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Development of autonomous progress payment system integrated blockchain and IoT technologies in construction industry

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Abstract

Typically, construction projects entail many contracts with particular billing methods. In fact, dealing with complicated contract arrangements presents major difficulties, particularly in terms of early payment and assured cash flow. In addition, a lack of openness diminishes trust. Consequently, late or nonpayment is a prevalent issue in the construction sector. That article introduces the notion of applying smart contracts for automated, transparent, and traceable financial transactions in construction projects using a dam building project as an example. Combining robotic reality capturing technology, Building Information Modeling (BIM), and blockchain-based smart contracts enables automated billing. Utilizing detecting, intelligent machines, and building information models for existing structures the construction process is recorded, evaluated, and documented (BIM). The progress data is transmitted through knowledge of addressable file-sharing and afterwards broadcast to a smart contract that manages payouts and transfers creditor rights utilizing cryptocurrencies. Consequently, portions of standard standards form of contracts are converted to smart contracts. The smart contract is created utilizing digital BIM-based tender papers and includes all pertinent financial transaction information. Once the client has accepted the contractual building work, payments can be issued automatically through authorized banking institutions. The architecture for container-based information interchange and the digital contract administration process are described in this thesis.

Introduction

One of the issues that affect many points of the system in the building production process at the same time is the progress payment practices that regulate the financial relations between the employer-contractor and the contractor-subcontractor. Progress payment arrangements, which impose serious procedural and bureaucratic obligations on the participants, have a vital importance in the project cycle. Some authors foresees that it is healthier for the process to ensure the financial control of the project with the progress payments arranged at regular intervals throughout the construction process, rather than the contractor not receiving any payment until the end of the work or providing the entire payment at the beginning of the work, since building production is a long-term investment that requires a lot of resources [1]. Progress payments made regularly and on time are directly related to the responsibilities of the participants in the construction process, their roles in the project and their relations with other participants [2].

In recent years, commercial solutions known as digital payment administration systems have been created that permit project members to submit their payment applications electronically rather than on paper. As a result, 84 percent less effort is needed to handle payments [3]. These digital platforms, however, are unable to handle automated payments. This is due in part to the fact that they cannot utilise reality capture technology's output and in part to the fact that they use the relatively similar manual and intermediary processes as paper-based apps.

Centralized control methods and a absence of reliable implementation hurt them as a result [4]. The construction sector requires a trustworthy and automated way to convert product stream (job site findings) to cash stream (construction payouts); recent methods are generally mediated, manual, and unable to automate payment processing using reality capture technology.

Material and Method

Scan to BIM is the procedure of creating a BIM using a 3D point cloud taken by laser scanning a specified building or object. The quality of the BIM model obtained by this method can be different, there are no standardized procedures or tools that would automate this task. The scan to BIM procedure is most widely used for contracts where a BIM model of an existing building is to be prepared, for example for the purposes of reconstruction, rebuilding, documentation of the actual construction or extension planning in a building, but also for the protection of monuments. The scanning itself can take place in several ways, which can be static or mobile. Before scanning, it is necessary to acquaint the subject of the measurement and its immediate surroundings. These generally serve to improve the accuracy of the connection of individual scans to a point cloud. The fitting points should form triangular to polygonal configurations around the built scanner and be arranged at different height levels. At the same time, it must be visible on multiple scans in order for the connection to be possible at all [5].

BIM AND IoT

There are different concepts for dealing with the challenges that arise. The main tools in these concepts are IoT, web services and BIM. The main goals of such approaches are established to enable the communication and trading building information using web services and to enable this information to be consolidated and managed. Developments in this direction are associated with far-reaching positive effects on urban systems [6].

The combination of BIM and IoT leads to the transformation of a building into a "cognitive building" [7]. The IoT framework enables the real-time use of data through the use of sensors and wearables and their integration into the BIM process. BIM is conceptually developed for maximum interoperability and is based on an open standard data format. These open standards, like the IFC, are used as neutral exchange formats when a platform-to-tool exchange takes place. An example could be getting a certain subset of data from the main model that was created by another software tool. In such a case, a model view based on the native model is defined to contain the desired data and transmitted either via direct exchange between applications, if configured in this way, or via the mentioned transmission using open standards.

BIM and blockchain

Building Information Modeling, or BIM, is a process that is based on intelligent 3D models and provides architects, engineers, and construction workers with the knowledge and tools necessary to plan, design, construct, and manage facilities and infrastructure in a manner that is more time and cost effective. This definition comes from Autodesk. Even though BIM is advancing at a fast pace, the majority of the developed world still employs Level 2 BIM, which requires various disciplines to construct their work on separate models. Level 3 BIM aims to encourage deeper cooperation by suggesting that all stakeholders collaboratively develop on a single, shared model. However, this level of BIM has not yet been implemented. The utilize of blockchain technology has the potential to significantly enhance BIM in terms of security, accountability, transferability, and the capture of live data [8,9]. In the use of the Blockchain-based Building Information Model (BIM), who did what, when and when is recorded and therefore reliable information management is provided for any legal argument that may occur [10]. Every single record on the blockchain is permanent. Because there are many people and teams working on a project, it is inevitable that a BIM model will be changed at the same time. Tamper-proof and time-stamped data can be saved for all collaborators in the project thanks to the blockchain. A record of all model changes can be kept. With the implementation of this record, the efficiency of data sharing can be increased significantly and the cooperation and trust between each participant can be increased [11–13].

Several phases of payment procedures must be formalized as scripts and executed using computer resources in order to automate construction payments. These phases include, but are not limited to, the assessment with on-site findings, the evaluation of completion of the project, and, most importantly, contract implementation and the issuing of banking operations. Before bank transactions can be made, each project stakeholders must run these computerized commands and distribute the conclusions to the others.

The client-server architecture presents solitary marks of failure, and the centralization and unequal distribution of resources expose payment processing to denial-of-service assaults, data rewriting, and asymmetric information.

Consequently, this kind payment automation is subject to relatively similar restrictions as modern payment programs.

This suggested method avoids this risk through the use of Blockchain-enabled smart contracts; the use of smart contracts increases the reliability of payment automation by avoiding a centralized client-server architecture and assuring contract execution. All blockchain miners freely run the contract commands, calculate the outcomes, and establish agreement on banking operations and cash management.

However, smart contracts are only as trustworthy as the agreement algorithms that govern the blockchain that underpins them. Architecture of these agreement procedures fluctuates according on the blockchain type used. public, private, or consortium. In private and consortium blockchains, project members function as miners, implement contract code, and find agreement on the actual status of social and physical facts. This kind allowed blockchain applications present antitrust issues [14,15], since users may conspire and damage the decentralized origin of the agreement process. There is no assurance that the preservation, unchangeability, and execution guarantees of public and consortium blockchains will always stay true.

As previously said, the deployment of smart contracts functioning on public blockchains decentralizes both payment government and cash flow records, giving trustworthy access to the social reality of a project. However, the use of smart contracts by itself cannot enable payment automation because of technology's separation from physical reality and inability to integrate off-chain and on-chain situations. This is a significant challenge to the implementation of smart contracts in project management systems.

This work leverages reality capture techniques to give the smart contract with a view of the actual life (i.e., an oracle) in order to circumvent this difficulty. The term "reality capture" refers to the process of gathering, evaluating, and establishing the condition of physical actuality on building project areas through the use of sensing, machine intelligence, and BIM.

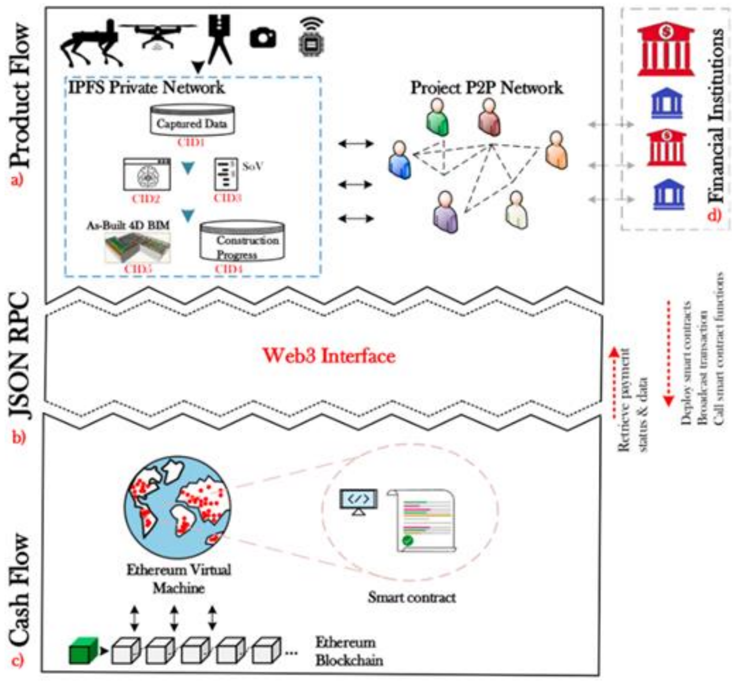

Figure 1. Autonomous progress payment system sample diagram [16]

- i) product stream recorded on secret IPFS network;
- ii) the JSON RPC functionality allowing circulation of data;
- iii) Funds circulation controlled by smart contract residing on the Ethereum blockchain;
- iv) Institutions of finance on the fringes.

Through the use of reality capture technologies, IPFS, smart contracts, and public registers, centralized, mediated, and asset processes like billing collection and payment application/certification are rendered unnecessary, as shown in Figure 1. This allows for the automation of payment processing, which translates advancement at job sites (Figure 1a, product stream) into construction progress payments (Figure 1c, Funds circulation).

Conclusion

Payment autonomy requires a change away from today's conventional and strongly payment operations, which comprise payment application preparation, review, and execution. Due to two essential aspects of smart contracts provided by blockchain technology, it is anticipated that these constraints may be overcome: decentralization and execution assurance. The absence of a connection between on-chain payment settlement and off-chain actual world hinders the technology's adoption in payment systems, despite its potential advantages.

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