ETCH

A shared financial ledger for the construction industry

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Etch White Paper

Abstract — This paper describes a blockchain based construction industry focused real-time employee remittance platform. Etch distinguishes between employer contract obligations based on physical presence (Category 1 payments) and those based on performance (Category 2 payments). We provide an overview of a functioning payments system that allows for real-time employee payments used the Ethereum blockchain. Properly structured, the platform also allows employers and employees to facilitate real-time international salary transfer to an employee's family members. We also describe future contract automation based on more complex performance based criteria.

1. Introduction: Why Etch?

Payment disputes are a common source of construction industry conflict. Disputes can have a ripple impact — increasing costs, delaying completion and reducing profits. Etch solves this problem with "smart contract" blockchain technology and IoT beacons. Etch provides a payment infrastructure that we believe will increase construction industry efficiency, reduce conflicts and increase profits for participants.

We begin with a brief discussion of the construction payment process. We then describe how Etch facilitates real-time employee payments based on presence at a job-site. We next describe an industry specific "stable coin" tied to escrowed fiat currency, which (1) allows for real-time payments but (2) minimizes crypto-currency exchange risk. We conclude with a discussion of future plans for performance based construction contract payments.

1.1. The Problem with Payments

Few construction projects of any scale involve completely self-performed work. As such, construction projects involve many contracts. Each contract contains a separate payment obligation. As a simple illustration: (1) a subcontractor's employees rely on payment from their employer, who may in turn (2) rely on payment (via a payment application) from (3) a higher tier subcontractor, who in turn must (4) seek payment from a prime contractor, who in (5) turn looks to the Owner for payment. If the Owner approves a payment application, funds flow back through each participant in the payment process.

With each additional party and contract, complexity is added, along with the potential for delays and disputes. The process is even more complicated by the fact that funding may flow ultimately from an Owner who is not in direct contractual privity with subcontractors who are providing actual labour. At each point in the payment process, there are opportunities for conflict. Managing this payment process can create a significant administrative burden, along with financial risk.

Indeed, subcontractors have considerable concerns about timely payment. According to a recent industry survey, more than a quarter of all subcontractors who responded stated that it threatened their businesses [38]. Cashflow and insolvency have been historic problems in the construction industry, with cashflow noted as a key concern for 17 percent of subcontractors in a recent survey. [42] While edge cases with idiosyncratic motives can always be identified, we believe that most construction projects will benefit from reduced conflict and greater cooperation.

Owners and prime contractors can benefit from faster and more efficient payment processes too, not only because of the potential for reduced conflict. Payment automation can reduce administrative overhead, obviating the need for manual review of certain components of the payment application. In addition, Owners can remain outside of the contractual relationship between various tiers in the contracting process, but have access to real time information about labour cost and spend.

1.2. Our Solution

Etch ("Etch") is a shared financial ledger for the construction industry. Because construction payments are so complex, our first step in automating these is with paying employees.

1.3. Types of Payment Obligations

We divide payment obligations generally into two categories: (1) those obligations that can be measured in time and confirmed by physical presence ("Cate-

gory 1 Obligations") and (2) those obligations that can be measured by satisfaction of (i) a design specification or (ii) a performance specification ("Category 2 Obligations"). Examples of Category 1 Obligations include, for example, mobilization of work-force to the site, or delivery of materials, machinery or temporary structures such as construction trailers. Examples of Category 2 Obligations include satisfaction of load requirements for an HVAC system or completion of mill-work to an architect's design specifications.

Category 1 Payments

Category 1 obligations are easier to validate than Category 2 obligations. In order to create a system that automates payment for Category 2 obligations, we first devised a solution for Category 1 payments. Thus, as currently designed, Etch provides an automated payment guarantee construction employees for money which is due to them. By using blockchain based 'Ricardian contacts', [See Section 3.1, below], payments can be made automatically based upon pre-programmed and mutually agreed-upon business rules. Our design uses a secure Internet of Things beacon to confirm the identity and location of the employee or contractor. The data is counter-signed by the contractor/employee via his mobile phone.

Construction laborers' employment contracts are typically time-based, and require employees to record time using a variety of timekeeping systems. Timekeeping systems are widely used but under the exclusive control of employers and subject to manipulation by both Employers and employees.[9, 10]. We use beacon technology tied to a blockchain based smart contract to create an employment record that is (1) difficult to falsify, (2) available to both Employer and employee and (3) difficult to alter. (We assume for current purposes that evaluating a laborer's performance will involve qualitative external evaluation and validation).

Category 2 Payments

For performance based payments, we propose using smart contracts on the Blockchain to automatically agree when milestones have been completed and hence what payment is due. This approach has been proposed within the legal circles in the past[12, 13, 14]. We will build performance based payment functionality into later versions of Etch.

1.4. Blockchain 2.0 Infrastructure

Blockchain 1.0 provides a decentralised public transaction ledger, instantiated by the Bitcoin protocol. Bitcoin allows peer-to-peer transfer of currency value between parties in the absence of a central authority or third party [26]. Blockchain 2.0 builds upon Blockchain 1.0 by enabling complex assets (such as property) to be transferred under the control of a "smart contract." Smart contracts are "Turing complete" scripts, which means that they are able in theory to solve a computational problem of any complexity (assuming available computational power and resources).

Ethereum is a Blockchain 2.0 ledger. It provides a fundamentally *blockchain agnostic infrastructure*. In other words, Ethereum does not require a user to use Ether as a store of value for transactions. To the contrary, users can create their own cyrpto-currency ("coins" or "tokens") to be created that represent tangible and intangible assets, including (but not limited to) fiat currency. Thus, Ethereum allows the original concept of "programmable money" envisioned by Satoshi Nakamoto and others to be extended to allow for conditional payments and payments based on pre-programmed contractual conditions. [25] [3]. This means that ink and paper contracts can be translated into computer code and programmatic payments can be created, based upon satisfaction of contractual conditions precedent.

We propose using Etch to record time related transactions onto the Ethereum Blockchain. This will allow for the creation of automatic payments based on employee presence at a job site, while simultaneously creating a tamper-proof record of the time worked by an employee which is equally available to the employee, employer and state regulators. This independence and transparency will reduce fraud by employers and employees [9] as one party will not be able to tamper with records or conceal them. (We address privacy concerns using cryptographic hashing, discussed in greater detail in Section , infra.

2. Payments Based On Presence

While the use of heavy machinery and automation has changed the construction industry significantly over the past century, it is still a industry heavily reliant on human labour. Labourers can generally be categorized as employees or independent contractors, each of which are compensated using different

measurements methodologies.[2][2]. To illustrate the different measurement methodology each requires, we present two actors - Bob and Alice - and two algorithms which determine their work related payments.

i) Bob employs Alice and pays her for the time she works.

Result: Alice is paid as an employee
Alice works for H pounds per hour. ;
while *Alice isWorking* **do**
  Alice performs work;
  if *Alice hasCompleteTimesheet* **then**
    Payment P = Hours Worked x Hourly Rate;
    Pay Alice (P);
  else
    No Payment;
  end
end

Algorithm 1: Employment

ii) Alice works as an independent contractor for Bob who pays Alice based on her completion of milestones.

Result: Alice is paid as a freelancer
Alice has a contract for P pounds for milestone M;
while *Alice isWorking* **do**
  Alice works towards Milestone completion;
  if *Alice hasCompletedMilestone* **then**
    Pay Alice(contractual sum);
  else
    No Payment;
  end
end

Algorithm 2: Independent Contracting

Therefore, we need systems to measure the time worked and then to transact the payment; or a system to determine when a milestone was reached and then to make a payment.

3. How Etch Works

Etch measures the criteria for payment to contracting parties, and then makes agreed-upon payments. Specifically, Etch will confirm someones location and hence their presence in a workplace.

As we explain below, wireless beacons (1) confirm employee presence, (2) communicate with blockchain based “Ricardian Contracts" to (3) make payment in real time (4) using a fiat-pegged ERC20 token backed by funds held in a bank escrow account (or secured by an insurance policy or similar financial instrument, such as a letter of credit, collateral trust, or other undertaking).

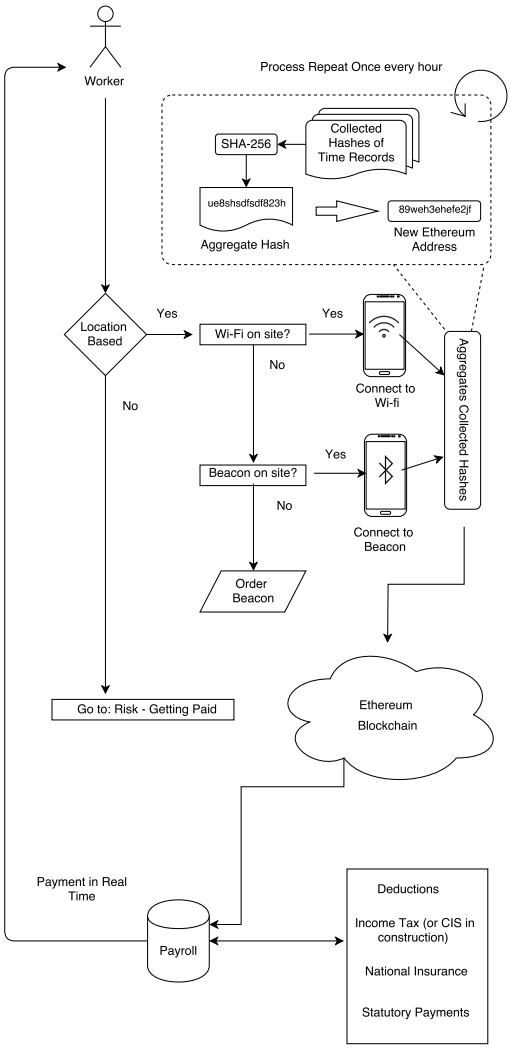

Fig. 1: Risk - Time

3.1. Ricardian Contracts

At a high level of generality, ’Ricardian Contracts’ are contracts that can be read by people but understood by a computer. Ian Grigg defines them in his seminal paper on Ricardian Contracts[5] as

(a) a contract offered by an issuer to holders,

(b) for a valuable right held by holders, and managed by the issuer,

(c) easily readable by people (like a contract on paper),

(d) readable by programs (can be parsed like a database),

(e) digitally signed,

(f) carries the keys and server information, and

(g) allied with a unique and secure identier [5].

Etch uses a Ricardian contract implemented as a "smart contract" script on the Ethereum Blockchain. This contract allows employees and contractors to understand the contract. It can also be parsed and understood by Etch.

Ricardian contracts will (1) monitor employee hours or milestones for contractors; (2) approve payments; and (3) make payments. In the Etch system, escrow via a multi-signature contract will ensure only correct payments will be made, implementing "programmable money" to effect a transaction [25].

3.2. Location

The Etch system uses location and presence verification to provide a complete management system for (1) contract determination between contracting parties,(2) monitoring time worked or milestones completions, (3) approving payments, and (4) making payments.

3.3. Installation

Many systems on the market which manage timekeeping require hardware at the employer's premises such as card readers, retina scanners, and punch machines [9].

Etch requires only a normal site based Internet connection via Wi-Fi or GSM/3G. Thus, it can operate almost immediately at an employer's site using existing equipment.

3.4. Location Determination

For employees who perform work at a specified location (e.g. on a construction site, office or workshop), a verifiable action at that location confirms their presence in their workplace (use of biometric data presents one difficult to defeat verification option). To determine an employee's position we use Wi-Fi or iBeacon connections.

Wi-Fi signal strength may determine context for a user, such as the user's location [7]. Wi-Fi (802.11 wireless infrastructure) has a limited transmission range [8] for example up to 32 metres from the transmitter. If an employee is able to connect to Etch via the Wi-Fi connection at their place of employment, their presence is confirmed.

An iBeacon is a Bluetooth Low Energy device that only sends a signal in a specific format [6]. iBeacons can be used to determine a user's location because, in similar manner to WiFi, the field strength is dependent on the distance from the transmitter [15].

In our design, a user will confirm their location via a connection to Wi-Fi or iBeacon.

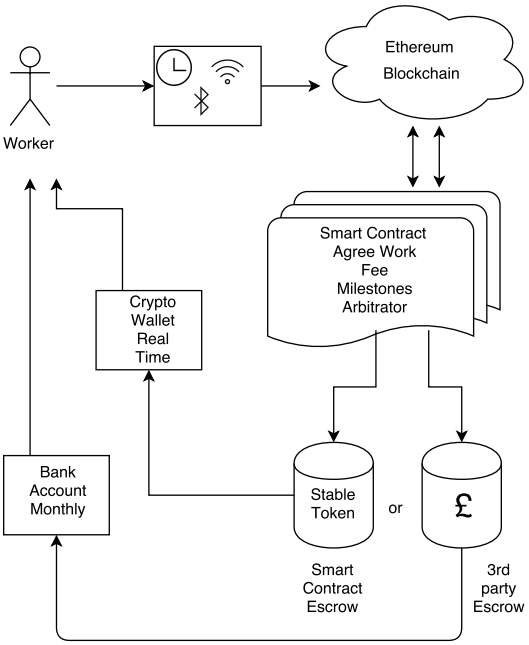

Fig. 2: Risk - Getting Paid

3.5. Proof of Identity

Of course it is not enough to merely prove that a hardware device is present at a location. One must confirm that the person carrying the device is the assigned employee. Therefore, one challenge to the use of presence-based payment is identify verification. Without additional validation, it is possible for a co-worker or friend to bring an employee's device on site and thereby seek to defeat the system. Several complementary approaches can be used to prevent this. We propose using a recognized identity system such as uPort [24] to identify the employee/-contractor who then creates data structures on the blockchain under Etch for the time they have worked.

3.6. Payment Deductions

Companies may be required by law to deduct payments for such things as income tax, national insurance, court fines, student loan repayments, or other statutory payments to public authorities.[20]. There are many cases where deductions lawfully due to HMRC are not paid. This can occur due to fraud or insolvency [22]. Under CIS, contractors deduct money from subcontractors pay for HMRC purposes[40]. Etch provides detailed time records on time and earned money, hence it can provide a clear record for the contractor and subcontractor for tax purposes.

4. Payment Infrastructure

Etch will provide a real-time payment infrastructure using ERC-20 stable tokens backed by fiat based guarantees. We describe this payment functionality below.

4.1. Realtime Payments

Real-time "end to end" payments are possible using blockchain payment systems [28], [17]. We propose an implementation in which payments are processed in real-time as work is done by the employee. The employee benets from immediate remuneration (e.g. by the hour or even in smaller intervals).

Employers also benefit from real-time management of costs and invoicing, reducing supervisory overhead associated with manual review of time entries and automation of the payment application process.

Real-time payments is a significant benefit to employees. If Bob employs Alice under our proposal, he would pay her in real-time and Alice would receive her salary for that morning by lunchtime and pay for lunch with that money. Hence Alice would have access to a greater degree of liquidity than in a retrospective remuneration payment system.

Real-Time international remittance transfer is another important benefit to employees. In short, Etch allows employers to create a payroll structure by which employees can designate family members as assigned recipients. This functionality allows workers to easily transfer wages to family members in other countries in real time or real real-time, as opposed to using costly intermediaries or relying on payment systems that can take weeks to faciliate international transfer. AML/KYC compliance obligations will be addressed by the Employer who assures that wages are transferred appropriately.

4.2. Stable Tokens

Etch uses crypto-currency tokens to make real-time payment possible. Because neither the construction companies nor the employees/contractors will want to gamble their liquidities by using a highly volatile tokens such as Ether as a payment mechanism, users must be assured that the tokens can be converted to an equivalent value in fiat currency. A labourer paid £X per hour should be assured that the value of their token will remain constant with its fiat denomination.

So that participants do not take currency fluctuation risk, we propose an implementation in which an employer would make advance payments to reserve pegged at ERC-20[33] tokens or stable ERC-20 tokens similar to the DAI[32] in an escrow account with a congurable rolling period. We will also explore insurance or insurance-like products that can provide an equivalent guarantee to cash on deposit in a bank.

To create liquidity and foster ease of payment, we also propose linking the ERC-20 tokens to debit card and ATM usage in the same way TokenCard works [30].

The TokenCard is a debit card usable at payment terminals around the world, including ATMs. TokenCard customers back/fund their own card with allowances from ERC20 compatible contract wallets. Etch users would be able to spend their tokens by using ATMs and debit cards.

Fiat money may be converted into ERC20 tokens through an instant digital exchange similar to Shapeshift.io [31]. Fiat money could be transferred out of the system in the same way, while observing the compliance and regulatory requirements.

Etch proposes to either partner with, or become an issuer of a prepaid, stored-value debit card, and therefore will be able to directly interact with the merchants and their acquirer banks to provide efcient means of wage delivery.

5. Token Usage

As the main token of the Etch platform, Etch is used as the 'fuel' to pay for the services offered by the platform. The token is "analogous to [a] paid API key."[45] We will define a complete series of services for which a

construction company will pay, including the following:

- A retainer subscription that construction companies pay for using the platform. The subscription will include rent of all the hardware needed on-site.
- Creating and registering blockchain identities.
- Calling an API endpoint to store a bundle of data representing worked hours with signatures from the iBeacon and all involved parties.
- Building the Merkle tree from the last blockchain checkpoint and anchoring the root hash into one or more blockchains.
- Checking if a data bundle is correctly anchored into the blockchain.
- Reporting to HMRC according to the CIS scheme.

The Etch platform will publish public prices for all offered services, beginning with labor rates. Because some of the published prices will be parameterised by volume of data or other resources needed to execute the request, the Etch payment process will follow the following pattern:

- Client: Ask for a quote from the platform providing all details of the service required.
- Platform: Analyses resource requirements and return a quote based on already published guidelines. The quote will contain both the payment reference that needs to follow the blockchain transaction and the destination address.
- Client: Perform the request for the desired service using the API. Accompany the request with the quote reference.
- Platform: Verify payment and execute service request. Return signed proof of the executed action.

Token creation, issuance and sale will be addressed in a separate token issuance offering paper. The rollout will begin with the UK, with the offer of sale to UK residents only, and then country by country. We are mindful of the fact that tokens sales may be deemed securities offerings and will work with our legal team to assure full compliance within country specific law.

6. Data Privacy

Use of a public blockchain raises understandable privacy concerns. Etch is designed to provide a record of employment that does not disclose personally identifiable employee data. We do this using cryptographic hashes, which convert data into encrypted strings of letters and numbers that cannot be underestood by a third party.

Data Privacy will be preserved by hashing data onto the blockchain. By using the consensus algorithm in blockchain protocols, the hash may be conrmed as being unchanged and hence any tampering will be detectable.

However, the hash cannot be reasonably unhashed and a third party may not see the actual un-hashed content. Hence data privacy is preserved.

The original contracting parties may confirm the content is the actual stored blockchain hashed content, by hashing themselves the original content and then comparing the hash value with the stored one on the blockchain.

When there is a difference in the two hashes, then the record on the blockchain was not the original (eg someone committed a false record for a pecuniary advantage). Proprietary data that can be tied to particular itself will not be recorded on the blockchain.

7. Future Growth

Blockchain technology has the potentially to fundamentally change the way parties enter into, manage and perform contracts.

7.1. Performance Based Payments

We have described how Etch can be used to make construction contract payments based on presence at a job site. In future versions of the platform, we hope to design smart contract functionality that will judge satisfaction of performance requirements and make automatic payments triggered by their successful completion.

One potential implementation has been described in the form of a "payment and performance drone" that would be used to confirm delivery of goods or material to a job site. [46] For example, using photogrammetry, a more sophisticated implementation could measure excavation and confirm payment for quan-

tity take-off payments to excavation contractors. The workflow this process has been described by an industry observer as follows:

1. Contract specifies that when subcontractor delivers material meeting a required specification on a specific date, contractor will be paid X, within Y days.
2. Prior to delivering materials, subcontractor would receives confirmation that funds have set aside for payment if materials are delivered as agreed.
3. A payment and inspection drone would capture time-stamped photo and video information sufficient to verify delivery.
4. The drone would send a message to the smart contract confirming delivery in compliance with subcontract requirement along with data confirming the amount of excavated materials.
5. The contractor would receive notice subject to an agreed upon time-period to lodge objection, which might over-ride automatic payment.
6. Assuming no manual over-ride or objection is received by contract, payment would then be automatically transferred to subcontractor within specified time period. Payment accompanied by any agreed upon lien release or other language typically contained in Contractor payment application, which is deemed fully executed on receipt of payment.

This is one work-flow of many for which Etch will be able to automate payment based upon performance. [46]

7.2. Exception Handling

In its default state, Etch is an automated payment system that includes an audit trail of all recorded actions. In practice, external events may interrupt the automation process and create an exception. Examples of failure could be an employee forgetting their phone, Wi-Fi or iBeacon not working, Bluetooth not installed on the phone, or time fraud ("buddy clocking". In the case of an exception, all parties will be notified and payment will be manually approved, subject to the parties' digital signature. In the event that agreement cannot be reached regarding payment for an exception, contractual dispute resolution procedures would be triggered including use of multi-signature arbitration, described below.

7.3. Multi-Signature Arbitration

A multi-signature contract is one in which instead of two parties controlling a decision, a third party (mediator) is added to the decision making process [4]. The mediator is independent to the employee and employer and makes a decision favouring one of the conflicting parties when a dispute arises.

Therefore if an employee challenges the validity of a record, then a dispute could be initiated and the mediator decides if the employee is correct or not. The decision would be based on a pre-agreed set of criteria.

For example, if Wi-Fi stopped working, then the business logic could specify that an analogue form of identity verification would be accepted. During a resolution, the employee could email an image of an analogue record confirming their work times, and the mediator could then decide if the work had been done. While such an approach relies on a human-decision maker, payment can still be automated when a decision is reached, and a quick time-frame for resolution included.

8. Conclusion

Etch is solving key problems associated with construction contract payments. We begin with presence based payment automation and describe how our system can be used to automate certain performance based functionality. Etch requires no special hardware (except a smart phone and Wifi or an iBeacon) and the system is implementable globally. It is customisable and it has no language or national restrictions.

The construction industry contributes more than 110 billion, or 7 percent, per year to UK GDP. [47]. Our solution can scale to reduce payment friction in this massive and important industry sector and provide important services to employers and employees. Etch can also be extended to apply to any employment relationship that relies upon time based payments.

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