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CONCEPTUAL FRAMEWORK OF A PROJECT BANK ACCOUNT (PBA) BLOCKCHAIN PAYMENT APPLICATION FOR THE CONSTRUCTION INDUSTRY

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Abstract

The UK government published a guidance document in 2012 stipulating the use of project bank accounts (PBA) to promote fair and prompt payment practices in the construction industry. PBA utilises a project-specific escrow bank account to provide greater cash flow auditability and mitigate cascading payments down the supply chain. However, PBA is bureaucratic to manage and costly to set up. This paper will investigate whether blockchain can be used as an alternative system for executing PBA payments.

Introduction

The construction industry has a longstanding bad reputation for managing project payments (Ali, 2006). Statistics from the UK's leading retail payment authority suggest that 78% of small and medium enterprises are forced to wait 30 days or longer beyond agreed payment terms (Pay.UK, 2019a). Commercial solutions that have attempted to mitigate this include parent company guarantees, and collateral warranties (Cheng et al., 2010). However, these do not solve the problem because these guarantees/warranties take many months to process, and typically, when a payee makes a claim, it is because the liability is already several months overdue. Therefore, more immediate solutions are required to remedy the bureaucratic payment processing systems that are existent in throughout the construction industry.

Data from the UK National Office of Statistics in 2019 suggests that for every large company in the construction industry, there are an average of 1,000 small and medium enterprises (SMEs) (Office_for_National_Statistics, 2019). This imbalance creates over-competition and forces subcontractors to accept unfair contractual conditions, such as high-risk work for less pay, and tolerance for late payments (Gruneberg and Ive, 2000). Solving the payment problem would increase the stability of the construction industry by improving cash flow management, resulting in reduced project risk (Kenley, 2003).

Software systems in the construction industry do not interoperate effectively; for example, project payments that have been approved for processing cannot directly trigger a payment execution with the banks' software system. This leads to more stages of data management in an industry that is already overly bureaucratic. However, automating payments alone will not solve the payment problem. A greater problem exists in construction contracts and inefficient management structures. In construction projects, the client is not penalised for overdue payments to the main contractor, and there is a lack of auditability with how the main contractor manages cash flow, whereby, they strategically withhold payments to subcontractors to increase cash flow stability, at the cost of financial instability to the subcontractors. PBA mitigates the main contractor from unfairly withholding payments, however, it also creates an additional management task, and banks charge high fees for permitting the use of PBA. Additionally, not all banks provide the service.

The first documented use of a PBA in a construction project was in 2005, through a joint venture between the UK Ministry of Defense (MOD) and a UK main contractor. The PBA was created to increase the auditability of government funds throughout the entire project (NationalAuditOffice, 2005). However, it took until 2012 for the UK government to capitalise on its benefits and promote its use in projects, through the publishing of an official guidance document on its implementation (CabinetOffice, 2012a). It instructs the partitioning of the project account away from the main contractor to mitigate against the unfair withholding of liabilities, and alleviates payments from having to cascade down the supply chain; furthermore, it protects subcontractors and suppliers against the risk of the main contractor becoming insolvent (CabinetOffice, 2012b).

Research question

The research question of this paper is: What is the potential for the PBA to be hosted on the blockchain? What systems will it incorporate? And how will project participants interact with it?
In response to the 3-part question research question, this paper presents a conceptual framework that amalgamates blockchain with PBA to automate the processing of supply chain payments, without using the bank as the intermediary to host the PBA. In the proposed framework, the PBA account is represented by a smart contract that controls the release of funds from the client to the supply chain upon signed approvals from validating authorities. These signed

approvals are in the form of cryptographic signatures that are signed with the account address of authorised parties (E.g., project manager, and client). This article discusses at high-level, the process flows of the PBA blockchain framework and the responsibilities of each transacting party in the system. The discussions chapter will outline the benefits and limitations of the proposal, and whether its contribution brings value to the construction industry.

Background

One of the earliest publications on the detrimental effects of late payments in the construction industry was the 1964 Banwell report (Banwell, 1964). The industry is known for having a lack of trust caused by poor procurement, cash flow, and collaboration (Tai et al., 2016). As a result, clients are hesitant to take on new work because of undisclosed risks and tight margins (McDermott et al., 2005). This results in projects being selected based on cost instead of long-term value.

The construction industry is a big contributor to global GDP (Gross Domestic Product); however, it has the potential to increase its contribution through revising outdated processes, such as bureaucratic management structures, and updating legacy technology systems (Wu et al., 2008). Innovation remains a perpetuating problem despite efforts in digitalization, such as the lack of widespread adoption of BIM (Xu, 2019). Project participants in the construction industry transact and communicate through fragmented systems that do not integrate effectively (Safa et al., 2019). These systems suffer from a lack of transparency and traceability, which limits the ability to accurately log and report data (Safa et al., 2019). Despite this, the industry is pushing towards greater standardization to increase productivity through bodies such as the International Standard Organisation (ISO), Industry Foundation Class (IFC) by buildingSMART, and governmental mandates for BIM (Hargaden et al., 2019).

The construction industry is dominated by a small selection of main contractors who provide work for many SMEs (small and medium enterprises). This causes over-competition and provides main contractors with unfair controlling authority over the supply chain (Cui et al., 2010). SMEs are forced to accept unfair contractual conditions with overextended payment terms due to the hierarchical nature of the industry; whereby, contractors exercise *cash farming* techniques and *pay when paid* clauses (Kenley, 2003). Cash farming is a strategy implemented by contractors to improve internal cash flow at the cost of delayed payments to their supply chain; furthermore, it allows the project budget to be used for investing in new work rather than paying outstanding debts (Gyles et al., 1992). Despite the benefits of cash farming to contractors, it is the primary cause of SME insolvencies (Lowe and Moroke, 2010).

Data from the Office of National Statistics suggest that the average quantity of individual insolvencies in the UK construction industry is recorded at 2,595 cases annually, accounting for 18% of the overall insolvent population in the UK, and the highest across all other industries (HM_Government, 2021). The danger of bad cash flow management is exemplified by the demise of Carillion, the second-largest construction company in the UK in 2017 (based on turnover); however, when it liquidated in 2018, it owed GBP 1.3 billion worth of liabilities to SMEs (Thurley et al., 2018). From 2009 to 2018, Carillion's debt increased from GBP 242 million to GBP 1.3 billion; furthermore, they imposed payment terms of 120 days to SMEs, which is four times the duration of what is typically agreed upon in construction contracts in the UK (Hajikazemi et al., 2020).

Project bank account (PBA)

The first recorded use of a project bank account (PBA) in a construction project was in 2005, through a joint venture between the UK armed forced client, Defense Estates, and a UK main contractor (NationalAuditOffice, 2005). The PBA was set up due to the adversarial nature of the construction industry, and the client having a trusting relationship with the subcontractors (NationalAuditOffice, 2005). The result was successful, with PBA managing all payments to subcontractors on time and within the agreed budget; furthermore, all expenditures were openly auditable throughout the entire construction process (NationalAuditOffice, 2005).

According to the "UK Office of Government Commerce report on PBA implementation, clients can save up to 2.5% on public sector projects (OfficeGovCommerceUK, 2007). PBA was trialled in the public sector between 2012 to 2015 and was used to manage over GBP 4 billion worth of work (CabinetOffice, 2012b). In 2013, the government of Northern Ireland, in conjunction with the Central Procurement Directorate, mandated the use of PBA in construction projects worth over GBP 1 million; similarly, in the same year, Wales mandated the use of PBA in projects worth over GBP 2 million (Hooks, 2019). In a typical construction contract, main contractors customise contract clauses to protect themselves against legal disputes (Theodore, 2009). A barrier to SMEs requesting PBA in construction contracts is the fear of potential reprisal from contractors, such as exclusion from future work (Brand and Uher, 2010). In a questionnaire conducted by PhD researcher Rachel Griffiths and Wayne Lord from Loughborough University, on the topic of PBA adoption, consisting of a combination of 58 main and subcontractors, 42% voted *fear of reprisal* as the principal factor preventing the adoption of PBA, followed by *legal expenses* (34%) and culture of

industry (25%) (Griffiths et al., 2017). Standard forms of contracts include various certifications, valuations, and compliance checks that require amending to suit the implementation of PBA (Griffiths et al., 2017). However, the UK governmental department, the Cabinet Office, asserted that PBA would not cause interference with contract valuations and certifications (CabinetOffice, 2012a). Removing the ability for main contractors to perform cash farming (through PBA) promotes responsible working practices (CabinetOffice, 2012a). Progress on the uptake of PBA in existing contracts such as NEC, JCT, and FIDIC has steadily increased; however, PBA is challenging to enforce across all built environment contracts due to the variety of project types and complexities of agreements in construction projects (Penzes, 2018). The PBA concept of ring-fencing the project account contributes to mitigating a long-standing payment problem in construction, which includes cascading payments down the supply chain, late payments, and cash farming (Ing, 2019).

Blockchain includes the potential to integrate with PBA to automate the processing of supply chain payments through smart (automated) contracts (Li and Kassem, 2018b). Benefits include reduced administrative processing delays and increased transaction traceability (Wang et al., 2017). Payments can be automated through preprogrammed functions that control the execution of transactions; furthermore, these codified instructions can be audited by regulatory controls to ensure compliance with standards and project specifications (Cohn et al., 2017). The inbuilt properties of the blockchain (such as immutability and traceability) make it a trusted medium for value transfer, and it provides reliable data for dispute resolutions (Shumsky, 2019). Data stored on the blockchain can integrate with enterprise systems through an application programming interface (API) that relays blockchain data to proprietary software systems (Shojaei, 2019). Blockchain operates using a shared technology protocol layer that allows diverse types of applications and systems to integrate efficiently, reducing reliance on intermediary technology systems (Higginson et al., 2019).

Methodology

Existing UK government payment charters were investigated to assess whether blockchain could provide value through data trust, automation, and transparency, which are some of the key benefits of blockchain. These included reviewing the "revised prompt payment code", published in 2021, which enforces that overdue payments cannot exceed 30 days (CICM, 2008); the 2013 "revised late payments of commercial debts regulations", which allows payees to charge 8.5% statutory interest on invoices that have been left unpaid for 30 days (CICM, 2008); the "supply chain finance scheme", established in 2012, which allows small and medium enterprises to obtain finance at lower interest rates, provided that they provide signed proof of approved invoices (GovUK, 2012); and finally, the PBA guidance document, published in 2012, which stipulates the use of an escrow bank account for managing project funds (CabinetOffice, 2012b). Of these, PBA was identified as the most suitable to benefit from blockchain. Additionally, (Li et al., 2019) conducted a focus group interview of experts in the construction industry, on the topic of PBA with blockchain, and the results showed that blockchain would reduce cost, increase payment speed, and improve reliability.

Conceptual framework

A simulated video walkthrough of the proposed application is available on: https://www.youtube.com/watch?v=mwAAAhnowxQ. The application is also available for testing on: https://console.atra.io/app/bf26f846-7f16-4f80-90a0-c5488ab6edd3/0.

The numerical annotations, shown below, are to be read in conjunction with the Figure 1 diagram that is displayed on the following page. It illustrates the actions of each participant and system in the framework. The simulation was developed on the Atra blockchain platform, which allows users with no coding experience to deploy and test applications, through templates that are predefined on the site.

1. Client: The client would be responsible for approving the project budget through a PBA blockchain application user interface. The user interface would allow them to execute blockchain transactions from their digital wallet. Furthermore, it allows the client to appoint a project validator (such as a project manager), whose role includes validating the supply chain's completion of works and appointing new project participants.

2. Project bank account (PBA) payment application: The PBA blockchain application allows participants to conduct transactions, approve completion of works, and assign project participants. This occurs through the interoperability of a decentralised database, blockchain, and user interface.

3. On/Off-chain database: Data such as signed messages can be stored either on-chain in a smart contract, or off-chain in a decentralised database (Bai et al., 2019). For simplicity, the off-chain variant, the decentralised database, will be used hereinafter.

4. Blockchain: The blockchain would autonomously receive signed messages from the off-chain database when a transaction is required for execution. The data input field of on-chain transactions can be used to store validation signatures, or IPFS hash links, which can be used to store project data (Davies et al., 2020). The data stored on the blockchain can integrate with enterprise systems through an application programming interface (API) that relays blockchain data to proprietary systems (Tempesta, 2019).

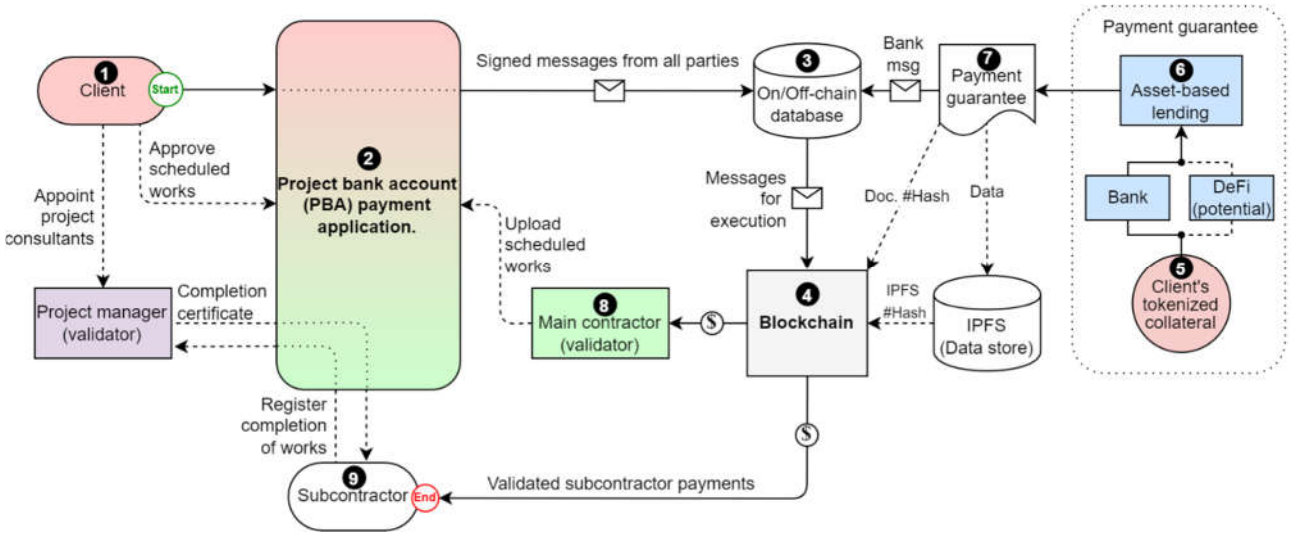

Figure 1. Project bank account (PBA) blockchain framework.

5. Client's tokenized collateral: Although tokenizing assets through blockchain is a new concept, it provides the client with the ability to tokenize assets on a blockchain platform to provide collateral against non-payments. In response, a bank can provide the client with finance in exchange for tokenized securities, whereby, if a non-payment event is triggered, then the bank would maintain hold of the client's tokenized securities until the overdue balance is paid. Major banks such as HSBC, JP Morgan, Bank of China, China Construction Bank, and Santander have been tokenizing billions of USD worth of blockchain-based securities since 2019 (Security_Token_Advisors, 2020). Alternatively, decentralised finance (DeFi) is another nascent blockchain-based service that emerged in 2020, introducing collateralized peer-to-peer borrowing/lending through a decentralised network (Mitra, 2019). However, due to the nascency of blockchain, DeFi currently lacks regulatory maturity, thus it is difficult to integrate into the current environment. Therefore, any blockchain-based payment guarantees are likely to arise from the integration of existing banking systems with blockchain.

6. Asset-based lending: Asset-based lending is an existing service offered by banks to provide compensation to the client in the event of non-delivery from the contractor, similarly, contractors also obtain payment guarantees to insure against non-payment from their client (Chovancova et al., 2019). Both compensation events are implemented in construction contracts to hedge against risk, however, banks charge high fees for providing it (Maritz, 2011). Stock Exchange Group, IBM, and Borsa Italiana are collaborating to develop an asset exchange platform hosted on the blockchain, allowing enterprises to tokenize securities without having to use the services of a bank (Biedrzycki, 2019).

7. Payment guarantee: A payment guarantee is an administratively time-consuming activity to process when a payout is required, as it requires the bank to refamiliarize itself with agreements that were signed many months in advance (Chovancova et al., 2019). This delay can be mitigated through the bank creating a smart contract that automates the payout. The signed cryptographic messages that instruct the execution of funds can be stored either on-chain in a smart contract, or off-chain in a decentralised database.

8. Main contractor: Through PBA, the main contractor is relieved of their responsibility as the sole proprietor of the project budget. Their main responsibility in the proposed framework is to insert and manage activities that are stored in the off-chain database. A user interface would allow participants to interact with the blockchain to approve/validate works. Successful validations permit the flow of transactions from the off-chain database to the blockchain.

9. Subcontractors: Once subcontractors register completion of works through the PBA application, this autonomously notifies validators of their responsibility to approve works. To protect against negligence from validating parties, an automated reward/penalty system can be embedded into the application to stimulate user activity, such as the main contractor updating the project schedule, and the project manager approving completed works.

Discussion

When the client approves the project budget through a signed cryptographic message that is instantiated through the PBA application, this can be used as part of a promissory note that guarantees financial certainty to the supply chain. It is envisaged that the client's signed message could integrate as part of a formal digital document to provide legal certification of good payment practices.

The proposed framework imposes automated finance to the client based on their unpaid liabilities; however, clients are likely to dispute this, as they are not typically penalised for late payments. To combat

this, interest obtained through late payments could be included as part of the project budget, and reimbursed to the client upon project handover, like retentions. Incentives for the client to use the PBA blockchain application include the ability to provide payment guarantees, accounting automation, and immutable provenance of events.

Some of the risks associated with blockchain include incorrectly written code and malicious hacks. If project funds are stolen or misplaced, it is extremely difficult to retrieve due to the decentralised nature of blockchain. Furthermore, insurance against blockchain-related cybersecurity attacks is difficult to attain due to the nascency of the technology.

Due to the volatility of cryptocurrencies, payments would need to be conducted through stablecoins or central bank digital currencies (CBDC). CBDCs are blockchain-based reproductions of a national currency, issued and managed by the government. However, it is currently in the testing stage, with China being the first to conduct a large-scale pilot in 2021 (Becky, 2021). The Bank of England and HM Treasury created the CBDC Taskforce in 2021 to further explore its viability as legal tender (BankOfEngland, 2021). Stablecoins are like CBDCs in that they are cryptocurrencies pegged at a one-to-one ratio with a national currency, such as the US dollar or Euro, however, they are not minted or controlled by a central bank (Calle and Zalles, 2019). Commercial adoption of blockchain is dependent on CBDCs or stablecoins being fully regulated and accepted as legal tender for it to be integrated with existing financial infrastructure.

Decentralised applications that are built on a blockchain platform benefit from high interoperability. However, most proprietary systems, such as the software used in the construction industry, are built using a centralised system architecture; therefore, application programming interfaces (APIs) would be required to interconnect the technologies, which requires investments in developing and testing blockchain-based solutions. Furthermore, any new technology includes risks that are extremely difficult to mitigate, due to their nascency, thus adding additional risk to an already risk-averse industry.

Conclusion

Between 2012 to 2021, four UK government payment charters were published to address the payment problem in construction. From these, the project bank account (PBA) strategy was identified as an area that could benefit through the integration of blockchain. Despite its nascency, blockchain is rapidly evolving and changing the outlook of how businesses, people, and services operate. In a report discussing the impact of blockchain, it was identified as potentially transforming 58 industries globally, including the construction industry (CB_Insights, 2021). The values of PBA and blockchain harmonise across several key attributes such as transparency, auditability, and disintermediation. The PBA blockchain framework provides insight into the applicability of blockchain with PBA to reduce late payments and increase data trust. However, the main barriers to its adoption are a lack of regulatory maturity and lack of interoperability with existing proprietary systems.

Further work includes testing the proposed framework through a proof of concept to address its technical limitations and feasibility. Additionally, interviews with industry practitioners knowledgeable in PBA would provide constructive criticism on the integration potential of blockchain with PBA.

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