Programmable Payments & Smart Contracts

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Research By Jaskaran Singh

About the Author

Jaskaran has completed his studies from the Frankfurt School of Finance & Management in Frankfurt, Germany. With an extensive experience of living, studying, and working in five different countries namely Germany, US, India, UK, and the Netherlands, he has gained significant international exposure and honed effective intercultural skills. The financial sector has always intrigued Jaskaran, as a result he gained professional experience in some of the most well-reputed firms and banks such as Deloitte, The World Bank, BNP Paribas, and LBBW. He is also a TEDx Speaker and delivered a motivational TED Talk about the 'Aspect of Change'. He was awarded with the title of Outstanding Personality by the city of Frankfurt and the FS Spirit Award by the Frankfurt School for extra-ordinary academic achievements and social engagement. Given his interest in politics, he is also a part of the Konrad Adenauer Foundation which focusses on promoting core values such as democracy, peace, and equality both at national and international level. Jaskaran specializes and enjoys collaborating on projects in the field of financial innovation, financial technology, central bank digital currency and the future of banking and payments. Feel free to get in touch with Jaskaran via the contact details below.

LinkedIn E-Mail Twitter

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1.1 Background & Motivation

The notion of programmable payments is not a radically new one (Gross, 2020). Basic programmable payments such as standing orders or direct debits already exist in our financial system. However, the capability of integrating complex business logic into the payment systems and making them inter-operable with multiple network-connected devices is a fairly new and evolving topic. With the rise of the IoT (Internet of Things) it has become possible (and desirable) to automate repetitive business processes and reduce human intervention as much as possible. Therefore, programmable payments have the potential to transform existing business processes but more importantly create new business models which were unthinkable in the past (Bundesbank, 2020). Settlement of programmable payments is a crucial part the process and is a highly researched topic in the existing literature. Given the current technological advancements, many advocate an instant settlement feature as an integral part of the programmable payments. However, the current available payment protocols such as SEPA or SWIFT do not support instant settlement option. Certain challenges exist in the implementation of programmable payments, however with the massive strides in technology (for example the blockchain technology), research efforts in the instant payment and settlement space and the willingness of the users to embrace convenient payment systems, large scale adoption and implementation of programmable payments can be expected in the future.

1.2 Introduction

Programmable payments can be defined as a set of pre-determined conditions in which the payment is triggered as soon as the conditions are met (Bundesbank, 2020). The conditions need to be developed and agreed upon by both the parties prior to the implementation of the contract. These conditions can then be represented through a smart contract on a blockchain. The use of blockchain technology is particularly well-suited for smart contracts due to the immutable property which eliminates the threats of potential hacks or intentional tampering with the digital contract (Fauziah et al., 2020). Moreover, the blockchain technology completely automates the execution of the smart contract thus eliminating the role of a third-party intermediary and ensuring trust and transparency between the contracting parties. The entire process can be depicted through Fig.1.

Fig. 1: Smart Contracts & Programmable Payments

1.Agreement on Conditions

2. Execution of Smart Contract on Blockchain

3. Payment & Settlement

The concept of programmable payments is not just limited to the last step (step 3) of payments/settlement (see Fig. 1). The preceding steps (step 1 and step 2) form the basis of the inherent logic which triggers the payment. Hence, for a better understanding of programable payments, one needs to understand the above-mentioned process in its entirety rather than just looking at the payment part of the process on a standalone basis.

Step 1 - Agreement on Conditions

- The contracting parties must agree on terms and conditions of the contract which dictate the fulfillment or non-fulfillment of the obligations of the parties involved.

- Given that the contract will be in digital/smart form, the parties must also agree on a suitable blockchain network and how exactly the real-world situations such as centralized observable inputs will be represented on a decentralized blockchain.

- Special attention needs to be given as the contract features agreed upon during this stage cannot be altered, changed, or amended. This may be defined as a strength as well as a weakness of the blockchain technology as it ensures immutability of the data but at the same time leads to limited flexibility in case the contracting parties decide for amendments in the future.

Step 2 - Execution of Smart Contract on Blockchain

- Upon the completion of Step 1, the contractual conditions and obligations can be represented through a smart contract on a blockchain. Based on the programmed logic, the blockchain automatically verifies the conditions of the contract thus eliminating any scope for subjectivity when deciding on the fulfillment of the contractual obligations.

- The smart contract also takes the role of a third-party intermediary which is needed at a time when disputes between the contracting parties arise. In the status quo, it is the judicial system (courts) which are responsible for dispute management. With the implementation of smart contracts, the potential for such disputes reduces tremendously due to the decentralized and immutability features of the blockchain (blockchain as the single source of truth – SSOT).

- The conditions of a smart contract may be based on real-life situations such as weather (in case of weather betting), natural disasters (in case of insurance contracts) or emission levels (in case of emissions tax). Integrating such data into the smart contract requires the need for oracles which could be software-based, hardware-based or consensus-based. The ‘Oracle Problem’ is a relevant

shortcoming in the implementation of smart contracts and will be discussed in detail in the 'critical analysis' section of the paper.

Step 3 – Payment & Settlement

- The predefined logic initiates the payment mechanism in the contract upon the fulfillment of contractual obligations.

- For a seamless process, instant payments are desirable as they ensure instant settlement (delivery versus payment DvP) and reduce counterparty risk. At present, instant settlement can only be done through physical cash. Therefore, there is a dire need to develop a digital instant payment solution which is interoperable with the blockchain technology. There are several instant payment solutions which are in the research and/or development stage such as CBDC, Stablecoins, trigger solutions etc. which will be discussed in the 'current developments' section of the paper.

1.3 Current Developments

End-to-end automation of contracts is in fact the need of the hour. For programmable payments to reach the apex of their potential, an integrated instant payment and settlement leg is necessary which can be triggered by the smart contract. Current research and development in the field suggests various payment methods which can be used for the purpose namely CBDC (Central Bank Digital Currency), trigger solution or Stablecoins (Bundesbank, 2020). Unfortunately, most of these methods are either in their research & development stage (e.g. CBDC) or have probably developed but have not received a green signal from the regulatory authorities yet (e.g. Stablecoins). Detailed analysis of the above-mentioned methods along with their integration/non-integration in the programmable payments space is described below:

1.3.1 CBDC (Central Bank Digital Currencies)

- CBDC refers to the digital representation of the central bank money which previously just existed in physical form as cash (M1). More than 60 central banks around the globe are presently researching on their own CBDC projects with a few jurisdictions which have already implemented their version of CBDC namely the Bahamas, Nigeria and Cambodia (CBDC Tracker, n.d.)

- CBDCs are being developed as a response to the growing demand for an instant digital payment and settlement mechanism which will be a direct liability of the central bank and not of the commercial banks unlike the status quo.

- **Advantages.** CBDC may offer a safe, reliable and low-cost digital payment method which could provide the possibility of inter-operability with different blockchain based platforms for the purpose of payments. CBDC is not expected to face significant regulatory hurdles since it is being developed by the respective central banks themselves.

- **Shortcomings.** Although in their research phase in most major economies such as the US, Europe and East Asia, there have already been indications from the authorities that CBDCs may be built on centralized mechanisms which implies that there could be a central authority which may keep checks on the payment system and significantly control the settlement of transactions. Such a centralized control on the payment leg of a smart contract may have far-reaching implications since it was initially programmed on a decentralized protocol. For example: A smart contract implemented on a decentralized blockchain may fail to serve its purpose if the triggered payment is flagged/not settled by the CBDC system. Such a scenario would refute the essence of a smart contract built on a blockchain since it was intended to be decentralized in the first place. Therefore, the usage of CBDC for the payment leg of the smart contract could entail significant risks.

1.3.2 Trigger Solution

- Given the delay in the roll-out of a functional CBDC system (especially in the Euro Area), private players in the financial industry developed a so called 'Trigger Solution' for the purpose of payments through smart contracts.

- The mechanism of a trigger solution is not complex to understand: Smart contracts are implemented on a decentralized blockchain. As soon as the contractual conditions are fulfilled the payment is 'triggered' on the existing payment protocols namely the SEPA, SWIFT or SIC (Bundesbank, 2020).

- **Advantages.** No additional regulatory approvals are needed for its implementation as the existing protocols are being used in their original form. Additionally, until the roll-out of CBDC or similar instant payment method, trigger solution maybe the most simple and convenient way to enable the use of smart contracts.

- **Shortcomings.** The desired functionality of instant settlement in a smart contract remains untapped as the existing payment systems (SEPA, SWIFT, SIC) do not offer instant settlement options. Similar risk of centralization (as mentioned in the CBDC shortcomings) emerges in the trigger solution since the payment leg of the decentralized smart contract still remains largely centralized.

1.3.3 Stablecoins

- Stablecoins refer to tokens which are pegged to fiat-currencies. Tokenization helps to digitally represent fiat-currencies on a blockchain, which enables the use of tokens as an exchange of value. Examples of established Stablecoins include: Tether, Binance USD, Dai etc.

- **Advantages.** Certain Stablecoins derive their stability from the hard peg to real-world currencies. For example, USDT (Tether Stablecoin) is pegged to the US Dollar where 1USDT ~ 1USD. The programmability of Stablecoins can provide instant settlement functionality as well as inter-operability with the smart contracts, thus making them a potential candidate for programmable payments.

- **Shortcomings.** Regulators have been reluctant towards a single private entity controlling the development and operations of a Stablecoin which in essence can replace the usage of the legal tender of a country. Therefore, regulatory hurdles pose a greater threat to the adoption of Stablecoins as a means of payment and settlement. Another criticism arises from the notion that maintaining a hard peg to real-world currencies in the long run is a challenging task. Historical experience indicates that hard pegs are difficult to sustain for example the CHF to EUR peg was scrapped in 2015 (Moskowitz, 2021). Argentina's hard currency peg to USD was one of the reasons for severe currency crisis in 1990s (Rabobank, n.d.).

The table below (Fig. 2) summarizes the above-mentioned solutions for the purpose of enabling smart contracts with instant payment and settlement functionality and compares them to each other based on the relevant criteria. An additional (4^{th}) category represents the 'Ideal Solution' which may not exist yet but may prove to be the most optimal solution for the purpose. In the absence of the 'Ideal Solution', Stablecoins may be considered as the next best option. However, the rigorous regulatory hurdles for the Stablecoin developers makes CBDC as a more appropriate method.

Fig. 2 Comparison of Instant Payment Methods

	CBDC	**Trigger Solution**	**Stablecoins**	**Ideal Solution**
Currently Available	No (except in select jurisdictions)	Yes	Yes (but face regulatory hurdles)	No
Instant Digital Payment	Yes	No	Yes (expected)	Yes
Instant Settlement	Yes	No	Yes (expected)	Yes

Regulatory Approval	Not Required (as developed by regulators themselves)	Not Required	Required	Required (expected)
Interoperability with external blockchains	Yes (expected)	Yes	Yes (expected)	Yes
Usability with Smart Contracts	Yes (expected)	Yes (in terms of the payment leg)	Yes (expected)	Yes
Decentralized	No (expected)	No (in terms of the payment leg)	Yes/No (depending on the developer of the Stablecoin)	Yes

1.4 Use Cases & Examples

As mentioned in the beginning, programmable payments triggered through smart contracts have the potential to transform existing business processes and at the same time create new business models which were inconceivable in the past. For a comprehensive illustration, 2 examples will be explained belonging to each category i.e. 1) New business model: Pay-Per-Use and 2) Improvement in existing business processes: Supply Chain Efficiencies

1.4.1 New business model: Pay-Per-Use (PPU) (CashOnLedger, 2021)

- Although PPU has emerged as a new business model through the usage of smart contracts, the basic economics behind the concept is somewhat familiar; instead of buying (and owning) capital-intensive machines one could lease them and pay for the exact usage of the machine based on a set of predefined criteria.

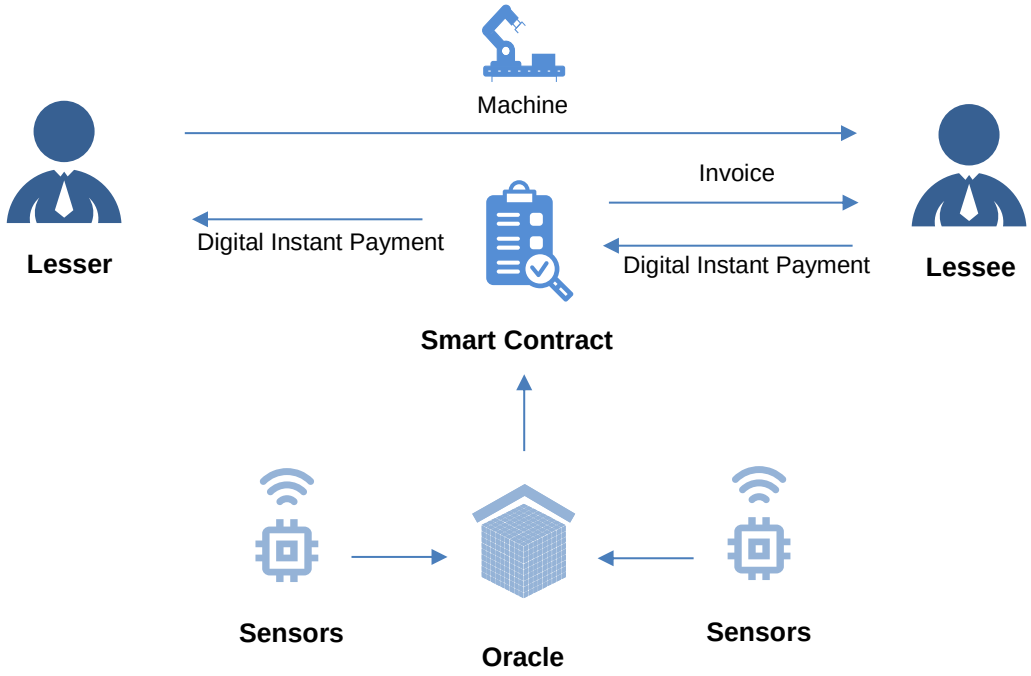
- The predefined criteria can be based on many observable or unobservable (but still sufficiently measurable) inputs of data which can be sourced with the help of software-based or hardware-based oracles. For example: heavy or light usage, emission levels, total running time, total idle time etc. of a machine can be tracked through hardware-based oracles.

- This data can be used by the smart contract to trigger an invoice to the lessee (the person who used the asset), for the purpose of payment based on the exact usage of the machine. The usage criteria is predefined and agreed upon by the lesser and the lessee before the implementation of the smart contract. For the payment leg of the process, the automatically generated invoice can further trigger the deduction of the calculated amount directly from the digital wallet of the lessee and credit it into the digital wallet of the lesser at specific intervals of time for e.g. on a bi-weekly or monthly basis.

- **Advantages & Value Added by the Smart Contract.** The process explained above is an end-to-end automated process with minimal (if at all) human intervention. From an economic perspective, the lesser pays for the exact usage of the asset based on predefined criteria rather than paying a lump-sum amount which could be higher in many cases. From a financial accounting perspective, the lesser is not the owner of the asset, thus preventing huge capital costs and reduced depreciation expense as the asset doesn't appear on the balance sheet of the lessee. For the lesser, several advantages exist as well; a longer-term relationship with the lessee instead of a one-off sale of the asset. Same machine can be used for leasing to other firms based on seasonal demand rather than manufacturing completely new machines which helps in increasing economies of scope and leads to efficient allocation of assets and resources.

- There are already several firms which are active in the PPU business. An example of such a firm is CashOnLedger in Germany which has cooperated with the Lindner Group for leasing tractors to its clients (mostly farmers) on a pay-per-use basis. Detailed information can be found here.

Fig. 3 Illustration Pay-Per-Use Business Model



1.4.2 Supply Chain Efficiencies

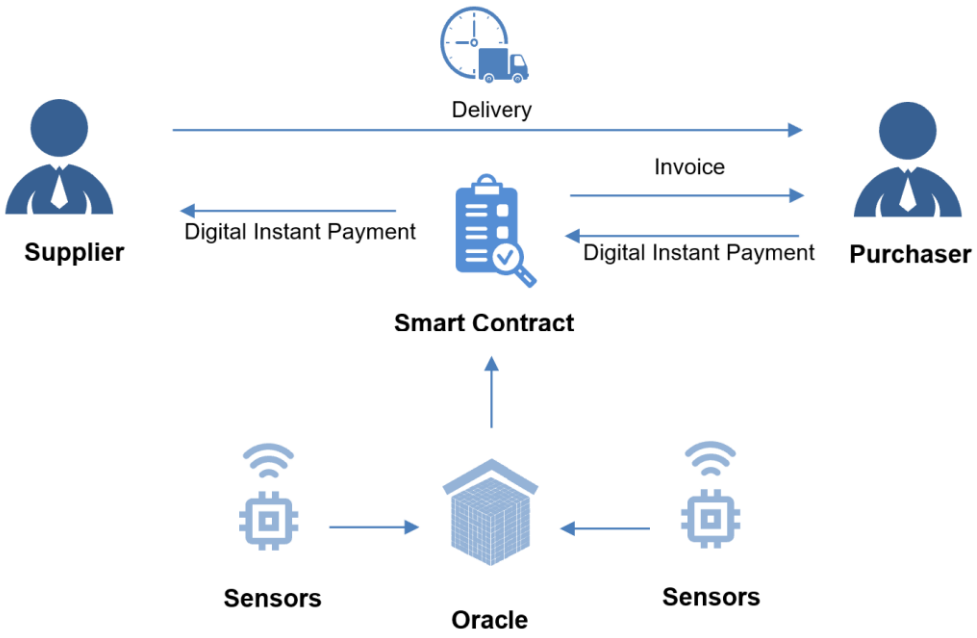
- Supply chains are becoming more and more complex. Timely delivery/adequate supply of goods is becoming even more important in the present economic environment which is prone to inflation shocks as delayed/inadequate supply can lead to a sudden rise in the prices of goods.

- Smart contracts enabled with instant digital payment solutions can be used for the purpose of tracking the consignment of freight arriving through cargo ships or planes and payment can be made in the form of installments based on the progress of the consignment for e.g. for every 1000km of distance travelled, the shipping firm will be paid a 10% installment of the total amount. Alternatively, a delivery versus payment option (DvP) may also be possible in which the shipping firm is compensated for the entire amount at the exact moment when the ship reaches the destination dockyard.

- For such installment and DvP structures to function, a smart contract can be established on a decentralized blockchain which represents the predefined contractual obligations. The data needed for the smart contract can be sourced from hardware-based oracles such as a GPS tracking device on the cargo ship. Additionally, one could even account for weather related delays or accidents by sourcing data from consensus-based weather oracles. Greenhouse gas emissions from the ship can also be identified and hence minimized through the use of oracles.

- **Advantages & Value Added by the Smart Contract.** Counter-party risk is significantly reduced in case of an instant digital payment and settlement mechanism (DvP). The blockchain acts as a single source of truth and creates trust, transparency and coordination between the parties involved. The data provided by oracles accounts for delays of the consignment and creates a data-driven invoice rather than a lump-sum payment. The shipping firm can even be incentivized to ensure timely delivery by putting a condition in the smart contract which allows for bonus payments in case the delivery is completed earlier than scheduled.

Fig. 4 Supply Chain Efficiencies



1.5 Critical Analysis

Although programmable payments have the potential to completely automate business processes, however the gaps in the underlying technology and interoperability barriers make it difficult to fully exploit its benefits. Two such challenges belonging to each category will be discussed below:

1.5.1 Gaps in the Underlying Technology – Data integrity through oracles

- As described in the use cases above, reliable and unbiased data is a crucial part of the programmable payments infrastructure since the validation/non-validation of the data triggers the respective conditions in the smart contract. Therefore, the data fetched by the oracles needs to be accurate and reliable.

- Another issue arises from the fact that many software-based oracles are centralized for e.g. an oracle fetching weather data from a popular weather forecast website. In such a scenario, there is a possibility that the data is biased or inaccurate. Additionally, a centralized website may also be vulnerable to hacks. Faulty data provided by such websites may trigger the contract in favor of one party and to the detriment of the other and hence goes against the principle of decentrality.

- In order to tackle such issues, one could opt for decentralized oracles provided by service providers such as Chainlink which retrieve the data from a network of sources and aggregate the data to ensure its accuracy. In case a particular source is hacked or faulty, the data provided by several other sources would still be reliable since it is unlikely for all data sources to be hacked at the same time.

1.5.2 Interoperability Barriers – Absence of instant payment and settlement system

- The absence of an instant payment and settlement system (atleast in the Euro area) has been a detrimental factor in enabling the smart contracts to reach their maximum potential. Present payments systems (SWIFT, SEPA, SIC) may provide instant digital payments but not instant settlement. Additionally, the existing payment structures are not fully interoperable with smart contracts on a blockchain.

- Interoperability barriers and cumbersome payment settlement may make smart contracts less attractive to the users. Therefore, a fully functional and interoperable instant payment and settlement system is a critical factor in determining the adoption of smart contracts by the users.

- Central banks in various jurisdictions are already developing instant payment and settlement systems in the form of CBDCs. Commercial banks and private technology firms are also coming up

with innovative solutions such as Stablecoins and ‘Trigger Solution’ which act as a bridge and facilitate interoperability between the existing payment systems and the smart contracts.

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