) interoperability models within the Finternet framework. We will employ a multivocal literature review approach, incorporating a wide range of perspectives and examining relevant global case studies. Our analysis will focus on the five interoperability models proposed by the Bank for International Settlements (BIS).

We will provide a detailed explanation of each proposed model, discussing how each one works in practice. Additionally, we will analyze Central Banks' projects that utilize these models, evaluating them against the eight Finternet design principles suggested by BIS. This assessment will include an overall comparison of the different models in terms of feasibility and functionality.

Ultimately, our goal is to identify several desirable models for practical implementation, offering valuable insights into effective CBDC interoperability.

1.5.2 Technical Simulation of Selected CBDC Interoperability Models

For the second part of our deliverable, we will realize the most promising CBDC interoperability model identified in the first focus area through a proof-of-concept demonstration. This demo will illustrate the practical implementation of the chosen model within the Finternet ecosystem. It will showcase key features such as:

- Cross-border Transactions: Demonstrating seamless international transfers and settlements.
- Currency Conversion: Highlighting efficient and secure exchange processes between different digital currencies.

- Integration with Existing Financial Infrastructures: Ensuring compatibility and interoperability with current banking and financial systems.

We will experiment with demo blockchain construction on key models that align well with the Finternet framework. This involves setting up a simulated environment to test the model's functionality, scalability, and security, providing a comprehensive view of its potential real-world application.

2 Project Methodologies

To accomplish the project objectives and develop the project deliverables, we have primarily two methodologies, with one methodology for each deliverable as identified in Section 1.5. For comprehensive analysis of the proposed CBDC interoperability models, this paper adopts Multivocal Literature Reviews, while for more in-depth technical analysis on the selected models, simulative blockchains are built for the evaluation.

2.1 Multivocal Literature Reviews (MLR)

2.1.1 Introduction

Multivocal Literature Reviews (MLR) is a literature review technique that includes both Systematic Literature Reviews (SLR) and Grey Literature Reviews (GLR). The key differences between these literature review techniques lies in their selection of literature.

Literature can be classified into 3 categories, namely White literature, Grey literature and Black literature [9]. With reference to [10] and [11], Table 2.1 summarizes the definitions and examples for each category.

Category of Literature	Definition	Examples
White Literature	Formally published sources produced by expertise via fully known outlet control, e.g. conferences, journals.	• Published journal papers • Conference proceedings • Books
Grey Literature	Materials not published formally through known outlet control but may possess impacts in research.	• White papers • E-prints • Preprints • Technical reports
Black Literature	Materials that are not easily accessible through traditional academic databases or libraries and are relatively more subjective.	• Ideas • Concepts • Thoughts

Table 2.1 Categories of Literature and Examples

SLR has long been used extensively in the software engineering field, in which only white literature is included. GLR, as suggested by its name, includes only grey literature. Thus, MLR includes both white and grey literature. However, grey literature should be handled with care as suggested by [11].

Grey Literature could further be classified into three tiers based on the level of credibility and outlet control [11]. Table 2.2 summarizes the examples for each tier.

Tier	Level of Credibility and Outlet Control	Examples
1st Tier	High outlet control or high credibility	• White papers • Government reports • Think tank publications • Magazines • Books
2nd Tier	Moderate outlet control or moderate credibility	• News articles • Annual reports • Company publications • NGO studies
3rd Tier	Low outlet control or low credibility	• Blogs • Emails • Tweets

Table 2.2 Tiers of Grey Literature and Examples (from [11])

Given the low outlet control or low credibility of 3rd tier grey literature, these materials will be excluded during the review. Specifically, the grey literature used by this paper will mostly include white papers or progress report provided by BIS and different central banks (1st tier grey literature), together with analysis reports provided by companies such as Deloitte and PwC (2nd tier grey literature). Figure 2.1 summarizes the types of literature as discussed above and the highlighted ones are literature that will be included in this project.

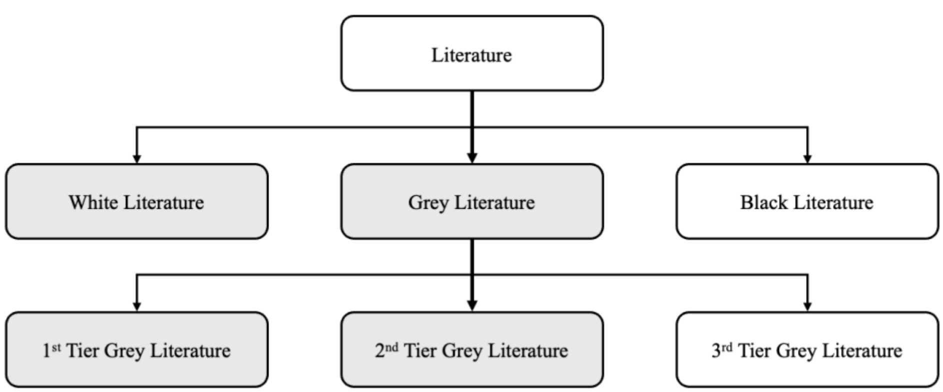

Figure 2.1 Types of Literature

2.1.2 Procedures and guidelines for MLR

Following the MLR guideline in [9], we first identified two research questions (RQ) for our project.

1) What is the current development of CBDC-to-CBDC interoperability?

2) What are the blockchain interoperability requirements for Unified Ledger in Finternet?

With these, we generated the following search expressions.

ID	Search Expression	Relevant RQ
#1	((central bank digital currency) OR (central bank digital currencies) OR CBDC OR CBDCs) AND (interoperability OR cross-chain)	1
#2	((cross-border payment) OR (cross-border transaction)) AND (blockchain OR (distributed ledger) OR DLT)	1
#3	mCBDC OR multi-CBDC	1
#4	Finternet OR (unified ledger)	2

Table 2.3 Search Expressions used in MLR

For Search Expression #1, #2 and #3, we referenced the literature review preparation in [12] with adjustments to ensure relevant forms of the same concepts are included. These search expressions have either explicitly or implicitly related to the interoperability of CBDCs. Search Expression #4 is less constrained as Finternet or Unified Ledger are new concepts and thus, has fewer materials. Therefore, we would like to review the materials manually before deciding whether to include or exclude.

For white literature, we would use four scientific databases, i.e. ACM Digital Library, IEEE Explore, Springer, and Scopus. For grey literature, we would use Google as our primary touchpoint. The search expressions will be the same for both literatures. We do not restrict the date of publications as these fields are relatively novel. To avoid translation inaccuracy of this paper, we restrict the literature materials to be written in English.

After we gather the pool of literature to review, each author of the paper would independently screen through the materials and decided whether to include or exclude based on the familiarity with the research topic. Later, we would gather all include/exclude list and conduct comprehensive review together to finalize the decision.

2.2 Model Simulation

2.2.1 Introduction

To conduct our blockchain simulation based on selected models, we chose to use Hyperledger Fabric as our platform.

Hyperledger Fabric is a consortium blockchain platform designed to be highly modular and extensible [13]. A consortium blockchain is also known as a permissioned blockchain, in which only authorized participants could join the chain. According to BIS, most of the CBDC projects carried out by central banks used Hyperledger Fabric [14]. Indeed, most of the CBDC projects involve private blockchain models with access control, and this exactly matches the characteristics of Hyperledger Fabric.

Besides the type of blockchain supported, Hyperledger Fabric also possesses strong versatility through its smart contract system. The smart contract in Hyperledger Fabric is called “chaincode”. Chaincode is a software program that allows users to encapsulate business logics for creating, modifying and terminating assets in the ledger [15]. Such programmability is essential to most CBDC projects.

2.2.2 Feature Selections and Evaluation Criteria

While the exact blockchain design will be determined by the selected model, we identified key features to experiment with each model. The report by BIS identifies multiple high-level technical requirements for a CBDC architecture [16]. Since this sector primarily focuses on how each CBDC interoperability model performs during regular operation, we have chosen the following relevant features for our model simulation, which covers a simplified cross-border payment between central banks.

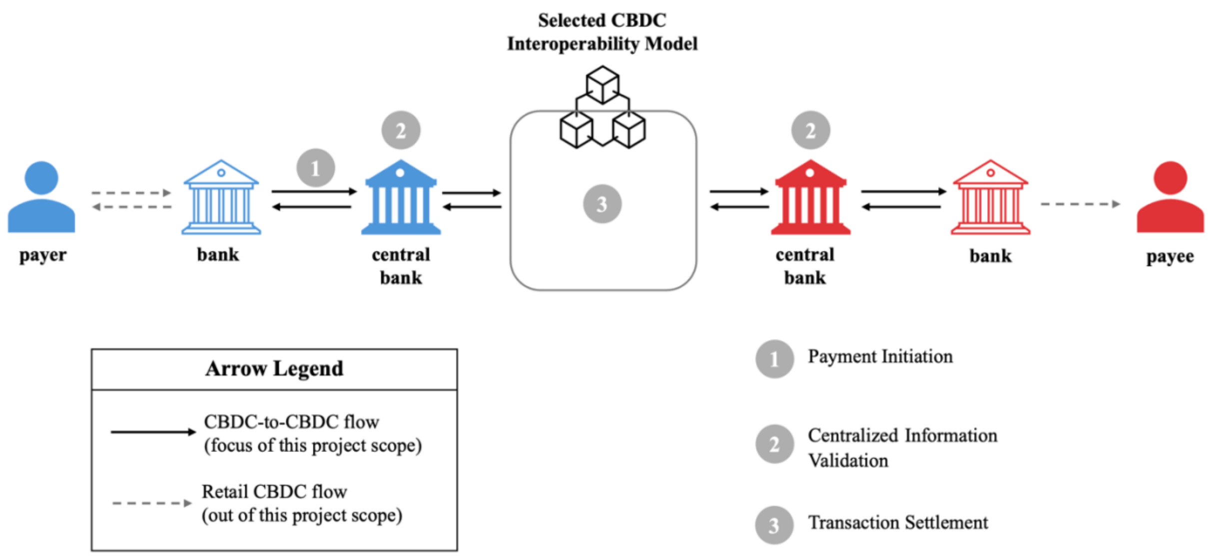

Figure 2.2 Simplified Cross-border Payment Flowchart

As demonstrated in Figure 2.2, we would primarily focus on the functions of i) payment initiation, ii) centralized information validation (in which only verification/signature from central banks are necessary), and iii) transaction settlement within the selected CBDC interoperability model.

To evaluate the models, we referenced the performance metrics in [17] and extracted the following criteria.

- Latency: Latency in blockchain refers to the time it takes from a valid transaction is initiated within the blockchain network to its confirmation is received.
- Throughput: Throughput is the capacity of the blockchain to process valid transactions within a specific timeframe.
- Scalability: Scalability measures the rate of change of latency and throughput when the number of nodes/participants in the blockchain increases

3 Project Schedule and Milestones

Time Period	Tasks	Completion
September	• Meet with supervisor	✓

	• ***Phase 1 Deliverable***
	  ○ *Write detailed project plan*
	  ○ *Develop the project website*
		✓

	• Do literature review on Finternet and CBDC's interoperability	✓

October	• Related work review
	  ○ Blockchain interoperability
	  ○ Unified ledger
		In progress

	• Case study of different interoperability CBDC model
	  ○ Inthanon-LionRock
	  ○ A Helvetia Phase II project
	  ○ Project Stella
		In progress

November-December	• Analysis and Evaluation
	  ○ Evaluate each interoperability model against the 8 Finternet design principles
	  ○ Compare models in terms of feasibility and functionality
		Pending

	• Demo Development (Phase 1) ○ Protocol Level Design	
	• ***Phase 2 Deliverable*** ○ *Interim Report*	
January	• Demo Development (Phase 2) ○ Application Level Design	Pending
February	• Demo Development (Phase 3) ○ Implementation Stage	Pending
	• Testing	
March- April	• Design the evaluation method and evaluate blockchain demo • Write the final report • Prepare for the final presentation	Pending
May	• ***Phase 3 Deliverable*** ○ *Final Presentation*	Pending

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