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Realizing Programmability in Payment and Settlement Systems

Payment and Settlement Systems Department
HOJO Masashi*, HATOGAI Junichiro

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Programmability in payment and settlement systems refers to the ability of computer programs to control and automate system behavior when funds and securities circulate. If payment and settlement systems are equipped with a high level of programmability, it could enable the provision of highly convenient services in which funds are automatically transferred in response to trade and transactions without requiring users to perform complicated tasks. Programmability is a concept that is often discussed while tying in with technologies related to crypto-assets. However, if we focus on the feature that various entities can write programs and automatically move funds and assets, we can see that even existing payment and settlement systems have improved their programmability as they continue to upgrade their functions. In considering future payment and settlement systems, it is important to advance technological research while exploring approaches to enhance programmability, thereby working to realize payment and settlement methods appropriate for a digital society.

Introduction

In recent years, programmability has been cited as an advantage when considering new payment and settlement systems. Although there is no commonly agreed definition of programmability at the moment, it is said to be the ability of a computer program to control the behavior of digitally recorded funds and securities that circulate within payment and settlement systems. There are heightened expectations that the automation of fund transfers fulfilling to various conditions and the flexible linkage with external services will be realized when payment and settlement systems are equipped with programmability.

Programmability has also been recognized as one of the characteristics to take into account in considering a Central Bank Digital Currency (CBDC). For example, a report published in September 2021 by a group of central banks[1] notes the need to deepen understandings on novel technologies such as programmability in order to meet both current and future user needs.[2]

This paper summarizes programmability and related concepts, and shows that programmability can be found in existing payment and settlement mechanisms. The paper then discusses how programmability is paving its way to play more important roles in future payment and settlement systems.

Distributed Ledger Technology and programmability

The concept of programmability has gained attention since the emergence of Distributed Ledger Technology (DLT), which underpins the distribution of crypto-assets. The distributed ledger on which crypto-assets are distributed not only provides such basic transaction functions as issuance and transfer but also allows user and developer communities, for example, to deploy programs (smart contracts) for additional service functions. Decentralized Finance (DeFi) services, which have seen an increase in the number of users in recent years, are another use case for smart contracts.

In the exploration of business systems using distributed ledgers based on the "consortium model", in which multiple firms and other parties are involved, there have been attempts to implement business functions using smart contracts. For example, in the "Proof of Concept Testing for Utilization of Blockchain/DLT in Capital Market Infrastructure" led by Japan Exchange Group, distributed ledger technology is being used to construct an inter-company information sharing platform for securities settlement. The platform is designed to allow for information sharing among multiple entities in a series of securities trading operations. Experiments have been conducted by financial institutions and IT vendors to implement business functions with smart contracts to confirm their feasibility and usefulness.[3]

All of the above examples highlight a common feature of business systems using DLT where various entities (e.g., users, businesses, and communities), not limited to system operators, can implement additional functions using smart contracts on the distributed ledger. Equipped with these features, distributed ledgers are recognized as a system infrastructure with programmability.

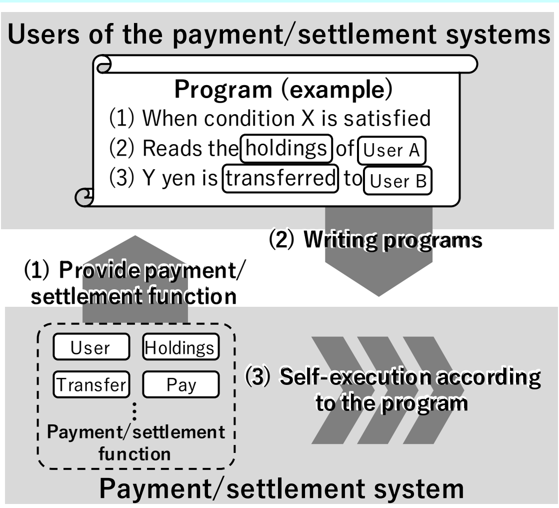
Programmability in existing payment and settlement systems

Although programmability of payment and settlement systems is often associated with DLT, its essence lies in the fact that various entities can write programs and automatically move funds and securities (Chart 1). In light of this, programmability is a characteristic that can be found in not only future settlement systems but also existing ones.

In understanding programmability, the diversity of entities that implement programs is an important factor. At first glance, conventional services such as direct debits and payroll direct credits, which automate payments based on prior agreements, appear to have programmability. However, payment options and conditions available for adjustment are limited. Today, programmability is expected to enable not only operators of payment and settlement systems but also various entities to program payment and settlement functions so as to meet specific user needs.

The following section refers to examples of existing payment and settlement systems that are closely related to programmability, and explains what entities can program what kind of functions.

[Chart 1] Programmability in payment/settlement systems



Banking API and Embedded Finance

In recent years, financial institutions have been providing banking Application Programming Interfaces (APIs) to enable external access to account information and payment initiation functions. This allows FinTech and non-financial companies to make bank API calls from their own service programs and combine banking functions as needed. This means that non-banks can program the behavior of payment methods (i.e., bank deposits) tailormade for each depositor's needs.

Banking APIs are classified into two types: "read APIs," which allow for inquiries on information such as deposit balances, and "write APIs," which allow for transmission of messages such as payment instructions. At the moment, the penetration of write APIs is not as high as that of read APIs in Japan.[4] However, if the number of financial institutions providing write APIs increase in the future, ties between financial institutions and non-financial business companies may deepen.

As part of such interactions, a new form of financial services, embedded finance, has emerged. Embedded finance is a model in which non-financial companies incorporate banking functions in their own service platforms by utilizing banking APIs, thereby providing financial services and their own non-financial services in an integral manner[5] (Chart 2). In Japan, there are several cases, mainly in the retail and service industries, where companies incorporate functions such as deposits and fund transfers into their own smartphone apps so that these banking functions can be used seamlessly within the apps. There are also cases of real estate companies using embedded finance to provide one-stop services for real estate sales and mortgages.

[Chart 2] Embedded Finance realized by banking APIs

Note: Prepared by authors based on various materials.

In embedded finance, functions provided by financial institutions through banking APIs are offered like components of the customer service experience. This allows diverse entities (non-financial businesses), which are not operators of the payment services (i.e., financial institutions), to utilize payment methods (bank deposits) to meet their customer needs.

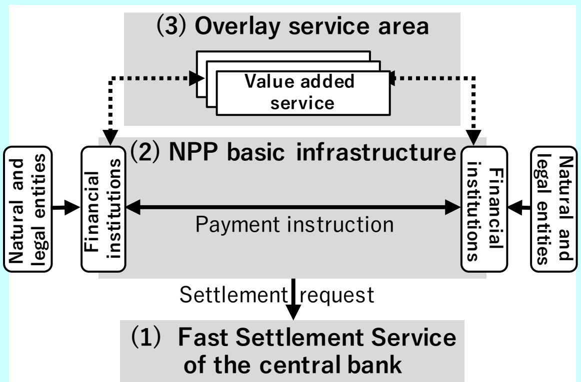
Upgrading the functionality of the interbank payment systems

In the area of interbank payment systems, there has been a continuous expansion/sophistication of functions through updates to existing systems and the introduction of new infrastructures, such as small-value instant payment systems. Recent efforts in various countries include architectures to equip payment systems with areas for additional functions to and attempts to connect interbank payment systems and financial institutions leveraging APIs.

An example of interbank payment systems with advanced programmability would be the New Payments Platform (NPP), the Australian interbank payment system that went live in 2018.[6] The NPP provides 24/7 instant payment functions and adopts a system architecture that incorporates the possibility of extending common functions and providing additional services (overlay services) in the future (Chart 3). In addition, standard specifications have been established for APIs that provide various NPP functions, allowing companies and other entities to smoothly access NPP via APIs from their own systems.

The overlay service area also enables providers of FinTech and other services to develop additional services leveraging common NPP functions and incorporate them into the NPP. Since overlay services are built sharing the same basic system infrastructure with the NPP's common functions, they can provide more flexible and advanced functions compared with making API calls from the outside. It is also possible to develop new overlay services combining the existing functions of overlay services as components. This design allows the NPP to expand its scope of services utilizing each function like a program component.[7]

[Chart 3] NPP's system architecture



(1) Fast Settlement Service of the central bank: 24/7 RTGS system dedicated to small value payments launched by the Reserve Bank of Australia, along with the NPP.

(2) NPP Basic Infrastructure: Network connecting each participant and providing common functions (e.g., transmission of payment instructions).

(3) Overlay service area: Area for additional service functions embedded by FinTech and other businesses.

Note: Prepared by authors based on publicly available information on NPPs.

In the Zengin system, which deals with interbank clearing and messaging for customer fund transfers in Japan, measures that could foster improvement of programmability are being discussed in the course of discussion on the future vision of the system.[8] One of such measures is technical verification of API gateway, a method where participants connect to the Zengin system via APIs. API gateway could enable participants to flexibly combine and use each function provided by the Zengin system within their own systems. Connection via API could further contribute to prompting addition of new functions by the Zengin system.

In addition, discussions are underway regarding the concept of dividing the various functions provided by the Zengin system into multiple areas so that additional functions can be added on an ongoing basis. There will be a "Mission Critical Area" where existing core business functions such as funds clearing and domestic fund transfers will be located, and an "Agile Area" where additional functions can be swiftly added. The Agile Area is being considered to gradually deploy additional functions to meet the needs of financial institutions and non-financial corporates, such as linkage with transaction and logistics information and functions supporting AML/CFT operations.

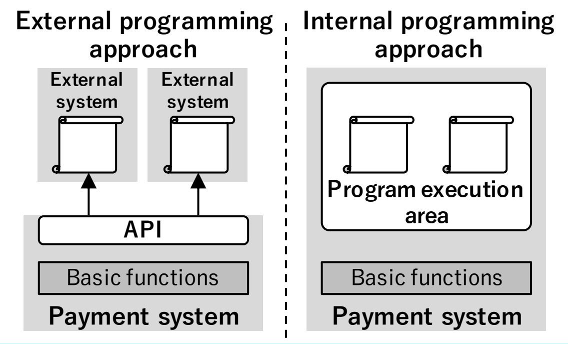
A typology of methods that bring programmability

Looking at the history of improvement of programmability in existing payment systems, the methods for bringing about programmability can be categorized into two approaches, depending on the area in which the program is deployed (Chart 4).

The "external programming approach" is an approach in which a program describing the behavior of funds is deployed in a participant's system outside the payment system. In this approach, a business implements a program to control funds using the API provided by the payment system and deploys it in its own system.

The "internal programming approach" is an approach in which a program describing the behavior of funds is deployed inside the payment system. In this approach, the payment system provides an area for executing additional programs, and the participant implements the program according to certain specifications and rules and deploys it in the program execution area.

[Chart 4] The external programming approach and the internal programming approach



Case	
● Banking API ● API of payment system (NPP, Zengin system)	● Overlay service (NPP)

Each of these approaches has its advantages and challenges, including the following.

- In the external programming approach, the division of responsibilities is clear, with the API as the boundary. As the methods around provision and use of API are widely used, the degree of difficulty in implementation is relatively low. On the other hand, if the functions provided by the API are limited, the benefits realized by the program may also be restricted.
- The internal programming approach makes it difficult to define the division of responsibilities because the basic payment functions and the functions introduced by participants are vertically integrated on the same system. In addition, there are few cases of introduction of this approach in the existing payment systems, and its realization is expected to be highly challenging. On the other hand, there are potentials to write more sophisticated programs with close linkages with the basic functions provided in the payment systems.

Given this typology, it can be said that banking APIs and APIs provided by payment systems take the external programming approach. On the other hand, the provision of overlay service areas in the NPP is based on the internal programming approach.

Programmability in future payment and settlement systems

As mentioned above, various attempts have been made to improve programmability in existing payment and settlement systems. In designing future payment and settlement systems, it is important to learn from such experiences and appropriately choose an approach of programmability in line with the objectives. In addition, a flexible mindset inviting innovations is expected, leveraging programmability that opens the way for the involvement of diverse actors.

Stability and a high degree of programmability standing together

In considering future payment and settlement systems, it is important to consider both stability of payment and settlement functions and a high degree of programmability, recognizing the advantages and challenges of external and internal programming approaches.

One path that could lead to the realization of this goal involves adopting a multi-layered structure, similar to the next-generation Zengin system blueprints and the NPP, and appropriately choosing between the two aforementioned approaches for each layer. In other words, the lower layer, which is expected to stably provide basic payment functions, will utilize standardized APIs with the external programming approach in mind, while the upper layer, which performs additional functions, will adopt an internal programming approach to flexibly provide each function according to its needs.

At the Future of Payments Forum[9] hosted by the Bank of Japan, the importance of taking into account the advantages and challenges of various approaches which bring about programmability in order to achieve both stability and a high degree of programmability in payment systems was pointed out in the discussions among the experts. It was also pointed out that expertise may be needed to bridge the users/developers who utilize programmability and the operators of payment systems.

In exploring the desirable form of payment and settlement systems of the future, it will be important to consider what kind of programmability should be realized, while envisioning payments and settlements in line with a digital society.

Payment instruments and programmability fit for a digital society

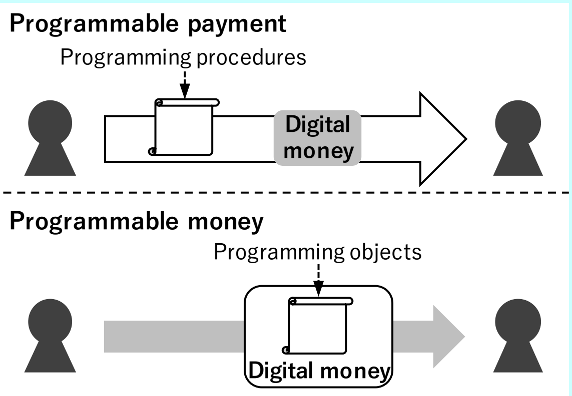
As society becomes increasingly digitalized, the number of digital devices and digital services around us will increase, with payments being made automatically more frequently even without payers being aware of it. For example, at checkout-free stores, which are being put into practical use, and with IoT payments (payments automatically initiated from devices connected to the Internet), which might become widely adopted in the future, payments will be made automatically without requiring users to take any action for it. In a future digital society, there may be growing needs to make payments more integrated into daily life. Programmability will become all the more important for payment services to meet such social needs.

In this context, it is possible that entities other than traditional financial institutions and payment service providers will become increasingly involved in payment services. This will lead to attracting ideas that go beyond those of the existing sphere of payments and finances. By enhancing programmability, payment systems will have a stronger role as a foundation for innovation. In the future, new services may be offered by new entities that previously had not been engaged in payment services, leveraging payment systems with advanced programmability. And such services may be so integrated with user behavior and with other services that they will no longer be recognized as simply "payment" services.

Potential of programmable money

The methods related to programmability that have been discussed in this paper so far are sometimes referred to as "programmable payment" because they program the "procedure" of fund transfer that occurs in conjunction with a certain event or transaction. In addition to this, a concept called "programmable money" has recently been attracting attention (Chart 5).[10]

[Chart 5] Programmable payment and programmable money



Programmable money is "digital money with specific attribute information and/or with inherent logic to control its own behavior." It is a concept that focuses on embedding specific attribute information and/or programs in an "object" called monetary data so as to control its behavior.

The adoption of programmable money into a payment system would require the internal programming approach so as to embed the program into the monetary data itself, which is recorded within the payment system. Furthermore, it is necessary to describe monetary data not as a "balance" associated with a certain user, but as individual value data to which a program is attached. Taking these into account, it is assumed that the adoption of programmable money would require the use of novel system infrastructure technologies.

Partly because of these technical challenges, programmable money, unlike programmable payment, would be considered a concept indicating its future course of development rather than one with which actual implementation is in mind at the moment.

Programmable money would allow for the "issuance of money with certain attributes" or "colored coins," and could allow digital money with a specific purpose to circulate within a payment system. By incorporating details of usage and its conditions into the monetary data, it may be possible to design digital money that can be used, for example, only in certain regions or only for the purchase of products of a certain category.

Programmable money could also be useful in the areas of RegTech and SupTech, which are efforts to make regulatory compliance and operations in the financial sector more efficient and sophisticated with information technologies. For example, if it is possible to implement digital money that is transferrable only for transactions that comply with regulations, the burden of monitoring and verifying transactions could be reduced. This could also lead to an improved sense of security for users when transferring funds.

Furthermore, programmable money could increase the diversity of entities that implement programs. For example, it is possible to imagine use cases where even consumers and other users, not to mention the payment system operators and service providers, can program the behavior of digital money in their wallet apps.

Many of the above potential use cases seem to be feasible also within the framework of programmable payment. However, "embedding a program in the monetary data itself" may lead to more efficient achievement of objectives and creation of more novel use cases. Further research is expected.

Conclusion

Payment and settlement systems have continuously introduced new functions and technologies, as user needs have diversified. In recent years, they have developed in a direction where their functions are becoming more easily accessible from external systems and services, in tandem with the acceleration of digitization in various business systems and personal services. Such efforts have improved the programmability of payment and settlement systems, resulting in the creation of new use cases and solutions by businesses.

In this regard, the programmability of payment systems will enable the provision of services by diverse entities, attracting ideas that go beyond the traditional sphere of payments and finances. By enhancing programmability, payment systems can play increasingly significant roles as a foundation for innovation.

As technological progress accelerates, it will become even more important to consider how the means of payment suitable for a digital society look like. In considering the future of payments and settlements, it is vital to make efforts to improve the stability and convenience of payment and settlement systems while being mindful of the programmability aspects mentioned in this paper.

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* Former Researcher at the Bank of Japan.

[1] Group of Central Banks (2021), "Central bank digital currencies: user needs and adoption."

[2] Other studies on programmability by central banks include the following:

Working Group on Programmable Money (2020), "Money in programmable applications - Cross-sector perspectives from the German economy."

Lee, A. (2021), "What is programmable money?", FEDS Notes. Washington: Board of Governors of the Federal Reserve System.

Washington: Board of Governors of the Federal Reserve System. https://doi.org/10.17016/2380-7172.2915

[3] B-POST Project Secretariat (2020), "Report on Pilot Test of DLT Information Sharing Platform in the Field of Securities Post-Trade (Project Name: B-POST)", JPX Working Paper Series Report.

[4] According to the "Survey of Financial Institutions FY2021" conducted by the Financial Information Systems Center (FISC), approximately 70% (71.2% for consumers and 70.2% for corporates) of responding financial institutions in Japan had started providing read APIs as of the end of March 2021. On the other hand, only 10.1% of the financial institutions provide write APIs for consumers and 7.1% for corporates.

[5] Embedded finance is also called "Banking as a Service (BaaS)," focusing on the characteristics in which banking functions are provided as a service. "As a Service" refers to the provision model of IT resources (e.g., CPU resources) and software functions via the Internet. From business model perspectives, it means the transformation of product functions into services by providing them as "services" when customers need them, as opposed to "sales" where products are sold out to customers.

[6] The descriptions on the NPP are based on publicly available information on the website of its operator, the NPPA. https://nppa.com.au/

[7] As an actual example of NPP's overlay service, as of June 2022, only the person-to-payment service Osko has been implemented.

[8] The Zengin System is scheduled to allow access by nonbank payment service providers by the end of FY2022, and is scheduled to be upgraded to the 8th Zengin System in 2027. The Task Force for the Next-Generation Payment Systems, organized by Zengin - net (Japanese Banks' Payment Clearing Network), is playing a central role in studying the realization of payment systems that are secure, flexible, and convenient.

[9] Bank of Japan (2022), "*決済の未来フォーラム デジタル通貨分科会：中央銀行デジタル通貨を支える技術（第3回会合） 議事概要* (Future of Payments Forum, Digital Currency Subcommittee: Technologies Supporting Central Bank Digital Currencies (3rd Meeting) Agenda Summary).".

[10] Definitions of programmable payments and programmable money are discussed in the Working Group on Programmable Money (2020), supra note 2, as well as, for example, in

Bechtel, A., Gross J., Sandner P., and Von Wachter, V. (2020), "Programmable money and programmable payments," Medium. https://philippsandner.medium.com/programmable-money- and-programmable-payments-8038ed8fa714.

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