DEUTSCHE BUNDESBANK
EUROSYSTEM

# Money in programmable applications

## Cross-sector perspectives from the German economy*

Frankfurt am Main, 21 December 2020

* At the initiative of the Federal Ministry of Finance and the Deutsche Bundesbank, the working group on programmable money held an expert discussion on the subject of programmable money. On the basis of a consultation with Germany's central associations of banking, industry and trade, employees from the following enterprises are represented in the working group with the aim of conducting a broad and practical analysis of the requirements and design options for programmable forms of money: Bundesdruckerei GmbH, Robert Bosch GmbH, DB Systel, Deutsche Bank AG, Deutsche Börse AG, DZ BANK AG, Evonik Digital GmbH, Frankfurt School of Finance & Management gGmbH, generic.de software technologies AG, Helaba Landesbank Hessen-Thüringen, IBM Deutschland GmbH, ING-DiBa AG, Landesbank Baden-Württemberg, Main Incubator GmbH (Commerzbank AG), MARKANT Services International GmbH, SAP SE, Siemens AG, Volkswagen AG, Zalando Payments GmbH.

# Content

# Executive Summary

Digital transformation is giving rise to new business models and is fundamentally changing existing business processes. Many of these processes will be much more automated still in future. Distributed ledger technology, which uses tokens to represent real goods and services and allows these to be traded digitally, makes it possible for flows of services to be programmable, autonomous and automated. This means that existing payment systems are set to be confronted with new challenges. The extent to which the advantages of digital settlement can be exploited is largely dependent on whether the associated cash flows will become equally programmable and can be synchronised with flows of services.

Types of transactions that might conceivably require innovative solutions for cash leg settlement are largely based on DLT and might contain smart contracts that control their execution. Machine-to-machine payments, payments in the internet of things and pay-per-use payments are examples of use cases that require programmable payments to settle the cash leg.

Three payment solutions are currently candidates: conventional payments, private crypto-tokens and stablecoins. As conventional payment systems do not have the technical capacity to integrate smart contracts into the payment process, they are reaching their limits in terms of meeting future needs. The need for 24/7 payments can already be adequately met at the current juncture, using instant payments. Many crypto-tokens and stablecoins have the technical capability to settle the cash leg of a large number of DLT applications. However, they are seen as unsuitable in practice due to volatility, limited interoperability and issues regarding legal certainty, in particular.

New and innovative solutions are therefore needed to meet the demand for programmable payment solutions. Trigger solutions, by means of which the settlement of smart contract-based transactions could be integrated into conventional payment systems, could conceivably be available in the near future. While limitations are to be expected in terms of the extent to which they can be implemented and applied, they have the advantage of being quick to develop.

However, tokenised commercial bank money and digital central bank money bring the greatest functional benefit in terms of settling programmable payments. The development of both payment solutions, which is still pending, offers sufficient scope to comprehensively take into account the need to implement programmable payments. Both options are particularly well-suited settlement solutions for programmable payments on account of the expected credibility of their issuers and their use within a binding legal framework.

There are also other general requirements for programmable payments, such as interoperability, ability to innovate, cyber resilience and data protection. Universal acceptance of any implementation measures as a functional and efficient payment solution for the real economy and the financial sector hinges on these requirements.

# 1 Motivation

As digitalisation increases, trading processes, business models and workflows are changing. This can be said in reference to both the real economy and the financial sector. In the emerging digital economy, many goods and services can be represented as tokens and traded digitally. The increasing tokenisation of the economy is leading to the more intensive automation and integration of existing processes.

New technologies, particularly distributed ledger technology (DLT), present an opportunity to significantly reduce transaction costs in the real economy and financial sector and to generate greater added value through new and improved services and products.

In order to leverage the potential of Industry 4.0, the cash leg of transactions must also be integrated into the new processes. Only then can service and cash flows be fully synchronised, determined and automated.

# 2 Definitions

Work commenced with the aim of studying programmable money. Programmable money is defined as a digital form of money which the user can program to follow an inherent logic for a predefined purpose, based on the attributes of the digital money itself. To really be able to speak of **programmable money,** the program would have to be stored in the respective "digital coin". Although this would indeed allow for a complete synchronisation of the flow of goods and cash, it requires considerable technological innovation.

**Programmable payments** are defined as transfers of money for which the time, payment amount and/or type of transfer are determined by conditions specified in advance rather than being set ad hoc during the payment process. In the simplest case, these are regular payments executed, for instance, by standing order. Furthermore, this means that the cash leg of even complex transaction processes can be settled whilst ensuring the fulfilment of the predefined conditions. The originator of the payment must be a legal or natural person, while the direct trigger can be any measurable event (e.g. products arrive at destination, service was provided, period of performance expired). Not all forms of programmable payments require the use of programmable money.

In a similar vein, the term **contract execution system**[1] is used in the following. A contract execution system describes the technical infrastructure used to initiate payment transactions. The information relevant to the payment transaction is transferred to the contract execution system. If certain conditions are met, the contract execution system initiates the cash leg of the transaction. In terms of definition, "contract execution systems" should be differentiated from "payment systems".

In many cases, the current need for money in programmable applications can be sufficiently met with a programmable payment that does not necessarily require programmable money. The following discussion therefore focuses on programmable payments.

**1** In their article "Programmable Money and Programmable Payments", Alexander Bechtel, Jonas Gross, Philipp Sandner and Victor von Wachter fit contract execution systems into the context of programmable payments and money, and put forward detailed definitions of these concepts. See https://philippsandner.medium.com/programmable-money-and-programmable-payments-8038ed8fa714.

# 3 Possible use cases for DLT

Nine stylised potential use cases for programmable money and programmable payments are presented below. The list of use cases does not claim to be exhaustive, but it does present applications that are of interest to the real economy and the financial sector. In practice, however, several use cases may coincide, as it is not always possible to clearly distinguish between them based on real-world conditions. Taken as a whole, the description of the various use cases in combination with a textbook example reflects the need for innovative payment solutions. It also provides a basis for matching use cases with potential and suitable payment solutions.

➔ **M2M payments:** Fully automated settlement between devices (machine to machine).
- Example: An electric car pays for the charging station at the car park or parking fees independently. The payment processes "car to car park" or "car to charging station" could be used here.

➔ **IoT payments:** Payments in the internet of things (IoT), which can be initiated by interaction with the end customer, unlike M2M payments.
- Example: One person pays their neighbours for the shared use of their photovoltaic system or payment for partial consumption from an energy network.

➔ **Automated settlement payments:** DLT-based settlement of a transaction, including the cash leg. For example, a smart contract can take over the control of contract processing (e.g. event-triggered payment flow) or act as a virtual trustee to eliminate settlement risk.
- Example: Securities transactions in stock exchange trading. As soon as the smart contract registers that the money or security has been received, it is transferred to the counterparty in the form of a delivery-versus-payment (DVP) settlement.

➔ **Pay-per-use payments:** Direct payment of an amount depending on consumption/use.
- Example: A leased machine charges a price measured in units of use and processes the payment independently.

➔ **Bidirectional clearing:** Settlement of many mutual claims/liabilities between counterparties.
- Example: Two enterprises clear their trades with each other in real time, with invoices being assigned and accounting carried out clearly and automatically as part of the payment process.

➔ **Cross-border payments:** Cash leg settlement of cross-border business. A reduced number of intermediaries involved, improved standardisation and greater transparency are necessary for efficient cross-border payments.
- Example: Letters of credit required for export handling are digitalised. A smart contract manages the payment, which is only made once the conditions set out in the letters of credit have been fully met.

➔ **24/7 payments:** Payments made outside the availability periods or amount limits of "conventional" systems.
- Example: Redemption of a security with a maturity date that falls on a Saturday morning. Round-the-clock availability reduces credit and counterparty risks. Alternative example: Meeting margin calls from a clearing house at 02:00 a.m. in order to carry out further transactions.

- **Payments as information function:** Integration of payment and information or communication systems: payment is designed to contribute to process and data integration across enterprises.
  - Example: Extended use of digital money by attaching "usage attributes" (coloured coins), which enable, for example, money laundering checks and whitelisting to be carried out directly through the act of payment, as the sender is clearly identifiable from this.
- **Offline payments:** Technical bridging of temporary or permanent disruptions to internet access as well as integration of non-internet-enabled devices.
  - Example: Integrating a production system without an internet connection into programmable payments. Alternative example: Paying with a smartphone at the supermarket when the internet connection is interrupted.

# 4 Types of programmable payments

The list of use cases above provides examples of the many scenarios in which programmable payments are essential. The degree of complexity involved and the type of payment programmability differ depending on the use case. In principle, different types of payment can be assigned to the various use cases.

**Conventional payment systems:** Conventional payment systems are based on the settlement of payments using existing payment instruments (such as direct debit, credit transfer or instant payment), which require payers and payees to be known to each other and addressable via IBAN. These include established instruments such as scheduled credit transfers, standing orders and direct debits with fixed execution dates. They allow simple programmability requirements to be met, as they only require timely execution without having to meet complex conditions. In addition, instant payment opens up the possibility of mapping payment scenarios that require almost simultaneous execution. For example, a supplier would only unload their goods in the yard once the buyer had checked them and had paid for them via instant payment. The goods are only handed over once the payment has been received.

**Trigger to conventional payment systems:** A trigger is a technological bridge that acts as a contract execution system connecting conventional payment systems and a DLT-based application. It enables the DLT application to initiate, or trigger, a payment in the conventional payment system by passing on the required information. The advantage of such a solution is that there is no need to create special tokenised monetary units that can be used within the DLT environment and, in case of doubt, result in the need to exchange them due to their parallelism with existing means of payment. However, as long as conventional payment systems do not offer 24/7 settlement, use of the trigger would be limited to certain times. This restriction could possibly be lifted by using an instant payment application if, assuming that the current instant payment requirements were in place, payments of less than €100,000 were being dealt with, or if the two payment service providers had bilaterally agreed to settle higher amounts via instant payments. An example of this would be the transfer of securities on a DLT platform, which simultaneously triggers a settlement in TARGET2.

In addition to these solutions based on traditional infrastructure, there would also be the option of using **privately created crypto-tokens.** These are **crypto-tokens from private issuers**[2]**,** the exchange rates of which are market-driven and pegged to official currencies. Bitcoin and Ether are prominent examples of crypto-tokens. For the most part, such crypto-tokens are volatile, which considerably limits their usability as a means of payment. Moreover, they generally have no intrinsic value and no liable issuer, meaning that their holders have to rely solely on the market value. The programmability of crypto-token payments depends heavily on the DLT structure's range of functions – for instance, whether and to what extent smart contracts can be executed. Smart contracts can be used to define the conditions under which units of value are transferred. Furthermore, the use of crypto-tokens requires the provision of separate liquidity in the DLT system. One example of an application would be units of value that can be used on a blockchain (such as Ethereum), which can also be stored there in smart contracts and controlled by these.

**Stablecoins**[3] were created to at least partly address the disadvantages of crypto-tokens – in particular their high volatility. In many cases, stablecoins are closely related in nature to crypto-tokens. As a general rule, these are crypto-tokens whose exchange rate with official currencies is to be stabilised by pegging them to an official currency or other real assets (by backing the tokens with real assets). The regulatory treatment of these tokens is currently the subject of political debate. There is also discussion regarding whether it must always be possible to redeem such stablecoins in legal tender at a defined "nominal value". The available functions are closely linked to the design of the underlying infrastructure. In comparison with other crypto-tokens, the existing default risk can be reduced by backing stablecoins with collateral. Probably the most prominent example of a stablecoin is Diem, a project initiated by Facebook that was originally named Libra and is still in the planning stage. Details on the exact range of functions and features that Diem will possess have not yet been published.

Another approach would be the concept of **tokenised commercial bank money,** which would mean that money would not only be storable in the accounts of commercial banks and transferable from these, but could also be used in tokenised form. It is conceivable that tokenised commercial bank money could either take the form of programmable money or, together with a contract execution system, simply be used for programmable payments. In principle, tokenised commercial bank money always carries a default risk, meaning that transferring large sums between the accounts of customers of different commercial banks would be risky. In order to mitigate this, timely intraday clearing would be a conceivable option, possibly with settlement of margins in central bank money. The most far-reaching concept to solve this problem focuses on an idea that has yet to be realised: tokenised commercial bank money issued jointly by the banking sector in the official currency of the relevant currency area. This would be based on a mutually accepted standard that ensures acceptance within the currency area. Banks would accept an obligation to exchange tokenised commercial bank money as account credit. The range of functions available for programmable payments would also depend here on the underlying infrastructure. However, as this would be a new development, it can be assumed that all current market requirements could be represented. The extent to which existing creditor

2 Issuers of such tokens can be clearly identifiable individuals, but they can also be decentralised and anonymous, as is the case with Bitcoin, which is also based on a private initiative but does not require an issuer in the legal sense.
3 The Regulation on Markets in Crypto-assets (MiCA) in the European Union, which is scheduled to enter into force in 2022 and aims to harmonise the regulatory treatment of crypto-assets across Member States, may result in a reassessment or recategorisation of stablecoins.

protection rules, such as deposit guarantee schemes, would be applicable to a model like this would have to be clarified. Related to this is the issue of who the holders can enforce their claims against if they change banks or if their house bank fails. To this end, it is conceivable that the claims would be directed to a special-purpose vehicle operated by banks, which would be responsible for issuing the tokenised commercial bank money.

**Central bank digital currency (CBDC)**[4] would be a fail-safe option that is also stable in value. The issuer would be the central bank, which would provide central bank money in tokenised[5] form. Here, just like in the case of tokenised commercial bank money, both the programmable money variant and the option of use in programmable payment processes are conceivable. Establishing an operational system run by the central bank for settling payments in digital central bank currency might involve the central bank's activities being considerably expanded into areas thus far reserved for commercial banks. As is the case in the examples outlined above, the range of services with regard to programmability would depend on the final design of the system. It is therefore necessary to highlight the elements required for using the CBDC infrastructure for programmable payments. In principle, there are hardly any limitations to CBDC, particularly from a technical perspective. However, from an economic perspective, any implications of the introduction of CBDC would have to be analysed in sufficient depth, including, amongst other things, the effects on the particular role of commercial banks and the issuing central bank.

# 5 Possible solutions for the stylised use cases

This section links the stylised use cases to the solutions for the settlement of their cash leg and evaluates the fundamental suitability of each payment solution in its typical use case. A clear overview of the results is provided in a suitability matrix at the end of the chapter.

Given their common characteristic, **M2M payments, IoT payments, automated settlement payments** and **pay-per-use payments** can be summarised in an evaluation of suitable payment solutions as use cases based on smart contracts. Conventional payment systems – for which only cashless payment instruments were considered – are currently unable to integrate smart contracts into the payment process. While less complex programmable payments can be carried out using standing orders or direct debits, these instruments are increasingly stretched to their limits in automated and non-discretionary use cases. This is especially true for DLT-based transaction types whose cash leg settlement cannot be carried out in a synchronised and automated way using conventional payment systems. A trigger solution with the integration of smart contracts is technically feasible

4 In this document, no distinction is made between potential partial solutions for CBDC, such as the provision of a digital wholesale token, which would be a form of central bank digital currency but would only be made available to a limited number of users (primarily banks). The use of CBDC therefore implies the "retail" variant – the provision of CBDC for the general public.
5 The literature has established the term "central bank digital currency". However, the use of CBDC as solution for programmable payments implies a tokenised form of CBDC. In general, an account-based implementation of CBDC is also conceivable.

and thus suitable in principle. Furthermore, it would have the advantage of building on existing payment systems. The absolute benefit depends to a large extent on the actual design – in particular on the ability to connect to real-time payment systems that would be available around the clock. In this respect, a potential limitation of the trigger solution lies in the operating hours of conventional payment systems. From a technological perspective, privately issued crypto-tokens and stablecoins could be used to settle DLT-based transactions. However, their application is hampered in practice, not least on account of high volatility, insufficient interoperability and outstanding legal issues, meaning these instruments appear to be unsuitable on a practical level. Purely from a payments perspective, tokenised commercial bank money and digital central bank currency are fully applicable assuming there is a legally secure, technically reliable solution that is interoperable with DLT applications. However, these instruments have the most far-reaching implications for the role played by the central bank and need to be investigated in more detail.

**Bidirectional clearing** via conventional payment systems (usually with a 140-character limit to provide reference or user information) is only possible with a loss in efficiency being incurred. This is because media disruptions would have to be dealt with (in addition to the payment message, a supplementary explanation message would be necessary), which, in many cases, results in incomplete reference data for the clearing process and often requires manual correction. Using a trigger solution should counteract such media disruptions. In principle, private crypto-tokens and stablecoins are suitable for bidirectional clearing. Since they are not generally accepted, volatility-free tokens, solutions of this kind will struggle to become established in the B2B sector. Tokenised commercial bank money and digital central bank currency are viewed as a suitable solution for bidirectional clearing as they involve the use of closed data cycles, meaning maximum data quality can be ensured. In this case, message transmission and value transfer are not only synchronous, but also take place in one system without media disruptions.

Although **cross-currency payments** can be represented via conventional payments, they are considered inefficient and costly (for smaller amounts). In this respect, conventional payment systems can only be deemed suitable to a limited extent for this type of transaction. The same applies to the trigger solution, which would create a technical interface to conventional payment systems and would therefore lead to the same limitations when identical networks are used. The overall evaluation of private crypto-tokens is the same. A lack of standards and interoperability result in a number of stand-alone solutions that offer little added value compared with conventional payments. Stablecoins could – depending on the underlying collateral – imply risks for the financial stability and monetary sovereignty of individual countries. Even if tokenised commercial bank money and central bank digital currency were introduced, efficiency gains in cross-currency payments are not guaranteed, as it is uncertain whether institutions and central banks from different currency areas would cooperate.

Conventional payment systems – and thus also the trigger solution in principle – already have a suitable instrument for the cash leg settlement of **24/7 payment**s in the form of instant payments. Although, in technical terms, private crypto-tokens can also be used for the settlement of 24/7 payments, volatile exchange rates with official currencies and legal uncertainty also lead to limited applicability here. It is likely that 24/7 standards will be integrated for tokenised commercial bank money and digital central bank currency due to the availability of 24/7 payments that already exists.

**Payments as information function** can already be executed via conventional payment systems; however, the amount of information is highly limited.

Given that the trigger solution uses the same message formats, no or only very little additional benefit can be expected compared with conventional payments. The additional information required would then have to be transmitted separately outside the conventional payment systems. While private crypto-tokens are applicable from a technical perspective, they are unsuitable for use in the real economy for obvious reasons. Tokenised commercial bank money and digital central bank currency are seen as suitable instruments for payments as information function on the basis of their closed data cycles and reliable system operators.

**Cashless offline payments** could be particularly sought after in the area of peer-to-peer payments and, to some extent, at the point of sale. Although it is currently possible to make offline payments via conventional payment systems, for instance by means of prepaid cards, increasing transaction volumes and extended offline functions are pushing them to their limits. The same applies to offline services offered by private crypto-token providers, the use of which is also limited with regard to issues relating to legal certainty and volatility. A trigger solution without a network connection is currently only viable using "second layer technologies"[6], as the availability of various interface functions must be continuously ensured. While the extensive range of forms that central bank digital currency can take also includes offline payment options, this only applies to tokenised commercial bank money to a limited extent, as the associated standardisation process could present a greater challenge for commercial banks than for a central bank.

In summary:

- ➔ The cash leg settlement of smart contract-based transactions using conventional payment systems is not viable.
- ➔ In principle, 24/7 payments can be covered adequately in the euro area by means of instant payments.
- ➔ Trigger solutions can be used to integrate the settlement of transactions based on smart contracts into conventional payment systems. Although limitations in their implementation and applicability can be expected, trigger solutions are nevertheless generally a suitable payment solution, particularly if they are connected to TARGET2 or TIPS.
- ➔ In some cases, private crypto-tokens and stablecoins are technically capable of settling the cash leg in the use cases presented. However, they currently appear to be rather unsuitable in practice due to volatility, limited interoperability and issues regarding legal certainty.
- ➔ In typical cases, tokenised commercial bank money and central bank digital currency can be considered suitable payment solutions for the use cases presented. However, a central bank digital currency in particular might have far-reaching implications for the role of central banks and needs to be investigated in more detail.

6 Second layer technologies are used to increase the scalability of blockchain solutions. A second layer is built on top of the blockchain (first layer), which does not constantly communicate with the first layer, but takes over the handling of individual processes. Such technologies can be used to help bridge offline periods.
See https://assets.bosch.com/media/global/research/eot/bosch-eot-direct-state-transfer_de.pdf.

Table with an overview of possible solutions for stylised use cases

| | Conventional payments[7] | Trigger to conventional payment systems | Private crypto-tokens (e.g. Ether) and private stablecoins (e.g. Diem) | Tokenised commercial bank money | Central bank digital currency |
|---|---|---|---|---|---|
| M2M | Conventional payment systems are not applicable for smart contracts. | Applicable if eligible for real/near real-time transactions. | Applicable from a technical perspective. Problems with interoperability, volatility and legal certainty hamper a practical application. | Fully applicable under the assumption of a safe, secure and interoperable standard. | Fully applicable under the assumption of a safe, secure and interoperable standard. |
| IoT | (see above) | (see above) | (see above) | (see above) | (see above) |
| Automated settlement payments | (see above) | (see above) | (see above) | (see above) | (see above) |
| Pay-per-Use | (see above) | (see above) | (see above) | (see above) | (see above) |
| Bidirectional clearing | Media disruption often leads to incorrect or incomplete reference data for the clearing process, which requires manual correction. | Media disruption often leads to incorrect or incomplete reference data for the clearing process, which requires manual correction. | (see above) | (see above) | (see above) |
| Cross-border payments[8] | Possible to a limited extent (e.g. via SWIFT), but inefficient and costly. | Possible to a limited extent (e.g. via SWIFT), but inefficient and costly. Furthermore, no scope for optimisation over conventional payments. | (see above) | Uncertain whether all European banks would participate. Therefore, cross-border functionality might be limited. | Uncertain whether central banks across different currency areas would cooperate. Therefore, cross-border functionality might be limited. |

7 Only cashless payments
8 Only cross-currency payments are considered

| | Conventional payments[9] | Trigger to conventional payment systems | Private crypto-tokens (e.g. Ether) and private stablecoins (e.g. Diem) | Tokenised commercial bank money | Central bank digital currency |
|---|---|---|---|---|---|
| 24/7 | Instant payment as basis for 24/7 payments. | Instant payment as basis for 24/7 payments. | (see above) | Fully applicable under the assumption of a safe, secure and interoperable standard. | Fully applicable under the assumption of a safe, secure and interoperable standard. |
| Payments as information function | Possible with a limited scope of information. | Possible with a limited scope of information. | (see above) | (see above) | (see above) |
| Offline payments | Possible to a limited extent. | Possible to a very limited extent. For example, if second layer technologies were applied. | Possible to a limited extent. For example via offline devices (prepaid cards, vouchers, preloaded wallets). | No concrete plans for a design have been revealed yet, therefore the implementation of offline functionalities is not guaranteed. | Design decision on CBDC is still pending, but scope for offline payments conceivable. |

Shaded in green: Payment solution is suitable for the relevant use case; text explains choice of colour

Shaded in yellow: Payment solution is of limited suitability for the relevant use case; text explains choice of colour

Shaded in red: Payment solution is not suitable for the relevant use case; text explains choice of colour

9 Only cashless payments

# 6 Requirements for programmable payments

The evaluation of the payment solutions and the suitability matrix can be used to derive general requirements that should apply to all forms of programmable money, irrespective of the issuer. Universal acceptance as a functional and efficient payment solution for the real economy and the financial sector hinges on the requirements being comprehensively reflected within any implementation measures. The basic principles of the current monetary system should definitely not be changed, nor should the monetary policy toolkit be adapted.

**Monetary stability** must remain the guiding principle of an effective payment and monetary system for programmable money and the execution of programmable payments. The stability of the value of programmable money that an institutional entity must maintain is the basis for those involved to have confidence in the monetary system and the basis for its use for transactions within an economic context.

This approach applies equally to maintaining a **fixed nominal value.** This allows all forms of money in the same currency to be converted on a one-to-one basis, meaning that money can be converted from one form to another without any loss of value and that it remains fully functional as a means of payment, a store of value and a unit of account.

It is equally relevant that programmable payments can be used within a **regulatory framework** that guarantees a technically reliable transfer of units of value for the respective payment solution which is legally sound from a formal point of view. If solutions for programmable payments cannot be integrated into existing legal frameworks, amendments may be needed.

The debate on new settlement technologies and forms of programmable money is led by various interests and different market needs. Nonetheless, a **uniform standard solution** is desirable. If several solutions for settling programmable payments co-exist, the benefits of their use will depend on the **interoperability** of the respective solution. Interoperability can be defined in various ways.

(a) Interoperability between various forms of money, e.g. CBDC to cash and transferable deposits
(b) Interoperability between the contract execution system and the form of money, e.g. trigger solution for central bank money
(c) Interoperability between legally different forms within a class of payment solutions, e.g. CBDC in different currency areas
(d) Interoperability between different DLT protocols, e.g. Corda and Hyperledger Fabric

In general, greater interoperability increases any payment solution's usefulness and scope of application. Assuming DLT systems evolve continuously, a high degree of interoperability is a prerequisite for the adaptability and longevity of the payment solution.

The technological infrastructure for the application of programmable payments and for the transfer of programmable money should also be implemented allowing sufficient **scope for innovation.** The dynamics of digital transformation and the ability of the economy to innovate require a high degree of flexibility and the ability to be able to respond to short-term changes in user and application needs. The application should therefore allow technical developments to be made in line with requirements and not prevent solutions with different technical features from being added. One conceivable option would be implementation options based on open source software. Specialised stand-alone solutions with a limited life cycle should be avoided.

The highest quality standards apply in terms of the operational systems' **information and cyber security.** This encompasses not only highly effective protection against unauthorised system interventions, but also resilience to system disruptions and failures. It is vital that ease of innovation and the use of new technologies should not be detrimental to system security. The experience gained from the operation and level of protection of current payment systems can serve as the model for implementing new payment infrastructures.

In any case, **operators** must be given clear **responsibility**. To this end, a uniquely identifiable operator must assume responsibility for the proper functioning, security and legal conformity of the operational network and meet the requirements of the supervisory and regulatory authorities.

This includes safeguarding **data protection** and the **privacy** of user groups. All transactions and payment processes must meet existing legal requirements for compliance with individual rights to privacy and the applicable data protection regulations. Both programmable payments and transactions with programmable money must meet these requirements. At the same time, it is important to ensure that the level of anonymity does not undermine rules designed to **combat money laundering and the financing of terrorism.** As with cash, the real economy and the financial sector prefer a certain degree of anonymity. It is necessary to differentiate between different counterparties requiring transparency or anonymity:

(a) **Counterparties:** Transparency refers to personal data that are relevant to the contract and are required for a payment transaction to be effected.
(b) **Payment infrastructure:** Limited anonymity vis-à-vis the operator of the payment infrastructure. There must be a justification for the limited anonymity on the basis of operator obligations and operational considerations. This partial anonymity is essential for reasons of competition law, especially if the operator is a private enterprise. Nevertheless, access to partially anonymised information is required in order to be able to fulfil obligations to report transactions that are relevant in terms of money laundering. Any other transfer of information should be prohibited and punishable.
(c) **Government institutions:** Principle of anonymity vis-à-vis government institutions. Exceptions may be defined where the government has a legitimate interest, in particular for the purpose of payments oversight, the combating of money laundering and the financing of terrorism or law enforcement.
(d) **Third parties:** Full anonymity towards third parties.

Programmable payments should be designed to be as general as possible and to grant unrestricted access. However, **inclusion** must not be limited to the economic participation of individuals without access to payment transactions; it should also, where possible, allow people with physical limitations to use them. Additional tactile, optical or acoustic recognition features should therefore be considered. This involves general considerations of user-friendliness, which place simple and practical use at the centre of the design.

Globalisation and digital networking are extending the business hours of enterprises that operate internationally. **24/7 (near real-time/real-time) availability** for the cash leg settlement of transactions is required to allow business processes to be synchronised.

In addition to general requirements, programmable payments and programmable money should have the following specific characteristics that support its use as a transaction medium, in particular:

(a) **Micropayments:** Multiple divisibility in order to be able to settle payments with amounts of less than one cent.
(b) **Feedback function:** Ability to retrieve status messages for the transaction, e.g. introduction, pending, success, decline.

# List of participants of the working group on programmable money

Initiators:
**Dr Jens Weidmann,** President of the Deutsche Bundesbank
**Olaf Scholz,** Federal Minister of Finance
**Burkhard Balz,** Member of the Executive Board of the Deutsche Bundesbank
**Dr Jörg Kukies,** State Secretary at the Federal Ministry of Finance

| Institution | Name |
|---|---|
| Bundesdruckerei GmbH | Sven Marsing<br>Florian Peters |
| DB Systel GmbH | Claudia Plattner |
| Deutsche Bank AG | André Bajorat<br>Alexander Bechtel |
| Deutsche Börse AG | Thomas Wißbach |
| Deutsche Bundesbank | Dr Martin Diehl<br>Constantin Drott<br>Marcus Härtel<br>Dr Heike Winter |
| DZ Bank AG | Claus George |
| Evonik Digital GmbH | Heinz-Günter Lux |
| Frankfurt School of Finance & Management gGmbH | Prof Philipp Sandner |
| Generic.de software technologies AG | Sebastian Betzin |
| Helaba Landesbank Hessen-Thüringen | Philipp Kaiser |
| IBM Deutschland GmbH | Elke Kunde |
| ING-Diba AG | Jürgen von der Lehr |
| Landesbank Baden-Württemberg | Joachim Erdle |
| Main Incubator GmbH (Commerzbank AG) | Michael Spitz |
| MARKANT Services International GmbH | Rene Clasani |
| Robert Bosch GmbH | Ricky Lamberty |
| SAP SE | Alessandro Gasch |
| Siemens AG | Ramin Ghafari |
| Volkswagen AG | Benjamin Sinram |
| Zalando Payments GmbH | Kai-Uwe Mokros |

**Deutsche Bundesbank**
Wilhelm-Epstein-Straße 14
60431 Frankfurt am Main

Postfach 10 06 02
60006 Frankfurt am Main

Telefon 069 9566-0
Telefax 069 5601071
Internet https://www.bundesbank.de