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INVOICE SMART CONTRACTS FOR DESIGN SMES

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ABSTRACT

In recent years, Blockchain technology has evolved from its original application in cryptocurrency and can now be used for applications such as Smart Contracts. Smart Contracts automatically excecute transactions without the need for a central authority however there are very few use cases of the technology, particularly amongst UK AEC Design SMEs. This paper uses a hybrid method approach which combines questionnaires with semi-structured interviews to create a framework which showcases how a Smart Contract invoicing process could work for Design SMEs. This could create an automated invoicing process which is more efficient and reduces the risk of late or non-paymnet.

INTRODUCTION

This paper explores whether a Smart Contract (SC) on a blockchain invoicing and payment process is a valid replacement for the current invoicing process used by Design SMEs in Scotland, UK. This is positioned within a context of introducing Blockchain as an information layer for project management, and within the constraints of the paper, at examining the shift that potentially needs to take place for SCs and Blockchain to become a valid information base layer for design SMEs. The difficulty and novelty of the question lies in establishing the first actions for SC and Blockchain to enter the space of Deesign SMEs, under the use case of transaction automation with smart contracts (Hunhevicz et al), and specifically invoicing and payment automation. It seeks to resolve potential issues of trust in tansactions, but also productivity, as SMEs might regain time lost to seeking payment.

The paper is structured in five parts: In part one, We present first the background to the work, where we discuss Design SMEs and invoicing practices, the identification of the problem regarding late payments and the RIBA plan of work in the UK, we then discuss Blockchain and Decentralised Ledger Technologies and smart contracts. In part two, we discuss our methods which followed a hybrid approach, their suitability of the methods to address the question along with the legal framework in Scotland, while part three discusses the implementation of the work, wher we explain the process of conducting interviews, a questionnaire, and developing a SC prototype in the solidity language. Parts four and five contain the discussion and conclusion.

The research for this paper was initially developed in “Invoice Smart Contracts for Design SMEs, 2021”, Dissertation on Escrow Smart Contracts for Design SMEs, Robert Gordon University by the first author. This paper will refer to the findings in the dissertation and discuss them in part three: implementation.

BACKGROUND

Using DLT/B and smart contracts for automating payments in construction is not new to construction computing researchers. A number of researchers have investigated in the past the process, either conceptually (Li et al, 2019) (Kinnaird et al, 2017) or through prototypes (Kifokeris et al 2019) Luo et al, 2019) (Dounas et al 2018). Of these only one (Dounas 2018) is focused in the design phase of the project and that was directly connected to describing the automation of payments through distributed CAD systems and blockchain integration, without engaging with the context of a real-

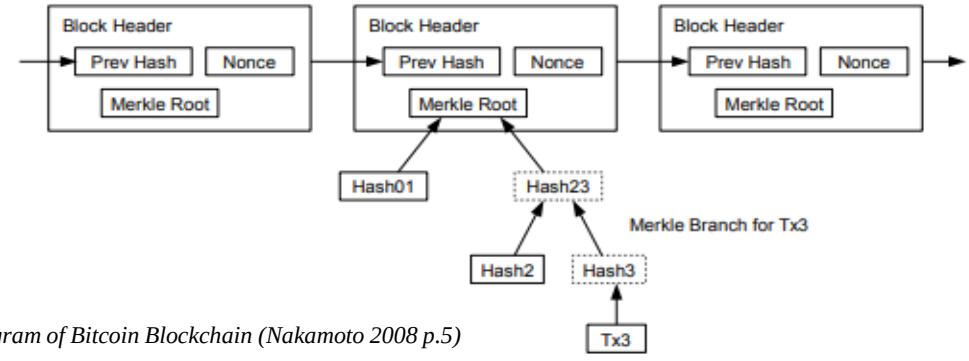

Figure 1: Diagram of Bitcoin Blockchain (Nakamoto 2008 p.5)

client scenario. Our paper brings to the fore the relationship between clients and design SMEs, and how a BSC on a Blockchain /DLT might help alleviate issues of productivity and trust.

UK Design SMEs tend to split their fees into smaller invoices (Design For Me, 2020) as per the stages set out in the RIBA plan of work (2020a) with fees being issued on completion of the services as required in The RIBA Standard Professional Services Contract (2020b). Despite this late payment still persists which leads to business owners chasing invoices which is both time consuming and uncomfortable. (RIBA 2018). The defining symptom of late payment is poor cash flow. Cash flow can be defined as "the difference in the amount of cash available at the beginning of a period, referred in accounting terms as opening balance, and the amount at the end of that period, reffered to as closing balance" (Smith, 2017).

For the context of our paper, we take Blockchain/DLTs to mean distributed computing state machines which are Turing complete (Turing 1936), with the additional ability to run smart contracts that hold value(Buterin, 2014), and, through various types of consensus and cryptographic security achieve information immutability and trust. (Antonopoulos et al 2018, Nakamoto 2008). Smart Contracts predate the creation of the bitcoin Blockchain by Nakamoto, (Szabo, 1994) and are conceptualized simply as a self-executing contract, i.e. automated with the terms of the agreement between involved parties written directly into lines of code. This concept has evolved in the Ethereum Blockchain to mean, "systems which automatically move digital assets according to arbitrary pre-specified rule" (Buterin 2014). However, within our paper we focus more on the ability of the smart contact to hold value and change the state of the state machine it resides on, by using its per-encapsulated rules in code.

Use or proposed benefits for Design SMEs

The use of Smart Contracts in design SMEs could have several potential benefits for businesses, employees and clients. To identify where Smart Contracts can be successful it is important to define the most important measure of a successful business. A recent survey found that the most popular answer was "success of a business is assessed on its ability to produce a profit" (Pletnev and Barkhatov, 2016 p. 189). For SMEs to make a profit they must be efficient in what they do and ensure that time is spent wisely and productively (Poirier 2015) . Smart Contracts have the potential to automate the invoicing process, which frees up SME time previously devoted to chasing payments and allows employees to focus on other parts of the business. It also has the potential to make payment immediate, which would eliminate the need to chase invoices (Lamb, 2018). Automating the invoicing process would also reduce the risk of payment errors, such as manual typing errors or issuing the same invoice twice (Ascend Software, 2019).

In terms of client/company relationship Smart Contracts could provide the benefit of a new layer of automation that previously never existed. This layer of automation would ensure payment for the design SME on completion of the work, but would also benefit the client by ensuring the SME is incentivisd to complete the work in the agreed timescale otherwise there may be consequences such as penalties for the designer. The Smart Contract could also be used as a mechanism of conflict resolution as it stores an immutable record of previous transactions which could be used as evidence in the case of an arbitration.

Barriers with introducing new technologies in the AEC Industry

Although Smart Contracts propose many benefits for Design SMEs, implementation could pose difficult for the UK AEC industry. Despite many advances in technology since the third industrial revolution "digital transformation meant so far for many firms merely to replace ink pens and slide rulers with computers and CAD software" (Belle 2017, p. 282). A report carried out by McKinsey & Company has revealed that the Construction industry is the second least digitized industry, with only the Agriculture and hunting industry being less digitized. (Agarwal, Chandrasekaran and Sridhar, 2016).

METHODOLOGY AND CONSTRAINTS

The paper uses a hybrid methods approach which combines a questionnaire, semi-structured interviews, and rapid software prototyping. A grounded methods study is used "to investigate a setting holistically and without preset opinions or notions." (Groats and Wang 2013 p. 234). Initialy a literature review was conducted to develop an undeerstanding of th state of the art. A suvey questionnaire (Molleri 2016) and semi-structured interviews have been used as part of the grounded methods study to confirm the issue of late payment amongst UK AEC Design SMEs and identify the requirements for a Smart Contract invoicing process so that it suits and benefits Design SMEs and addresses the failings of the existing process. A rapid software prototyping was developed to test the Smart Contract as a means of invoicing and payments at a basic level, and to operationalise the findings of the questionnaire and interviews. We used these methods as more appropriate for the question asked, as currently there are no existing smart contrract oducts that can be used to test fit for purpose. Hence a prototype had to be created, but to do so we needed a framework undeer which to empirically guide the creation of the software prototype (Wohlin et al 2003)

The literature review has been used to analyse the current state of the art of Blockchain/DLT and smart contracts in construction. It also covers the potential benefits to the use of Smart Contracts for UK AEC Design SMEs to confirm the validity of this paper. With the implementation of any new technology will have issues in

every industry and for this reason a review of previously implemented technologies in the UK AEC Industry was carried out to highlight any common issues or misconceptions within the industry that may have to be addressed.

The questionnaires were formulated around the question of late payments in dssign SMEs and were disseminated to CIAT and RIBA registered Design SMEs working on a variety of projects across the UK. This was done by advertising the questionnaire on the CIAT weekly newsletter and by contacting firms directly. The questions were based on research carried out by Tide which covered all types of SME in the UK (Penney, 2020).

The interviews were carried out with both CIAT and RIBA registered firms based in the UK. These firms ranged in size from single seat SMEs to 8 employees and worked on a variety of projects both domestic and non-domestic. The purpose of the interviews were to identify the current invoicing process used by firms and the issues they face using this process and triangulate and contextualise findings from the questionnaires. An initial Smart Contract invoicing prototype process was also presented in the interviews to confirm its validity and whether any issues could be forseen.

A prototype framework was used to test the validity of a Smart Contract mechanism as a means of invoicing for a Design SME. The framework was shaped from the data gathered from the grounded studies (Q&I). It was crucial to identify the methods Design SMEs were using to understand where they were successful and where they were failing. This ensured the framework would resemble the current methods to limit the size and number of changes to implement a Smart Contract process. Smart Contracts run on the Ethereum Network and are written using Solidity a high level computing language (Entriken, 2020). The framework also used Solidity however it was tested using an online development framework on a test network to avoid costly gas fees on the Ethereum mainnet.

Constraints

While we used the RIBA plan of works within the survey and interviews, the data collection and the targeted SMEs were all within Scotland, hence the first limitation with our method is that the results can not be indicative of the whole United Kingdom as Scotland uses a separate legal framework than the rest of UK, (SBC 2021) and for the appointment of architects (SCA/2014 2015). While we do not expect these to be significant for the nature of the paper, we expect that there will be nuances for the forging of a UK-wide smart contact scheme for invoices. As such we would adapt this in a next iteration of the research conducted UK wide.

IMPLEMENTATION

Questionnaire Findings

The data for the findings is taken from section 8.1 of Invoice Smart Contracts for Design SMEs Dissertation at Robert Gordon University. There were 15 respondents to the questionnaire with firms varying in size from one to eight employees, working on a range of projects from 15 (see Questionnaire 13) to 200 (see Questionnaire 12). All respondents were based in the UK and were working on design-based projects within the construction industry.

The results from the questionnaire confirmed late payment was thought of as an issue amongst AEC Design SMEs. Out of the 15 firms who completed the questionnaire, 73% agreed that chasing payment was an issue for them, whilst only 27% disagreed. The firms that disagreed stated they avoided late payment by issuing details of all the fees prior to starting work and invoiced using BACS transfer however these were not different methods from the other respondents. It could be down to factors such as fortune or because they filter clients, meaning they will turn them away if they seem untrustworthy. There was no way to confirm this without further research. One common characteristic was that all the firms that disagreed consisted of either one single seat SME or one employee working alongside them. However, this sizes of firm was not exclusive to avoiding late payment as there were other firms of the same size who found late payment to be an issue. It can be taken from this question that late payment was an issue for AEC Design SMEs regardless of their size.

When asked about the average amount of outstanding unpaid invoices for their firm at one time, there was a very wide range of responses. Only two firms stated that they had no outstanding unpaid invoices, while the rest of the responses varied between one and 35, resulting in an average of seven. The value of these invoices also varied considerably, from £800 to £40,000 with an average amount of £6770, slightly lower than the Tide UK average of £8,500 (Penney, 2020). A reason for this could be that the respondents consisted of Design SMEs with a small number of employees, the largest having only eight. In contrast the research by tide was for all SMEs, meaning a firm could have up to 250 employees (European Commission, 2020) which would mean the firm would presumably have a higher turnover which would increase the numbers as they are dealing with higher value invoices.

With regards to hours lost per day, 53% of the firms stated that they lost very little or no time chasing unpaid invoices, and the highest figure for this question was one hour spent chasing up outstanding invoices per day. Despite firms having low to no hours lost per day the questionnaires showed that late payment still caused issues for design SMEs with 66.7% of respondents agreeing that chasing late payment led to working outside normal hours and 60% stating that as an owner/manager they would spend unpaid hours chasing payment. One noticeable response to this part of the questionnaire was that “all non-billable work is unpaid, and we don’t pay ourselves by the hour.” (see Questionnaire 4). This could suggest that some owners of Design SMEs consider it normal practice to chase unpaid invoices outside working

hours and the number of hours spent on chasing payment could be higher than the results suggest.

Despite slightly varying figures for most parts of the questionnaire, there was concensus that no firms had a solution for establishing trust that a new client would pay their invoice. Some respondents suggested requiring a signed acceptance (see Questionnaire 1) and requiring payment prior to release of final output (see Questionnaire 15) but none of these methods can negate late payment. Background checks were also suggested in one response (see Questionnaire 11) however, this method could only be used with commercial clients and there is still no guarantee of payment. There was one noteworthy answer where a firm stated they "deliberately don't advertise, so all work is retained by referral." (see Questionnaire 4). This method may provide some security, but it also limits the type and amount of work that the Design SME could get, whilst still carrying the risk of late payment.

Despite late payments being an issue amongst firms, 40% of respondents stated that they would carry out work for clients with outstanding invoices again, with one explaining they had no choice in the current economic climate (see Questionnaire 6). Only 20% of firms responded that they would refuse to carry out work for a client with late payments. The remaining 40% stated they would possibly do so but that it would depend on the reasons behind the late payment. In response to the question on how firms would guarantee that they do not have to chase a client for outstanding payments again, the respondents provided a variety of solutions such as asking for a deposit (see Questionnaire 4) or adding interest to the value of the invoice if payment is late again (see Questionnaire 14). While these methods can help to reduce the financial impact for the SME, they could still lead to late payment. One answer provided a solution to late payment and that was requiring payment up front (see Questionnaire 5).

The answers provided from the quesionnaires have confirmed that late payment is an issue amongst the majority of AEC Design SMEs and that with their current invoicing process there is no way to establish trust with a new client. They have also found that for some Design SMEs if they have suffered from late payment from a client in the past they have no choice but to work with that client again due to financial requirements. This proves that a solution is required to reduce or negate the risk of late payment.

Interview Findings

The data for the findings is taken from section 8.2 of Invoice Smart Contracts for Design SMEs Dissertation at Robert Gordon University. 4 firms were interviewed as part of the research in the dissertation. These were a combination of both RIBA and CIAT registered firms based in the UK working on design-based projects within the construction industry. The firms had between 1 and 8 employees and were working on both domestic and non-domestic projects.

We first set out to establish the current invoicing process that Design SMEs were using. It was found that none of the interviewed firms were using the stages set out in the latest RIBA plan of work (RIBA, 2020) due to its lack of flexibility for the type of projects Design SMEs work (see Questionnaire 4). Instead firms opted for their own stages as they would suit their business model better. One interviewee (see Interview 1) stated that they used stages similar to the RIBA plan of work 2007 (RIBA, 2007). Initially Design SMEs would only include stages up to and including the Technical Design stage. If firms were to carry out work during the construction stage, this would be charged on a monthly basis rather than stages (see Interview 2). It was also found that SMEs would undertake tasks which are not included in the plan of work, such as site surveys. The small size of Design SMEs allow them to be flexible and carry out tasks that are traditionally not done by designers.

Using the stages from the RIBA plan of work 2007 (RIBA, 2007) and information gathered from the interviews the following is an example of the invoice stages an AEC Design SME could use for a design project: Site Survey, Concept Design, Design Development and Technical Design.

The insight provided in the interviews (see Interview 4) has also been used to create the Figure 2.

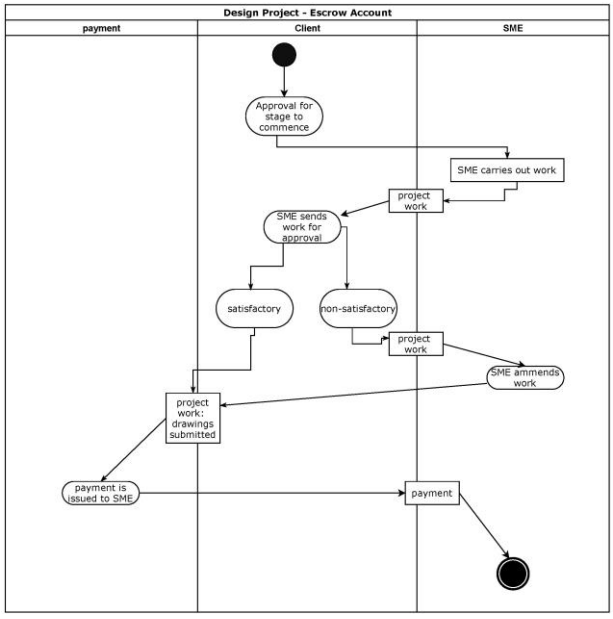

Figure 2: Conventional Design Process.

Figure 2 shows the process of how work is carried out within each stage. The process provides flexibility for clients to make changes or identify faults in the work however this can be manipulated by continually claiming a change is required or something is not to their satisfaction in order to postpone payment. Issuing the invoice on completion or submission of work can also invite late or non-payment. It also gives the opportunity for the stage to begin even if the client cannot afford it.

The designer could delay issue of the final drawings prior to payment (see Questionnaire 14) however the majority of the information has already been issued to allow the client to give their approval which means there is no incentive for them to make the payment. This point was reiterated by an interviewee who stated "It is not like BT where you can cut off the internet. There is no loss for clients if they do not pay." (see Interview 2).

These failings described affect the designer however the existing process can also have a negative effect on the client. During the period where the designer is carrying out the work there is no input from the client where the designer could create unwanted variations from the brief in the design. It also provides an opportunity for the Designer to claim that the project is progressing even if it has not started. This is of detriment to the client if a timescale has not been agreed before the commencement of the project.

When presented with the Initial proposed Smart Contract Staged Payment Process the interviewees agreed it could work (see Interviews 1,2,3 & 4) although there were concerns raised. There were a number of issues raised that would affect both the client and designer however there were 2 key issues raised. The first issue was how to clearly define when a level or goal has been met to trigger release of the funds, particularly in the design stage as design is subjective. The second issue was that the proposed process would allow the client the same opportunities to delay payment, therefore not improving the current situation (see Interview 4).

The information provided from the interviews has found that the current invoicing process is flexible to suit the flexibility of Scottish AEC Design SMEs however it places the majority of risk with the designer and lacks transparency between both parties. The interviews also found that the initial proposed Smart Contract Staged Payment Process could work however it could be difficult to define when a goal has been met as design is subjective and clients could be presented with the same opportunities to delay payment. For Smart Contracts to be successful as a means of invoicing these failings will have to be addressed whilst maintaining flexibility.

Prototype Findings

An Escrow Smart Contract has been selected as the basis of the prototype (Zynda, 2020). Holding the fee in Escrow distributes the risk more evenly between the Design SME and the client. It is also a much fairer method than the client paying up front or the designer requesting payment on the completion of work. The code starts by defining the version of Solidity that is used. As Solidity is a new computing language it is under development and changing to add new features and fix bugs (Fernandez, 2018). We have used the Enum states which are the states the contract will be in depending on project progress. When the contract is triggered by the Designer it will read "Awaiting Payment". Once the client deposits their funds into the Smart Contract where they will be held the state will change to "Awaiting Delivery". This is the point where the designer will carry out the work on the project and on completion the designer will request the client's approval. When the client approves the work the Smart Contracts state will change to "Complete" and the funds will be released to the designer. The addresses are stated in the string as the buyer and the seller. The buyer is the client as they are buying or paying for the services of the Design SME. The seller is the Design SME as they are selling or receiving payment for their services.

Modifiers are added to the string so that only specific addresses can use certain functions. The confirm delivery function for example has "onlyBuyer" in the string so that only the buyer (the client) can confirm that they are happy with the work. If this were not here then the seller (the designer) would be able to release the funds from the contract to their account, even if the work had not been completed. This makes the modifiers a safety feature to prevent manipulation of the Contract.

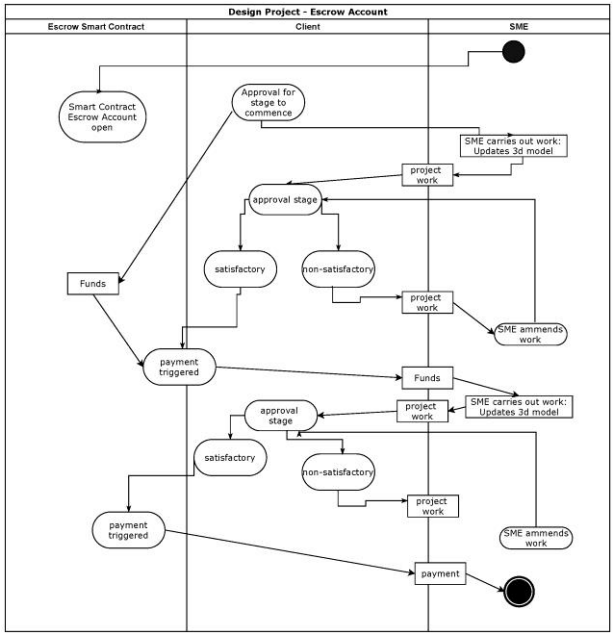

Figure 3: Smart Contract Design Process.

Figure 3 shows how the Escrow Smart Contract will be used in a new invoicing process. The proposed process starts by the designer triggering the start of the Smart Contract however they will not commence work until the client has deposited the funds into the contract. The designer will know when the funds are deposited as the Smart Contract will change its status from "Awaiting payment" to "Awaiting Delivery". The process is then divided into three phases that are pre-defined by the client and designer prior to the start of the project which are shown above (see Figure 5) in orange, blue and green. The three phases could be anything the designer and client agree upon prior to the start of the project, an example being plan layout, outlined structure, and material selection. The designer will complete work for the first phase and the client will give their approval or

disapproval. An additional feature is to delay payment by a st number of days, should there be a reason to do so on the side of the client. On approval the Smart Contract status will change to "Complete" which will release a third of the total value of the stage to the designer. On release of the funds the Smart Contract will also trigger a child contract (Lifanova, 2019) which will start the second phase of the stage by requesting the client's funds.

Creating three phases within each stage is a solution in terms of issuing invoices as the Smart Contracts are automated however most SMEs currently use a manual drawing issue process. This would mean issuing more drawings would be more time consuming. To overcome this a form of automated drawing issue would be required. For this process we could use a form of .ifc representation secured by a smart contract on the sam Ethhereum chain and a secure viewer (Dounas et al 2020).

This would also allow the information to be viewed by the client but not in a way that can be used which would maintain incentive for the client to give their final approval. The example uses three phases however any number of phases could be used. This provides flexibility to suit the business model of most Design SMEs.

DISCUSSION

The proposed process offers a safer and more efficient means of invoicing for design SMEs. It does this by distributing the risk more evenly by holding funds in escrow and improves transparency by involving the client more often by creating phases within each stage. There is still the opportunity for the client to slow or refuse payment however there is more incentive for the client to make the payment and if they refuse the financial impact is reduced as the designer is less heavily invested in the project. An immutable record of the clients approval is produced and stored on the Ethereum blockchain which can be used to remedy any disputes without the need for legal action. While not preesented as a global process, we believe that the work presented here is significant in the sense that it provides a model and prototype for incorporating escrow accoutns in the work of design SMEs in the AEC industry. The result of the introduction of this mechanism should be a reduction of time spent in invoice follow ups, a reduction in disputes and an increase in productivity. There are of course certain limitations in the research, on how clients might welcome this process. We are actively seeking to implemnt this prrototype in a Scottish SME, so thhat we can also survey clients. However there is a limitation to convinving clients to participate in this process as thy might percive it as ricky. As such we are seeking to implement this as a paralleel virtual process, where the clients and designr could compare between the two.

CONCLUSIONS

As identified earlier in this paper late payment is an issue amongst UK AEC Design SMEs as they rely on trust that a client will make payment. This paper aimed to investigate whether a Smart Contract invoicing mechanism would be able to solve the issue of late payment and be able to replace the existing system. A grounded methods study (Q&A) was carried out which identified that for a Smart Contract invoicing process to be successful and fair it would have to distribute the risk evenly between the client and designer more evenly than presently. It was also found that the process would have to be flexible to suit the nature of UK AEC Design SMEs.

The Prototype Framework shows how a Smart Contract invoicing process could be used by a Design SME. It evenly distributed the risk between the client and designer by holding the funds in the neutral point that is the Smart Contract. It also creates a more transparent relationship between both parties by increasing the clients involvement whilst maintaining efficiency by combining the automated nature of the Smart Contract with an automated information issuing system. It also provides flexibility by allowing the designer to write the Smart Contracts in a way that will suit their business model, a critical factor to AEC Design SMEs invoicing process.

Our paper successfully presents a framework that proves Smart Contracts could be utilized to create an automated invoicing process that reduces the risk and limits due to the loss of late payment for AEC Design SMEs.

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