BRINGING CERTAINTY TO PAYMENT EXECUTION IN SMART CONTRACTS

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Abstract: *This is a research conducted on the latest developments in the blockchain technology, which have established smart contracts as a standard form of legal manifestation of business communication. Commercial transactions in B2B environment require stable, predictable and reliable payment mechanism that could enable on-time and full-scale execution of obligations. Successful implementation of payment mechanism that is based on Distributed Ledger Technology (DLT) into smart contracts stands as the next step for final breakthrough of this technology into regular use. The research from this paper is focusing on legal implications of actual technical solutions which could allow self-executing, self-enforcing, and self-remedying of smart contracts.*

1. Introduction

This research emphasize the importance of adequate payment solution for executing obligations in B2B relationships from smart contracts. Creating a payment mechanism that will be compatible with the features of blockchain based smart contracts stands as an important task which could enable automated fulfillment of obligations. We can put the payment issues in the context of game theory, where efficient and accurate payment mechanism could contribute to contractual equilibrium[1] and could help in overcoming hold-up problem where one contracting party makes a sunk, relationship-specific investment and then engages in bargaining with an economic trading partner.[2] If we take for example a smart contract on transport of goods, hold-up problem is being created when the transporter has shipped the goods completely according to contract provisions, but it is still not certain that the sender will make the payment of the transport price and other expenses. Incorporating payment transaction in blockchain technology becomes a higher level of solving this particular hold-up problem. Reason for that is the fact that blockchain technology starts to be considered as a tool for overcoming a hold-up problem.[3]

The main advantage of smart contracts in comparison to traditional written contracts is that they significantly reduce enforcement-related costs and transaction costs, since they execute mechanically what the parties agreed on.[4] The role that well-structured blockchain-based payment mechanism has in reducing transaction costs is off essential significance.

The intention is to build an easy-to-use, highly secure and reliable payment mechanism that will be automatically triggered once the pre-agreed conditions are met. To be able to deliver this it is first required to have a deep analysis of technical framework for digital payment transactions that is in use and development.

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1 Watson, Contract and Game Theory: Basic Concepts for Settings with Finite Horizons, Games 4, 2013.

2 Hermalin/Katz, Information and the Hold-Up Problem, RAND Journal of Economics, Vol. 40, No. 3, 2009.

3 Holden/Malani, Can Blockchain Solve the Hold-up Problem in Contracts?, Cambridge University Press, 2021.

4 Borgogno, Smart Contracts as the (new) Power of the Powerless? The Stakes for Consumers, European Review of Private Law 6-2019, Kluwer Law International BV, The Netherlands.

Obtaining an adequate level of knowledge on technical parameters, especially concrete technical models for constructing payment application is of key importance. The aim of this research is to establish a general idea about the type of architecture that could be used when creating an automated payment mechanism for smart contracts. In this regard we will present some of the publicly available results that have been achieved in several projects.

2. Integration of payment mechanism into DLT

So far, there has been some significant achievements when it comes to integration of developed payment mechanism with the platforms that are run on some type of smart contract. In this process crucial is the agreement on a form in which possible integration between a smart contract and these payment mechanisms could be established in operationally and technically functional manner that will also be in compliance with existing legal framework. Most of the discussions were directed towards existing banking infrastructure and linking it with smart contract or smart legal contract with the help of a bridge solution.[5] This is an account-based solution which benefits from the well-established banking infrastructure and legal certainty of existing legal, regulatory, and compliance frameworks.[6] Other solution is token-based which also brings some significant benefits such as real-time settlement with other assets or DLT-based currencies, tokenization of all kinds of assets, shift of trust from institutions to technology, removing system breaks and increasing automation.[7]

3. Comparative solutions

There had already been recorded an intensive work of different subjects like universities, FinTech companies, banks and other institutions and entities from the financial and scientific sector on creating a solution that could achieve some level of integration between blockchain technology and traditional payment channels. This research will mention some of these results that could represent a roadmap sign to reaching most advanced solution for smart contract‘s payment mechanisms.

There are several latest projects that went beyond test environment and that are being implemented into practice right now. In this research we will also bring focus to some of these projects, which at the final stage could show desirable level of compatibility with the actual payment solution that other ongoing scientific projects are seeking to get. For the purpose of this paper we will examine four different projects which are Blockbaster project, Accenture digital payments, SIX Digital Exchange (SDX) and Bank for International Settlements (BIS) – Project Genesis.

3.1. Blockbaster project

Blockbaster is the name of a project that is being carried on by the Deutsche Bundesbank together with Deutsche Börse, with the aim of building a technical bridge (interface) between a private DLT environment for securities (asset chain) and the Eurosystem’s real-time gross settlement (RTGS) system, TARGET, by using a trigger chain.[8] For understanding the solution to which Blockbaster project partners came, it is impor-

[5] Bechtel/Ferreira/Gross/Sandner, The Future of Payments in a DLT-Based European Economy: A Roadmap, in Heckel, M., Waldenberger, F., (eds.) The Future of Financial Systems in the Digital Age – Perspectives from Europe and Japan, Springer, 2022, available at https://link.springer.com/content/pdf/10.1007/978-981-16-7830-1.pdf.

[6] Bechtel/Ferreira/Gross/Sandner, The Future of Payments in a DLT-Based European Economy: A Roadmap, in Heckel, M., Waldenberger, F., (eds.) The Future of Financial Systems in the Digital Age – Perspectives from Europe and Japan, Springer, 2022.

[7] Bechtel/Ferreira/Gross/Sandner, The Future of Payments in a DLT-Based European Economy: A Roadmap, in Heckel, M., Waldenberger, F., (eds.) The Future of Financial Systems in the Digital Age – Perspectives from Europe and Japan, Springer, 2022.

[8] Deutsche Bundesbank, Digital money: options for payments, Monthly Report, April 2021, available at https://www.bundesbank.de/resource/blob/865166/f28d25bc79a5c78c7cf67d8002b78c81/mL/2021-04-digitales-geld-data.pdf.

tant to be aware of the fact that only money in tokenized form can be transferred through distributed ledger technology (DLT).[9] In addition to this there is also a distinction between programmable payments and programmable money.[10] By looking at the proposed solution for automatized payment triggering, the impression can be made that it very much relies on conventional architecture of trading platforms that is being used at the stock exchange environment when trading with securities and other financial instruments.

The trigger solution offered by Blockbaster project meant that it was possible for primary and secondary market transactions between multiple market participants to be settled in TARGET2 on a delivery-versus-payment (DvP) basis using smart contracts.[11] According to project partner's claim, trigger solution could be used for asset chains of any kind, given the fact that it is a technology neutral approach.[12] This statement leads to the very possible outcome which could enable similar solution for other B2B transactions, where the only difference would require that instead of securities we have actual goods that are being involved in transaction. Similar to other commercial contracting models, Blockbaster project is dealing with the participation of multiple entities in the payment mechanism that is being triggered. Two participants in the payment execution are represented by two software modules, out of which one is a trigger chain from the Bundesbank and the second is transaction coordinator from Deutsche Börse.[13] These two software modules mutually connect TARGET2 and a DLT securities system.[14] Final outcome in the form of DvP settlement of the securities and central bank money, only takes place when all the parties involved have confirmed the transaction.[15]

Even though this project introduces DLT-based system, it doesn't rely solely on this particular architecture. This project integrates a DLT-based system with the conventional payments space, which is run by commercial banks. This fact is also very important, because companies are thriving for a hybrid solution for making payments that will integrate traditional financial institutions' services and blockchain based payment platform. According to Blockbaster project proposition, there is "asset chain" and "trigger chain" that are run parallel and in interconnection. "Asset chain" is being formed between two enterprises and "trigger chain" circulates between two banks, each representing enterprise from "asset chain".

It is possible to imagine a successful application of similar solution to payments that ought to be done in other B2B transactions. We can take for example contract on transport of goods from the German Commercial Code (Handelsgesetzbuch - HGB) and the process of calculation and payment of transport price. According to article 407, paragraph 2 of HGB the sender is obliged to pay the agreed transport price. Article 420, paragraph 1 of HGB states that the freight is payable upon delivery of the goods. In addition to the freight, the carrier is entitled to reimbursement of expenses insofar as these were made for the goods and he was allowed to consider them to be necessary under the circumstances. Other paragraphs of the same article are also prescribing other possible elements that could be taken into account when calculating the transport price. In this case the "asset chain" is being formed between the transporter and the sender of goods, with the assumption that all the elements that are important for calculation and execution of the payment which arise from the HGB provisions are pre-arranged. This particular "asset chain" that is run on DLT-based platform is supported by the "trigger chain" that is executed by corresponding banks. Because of interaction between "asset chain" and "trigger chain" banks are able to get notification when the trigger has been activated and accordingly execute the payment when "asset chain" is complete and unbroken.

In its essence, this solution translates blockchain based payment technology from the capital market environment to the usual business transactions between companies that are producing, buying and transporting actual

[9] Deutsche Bundesbank, Digital money: options for payments, Monthly Report, April 2021.
[10] Deutsche Bundesbank, Digital money: options for payments, Monthly Report, April 2021.
[11] Deutsche Bundesbank, Digital money: options for payments, Monthly Report, April 2021.
[12] Deutsche Bundesbank, Digital money: options for payments, Monthly Report, April 2021.
[13] Deutsche Bundesbank, Digital money: options for payments, Monthly Report, April 2021.
[14] Deutsche Bundesbank, Digital money: options for payments, Monthly Report, April 2021.
[15] Deutsche Bundesbank, Digital money: options for payments, Monthly Report, April 2021.

goods. It is worth to emphasize that high standards exist for the security of transactions on capital markets and on EU level it is being oversight by several authority bodies. Here the focus is on protecting investors and maintaining a considerable level of trust in safe and credible execution of transaction. The fact that blockchain technology already got a significant role in this regulatory strict business area makes it reasonable to actively consider applying these technical solutions from capital markets to other B2B transactions.

3.2. Hashed Time-Lock Contract (HTLC) and Jasper – Ubin Project

In addition to payment projects like Blockbaster project, there are also other very successful projects that could be examined as a use case of DLT based payment systems. In this part of research paper we will direct our attention to three projects that have DLT based payment system as their primary research area. First of them is Jasper – Ubin Project which has Hashed Time-Lock Contract (HTLC) as a bearing element of its architecture.

Jasper – Ubin project was jointly developed by the Bank of Canada and the Monetary Authority of Singapore, with significant contribution of J.P. Morgan and Accenture. These four project participants embarked on the Jasper-Ubin Project, a technology-based experiment to realize this all-or-nothing guarantee through an atomic transaction for a Canadian Dollar (CAD) - Singapore Dollar (SGD) payment across two distributed ledger technology (DLT) platforms based on Hash Time-Locked Contracts (HTLC).[16]

Central part of this project which enabled the project success was the use of Hashed Time-Lock Contract, a cryptographic technique, to move assets across different networks in an all-at-once or not-at-all way.[17] A Hashed Time-Lock Contract (HTLC) is a transactional agreement used in the cryptocurrency industry to produce conditional payments.[18] It is basically a payment wherein the receiver or the beneficiary is required to acknowledge the receipt of payment before a predetermined time or a preset deadline.[19] Validity of the payment is secured by automatic return of the payment to the sender if the receiving party fails to acknowledge the receipt of payment before a deadline. The receiver of the payment either acknowledges receiving the payment prior to a deadline (timeout) by generating cryptographic proof of payment (hash lock) or forfeits the ability to claim the payment, which results in the payment being returned to the payer.[20] HTLC eliminates the need for third-party intermediary and creates environment for real-time payment transaction to be executed in the least complex way. HTLC is a type of smart contract that has two elements that define it, the hash-lock and the time contract. The person that initiated the transaction is generating a public key, which is then hashed or cryptographically scrambled.[21] After that, the associated private key is used to unlock the original hash.[22] Time-lock as the second important element of HTLC is being implemented in two versions. The first one is CheckLockTimeVerify (CLTV) which uses a time base to lock and release the payment and the second one is CheckSequenceVerify (CSV) which uses the number of blocks generated as a tracking measure to determine when to finalize a transaction.[23]

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16 Bank of Canada/Monetary Authority of Singapore/J.P. Morgan/Accenture, Jasper – Ubin Design Paper: Enabling Cross-Borger High Value Transfer Using Distributed Ledger Technologies, 2019, available at https://www.mas.gov.sg/-/media/Jasper-Ubin-Design-Paper.pdf.

17 Jaan, Payments with distributed ledger technology: A new frontier in payments, 2019, available at https://www.accenture.com/us-en/insights/banking/pushing-payments-forward.

18 Corporate Finance Institute, Hashed Time-Lock Contract (HTLC), 2021, available at https://corporatefinanceinstitute.com/resources/knowledge/other/hashed-timelock-contract-htlc.

19 Corporate Finance Institute, Hashed Time-Lock Contract (HTLC), 2021.

20 Bank of Canada/Monetary Authority of Singapore/J.P. Morgan/Accenture, Jasper – Ubin Design Paper: Enabling Cross-Borger High Value Transfer Using Distributed Ledger Technologies, 2019.

21 Frankenfield, Hashed Timelock Contract (HTLC), Investopedia, 2022, available at https://www.investopedia.com/terms/h/hashed-timelock-contract.asp.

22 Frankenfield, Hashed Timelock Contract (HTLC), Investopedia, 2022.

23 Frankenfield, Hashed Timelock Contract (HTLC), Investopedia, 2022.

Except of this project, Accenture was part of another project for real-time gross settlement (RTGS) token-based exchange. It is collaboration between Accenture, SAP and R3 that resulted in designing RTGS prototype that uses currency tokens to facilitate end-to-end settlement.[24] DLT platform that is used in this case was also Corda and it was facilitated by R3. The aim of this prototype was to allow for integration and interoperability between DLT-based and classic government-issued payments and settlements.[25]

These two projects represent two approaches to DLT payments. Fist project is account-based while other is token-based payment mechanism. Both projects had been successfully launched into use and by making analysis scientific public is in the position to determine which approach would be best suited for further development and application on other use cases.

3.3. SIX Digital Exchange (SDX): Projects Jura and Helvetia

A similar distinction between account-based and token-based DLT payment mechanism can be seen in two projects run by SIX Digital Exchange (SDX) which is Swiss' main provider of financial infrastructure services. In September 2021, SIX Digital Exchange (SDX) received regulatory approval from the Swiss Financial Market Supervisory Authority (FINMA) to operate a stock exchange and central securities depository for digital assets in Switzerland. This authorization enabled SDX to go live with a fully regulated, integrated trading, settlement, and custody infrastructure based on DLT for digital securities.[26]

In December 2021 Banque de France (BdF), Swiss National Bank (SNB) and Bank for International Settlements' (BIS) Innovation Hub have successfully completed Project Jura, an experiment in cross-border wholesale CBDC, in collaboration with Accenture, Credit Suisse, Natixis, R3, SIX Digital Exchange and UBS.[27] Project Jura was exploring delivery versus payment (DvP) of a tokenized commercial paper issued under French law against a EUR wCBDC and a payment versus payment (PvP) of a EUR wCBDC against a CHF wCBDC.[28] According to available data, real-value payments and settlements under the existing legal and regulatory frameworks have been successfully executed within the project. Making cross-border settlements using multiple wCBDCs faster and efficient and issuing wCBDC on a third-party platform were two main outcomes of this project.

Research that was conducted in Project Jura was further continued through Project Helvetia and this project saw participation of Bank for International Settlements (BIS), the Swiss National Bank (SNB) and SIX Digital Exchange, accompanied with five commercial banks: Citi, Credit Suisse, Goldman Sachs, Hypothekarbank Lenzburg and UBS.[29] Exploring possibilities of tokenization of financial assets and running financial infrastructure on DLT along with real-time gross settlement and core banking systems took main part in the experiment that was done in Project Helvetia. Leading intention of this project was to create and test DLT platform which is able to support wholesale CBDC for settling tokenized assets end to end. These were the results of phase I and II of Project Helvetia and they could be very useful for reaching industrial agreement on payment solution, if any part of token-based payment mechanism gets accepted as a solution.

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[24] Accenture, Accenture and SAP Build Prototype that Uses Distributed Ledger Technology to Enable More Efficient, Secure and Reliable Payments Between Banks and Customers, 2019, available at https://newsroom.accenture.com/news/accenture-and-sap-build-prototype-that-uses-distributed-ledger-technology-to-enable-more-efficient-secure-and-reliable-payments-between-banks-and--customers.htm.

[25] Accenture, Accenture and SAP Build Prototype that Uses Distributed Ledger Technology to Enable More Efficient, Secure and Reliable Payments Between Banks and Customers, 2019.

[26] https://www.sdx.com/news/six-digital-exchange-gets-regulatory-approval-finma.

[27] https://www.sdx.com/news/bdf-snb-bis-and-six-digital-exchange-successfully-complete-cross-border-wcbdc-experiment.

[28] https://www.sdx.com/news/bdf-snb-bis-and-six-digital-exchange-successfully-complete-cross-border-wcbdc-experiment.

[29] https://www.sdx.com/news/bis-snb-and-six-successfully-test-wholesale-cbdc-settlement-banks.

3.4. Bank for International Settlements (BIS): Project Genesis

Bank for International Settlements (BIS) was involved in both projects described in previous section of this paper. Precisely it was BIS Innovation Hub, a separate unit within BIS which identifies critical trends in technology affecting central banking. BIS Innovation Hub is investing its views and knowledge on improving the functioning of the global financial system into these projects. In addition to this, BIS Innovation Hub together with the Hong Kong Monetary Authority (HKMA) developed two prototype digital platforms for issuing and trading with green bonds, bonds which will develop a green project.[30] Both prototypes are using blockchain infrastructure, the first relying on a permissioned distributed ledger platform and second using permissionless blockchain.

A second prototype managed to streamline the investor onboarding and facilitated the direct payment and settlement between the bond issuer and investor.[31] For facilitating payments this prototype uses fiat representation of cash tracked on-chain within the prototype to represent the individual payment obligations of each user. Prototype simply tracks a payment obligation in relation to the digital green bond asset. In order to make the bond payment, a user has to open a cash wallet that is managed within the platform and upon purchase of the bonds, the funds will be exchanged for the assets between the utility accounts in real time. At any time, funds can be withdrawn from the platform by a user in which the corresponding amount of money will be wired into their designated bank account from the utility trust account.[32] The prototype implements a basic on-chain cash equivalent that allows the digital green bond to be exchanged directly within the asset ledger.[33] Advantages in payment domain that this prototype has are contained in possibility to use traditional, fiat-based settlement, as well as atomic delivery versus payment (DvP) settlement by using native, on-ledger payment modes, for example stablecoins.[34] The prototype itself is set on Stellar Network, a public blockchain-based distributed ledger and can be connected to other DLT networks.

Project Genesis with its two prototypes stands as a well-structured innovation endeavor that brings new approach to digital payments. By its virtue this approach has its ground in financial markets and the way this commercial ecosystem creates and uses reliable and efficient payment mechanism.

4. Conclusion

We are able to see that trends in payment service industry are shifting with many entities starting from government bodies and central banks to private providers entering the discussion on improvement and implementation of digital payments. Instant payments so far have been mostly directed to C2B relations and enabling companies to receive payments from customers, leaving B2B not that well cowered.[35] Reason for this is that these transactions have proven to be much more complex with slightly different regulatory framework that is applied to them. DLT based payment schemes on the other hand reached higher level in the process of creating solutions that could facilitate B2B payment transactions. Especially in cross-border payment cases, main features of DLT such as immutability, technical synchronization of all servers participating in the ledger which increases the speed of technical processing, multilateralism of the system, and transparency are all assisting in removing or lowering barriers to efficient cross-border payment such as high costs, lack of speed, limited access and lack of transparency.[36]

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30 https://www.bis.org/about/bisih/topics/green_finance/green_bonds.htm.

31 Bis Innovation Hub, Project Genesis – Report 2: A prototype for green bond tokenization by the Liberty Consortium, 2021, available at https://www.bis.org/publ/othp43_report2.pdf.

32 Bis Innovation Hub, Project Genesis – Report 2: A prototype for green bond tokenization by the Liberty Consortium, 2021.

33 Bis Innovation Hub, Project Genesis – Report 2: A prototype for green bond tokenization by the Liberty Consortium, 2021.

34 Bis Innovation Hub, A prototype for green bond tokenization by Digital Asset and GFT, 2021, available at https://www.bis.org/publ/othp43_report3.pdf.

35 However there are some exceptions to this, one being Deutsche Bank's "Seal Solution" that is offered to their large customers. For detailed presentation on this payment project see OSTOJA-STARZEWSKI, Bargeldloser Zahlungsverkehr für automatisierte B2B-Zahlungen im Industrie 4.0-Blockchain-Netzwerk, Saarbrücken, 2022.

36 Zetzsche/Anker-Sørensen/Passador/Wehrli, DLT-Based Enhancement of Cross-Border Payment Efficiency: A Legal and Regulatory Perspective, BIS Working Papers No 1015, Bank for International Settlements, May 2022, available at https://www.bis.org/publ/work1015.pdf.

Within these solutions, mechanisms that come from financial markets, in particular payment settlement for financial instruments are standing out with their technical creativity and legal compliance. Several projects, initiatives and use cases of this kind have been presented in this research paper. Depending on their main features, further discussion on their acceptability for the whole commercial B2B transactions could be opened.

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