ASCE GRAND CHALLENGE

The Revolutionary Blockchain - An Opportunity for Engineering Stewardship

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ASCE Innovation Contest

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Executive Summary

The hallmark of an advanced economy is the extent, condition, and efficiency of its public and private infrastructure. The advent of Blockchain technology gives society the capability to represent value stored in infrastructure with an electronic token validated by engineers. The implications are staggering. Markets would elevate the engineering profession to the status of financial instrument currently reserved for banking and insurance industries. The decentralized storage of engineering value will provide a marketable working platform for elevating societal quality of life improvements.

This proposal describes a cryptocurrency for the engineering profession that stores and articulates public value in the infrastructure that engineers create. This new business model interfaces with existing engineering practice as well as a number of emerging applications such as bringing needed credibility to the internet of things and big data asset valuation. Civil engineers are uniquely positioned to leverage this new technology to help reduce costs and maximize benefits to society.

The Fundamental Problem

Engineers are increasingly marginalized in their ability to influence key decisions that impact the public. Market economics often favor short-term gains over long-term sustainability or resilience. This disparity is often subsidized by the public in the form of diminished safety, health, and welfare. The professions are divided and subdivided by discipline, title, jurisdiction, exemptions, corporate silos, ontology, and along lines that have little to do with natural laws. The laws of nature apply equally on all points on Earth, but the engineer does not.

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Today we are living on an increasingly crowded planet. Many of the social problems that exist in our country and the world are, at their core, engineering problems: clear water, clean energy, safe food, affordable housing, safe transportation, and local production. The fundamental problem is that the value of engineering is invisible – there is little or no accounting of 'true' engineering value in society because there are few tools that accurately measure it. The net result of this fundamental problem is that poor decisions are made too often in pursuit of short-sighted aims. Our economy's inability to translate engineering value represents a grave threat to life-cycle cost reduction as we continue down a path of deferred maintenance, re-allocated funding, and reduced standards of quality. A new business model is desperately needed.

The Core Blockchain Function

The introduction of the virtual currency Bitcoin in 2008 effectively demonstrated that value could be created and transferred digitally (Nakamoto, 2008). Before Bitcoin, if you send a digital contract to another person, both parties hold a valid copy and either can change the contract at will. After Bitcoin, if you send a digital contract, the receiver possesses the only valid copy with no intermediary. This may sound trivial, but the implications are vast. Bitcoin removed banks from the transaction while maintaining both the convenience of cash and security of formal authorization.

The real innovation behind Bitcoin was the derivation of the Blockchain. A Blockchain is computer software that manages all aspects of a database shared among many people. A Blockchain earns its name from a technique that assures that the database can only move forward in time and cannot move backwards in time. This time stamping thwarts any effort by bad actors to infiltrate the database and alter any prior transaction undetected. The cryptography is mathematically provable, extremely difficult to corrupt but very easy to audit.

The software controls access and can even execute scripted contracts including payment issuance or transaction authorization. Blockchain uses several techniques such as cryptography and tokenization (cryptocurrencies) to arbitrate human interactions with the software. The resultant database is called a decentralized ledger since it is not controlled by any one party.

The capabilities of the ledger can be extended further through incorporation of smart contracts, which serves as a self-executing digital contract that uses Blockchain technology to document and verify the contract's execution. The way a smart contract typically works is through a scripted code written to perform specific functions placed into production onto to Blockchain. By sending tokens to code, one party can join into contract. Additional parties enter into the contract by the same mechanism. The computer code takes the tokens and performs some function with them, potentially re-

redistributing them to all parties in the contract. These contracts can be customized to incentivize distinct and observable actions with the database (NSPE, 2016).

Introducing Quant: An Engineering Cryptocurrency

The Blockchain would be used to create a digital token called the "Quant" as an initial qualification method for engineers. Engineers will state their credentials (diploma, case studies, exams, licenses, projects, etc) to the Blockchain and receive Quant in return. Other engineers will verify the material, upvote or downvote content, or provide references, etc – in doing so they too will receive Quant. The software will be scripted to award Quant to author and verifier in proportion to the reputation of each. Reputation is determined by total number of lifetime Quant awarded. Everything is stored and time stamped to a Blockchain.

Since a Blockchain is an unalterable decentralized database, the timestamp and connections between engineers becomes a secure and traceable record. The Quant then becomes a currency traded between engineers that can be exchanged for verification of work, mentoring, cross state collaboration, or technical peer review. Each time an engineer interacts with the database more Quant are conjured into existence. Continued development results in a system that serves as basis for universal engineering qualification, costs virtually nothing, scales magnificently, impossible to forge, and through fault tolerance and network effects, reduces the statistical probability of an engineering failure.

The creation of Quant will be constrained only by the velocity of engineering interaction and production. Over time, the decentralized ledger will begin to resemble the “body of knowledge” that is embodied in engineers and engineering firms. Banks and insurance companies may seek to hold Quant to verify loans, policies, and other securities that are backed by physical collateral. Corporations may bid up the value of Quant in secondary markets in order to secure reliable engineering knowledge in the future.

Civil Engineering as a Lead Discipline

While by no means limited to a specific discipline, the civil engineer will have a critical role leading the definition and creation of the Quant. First of all, civil engineering projects serve as the foundation for the preservation and advancement of the quality of life. Secondly, the difference between public value and public investment is highly skewed and in glaring need of reconciliation. As the American Society of Civil Engineers highlight “a significant backlog of overdue maintenance across our infrastructure systems, a pressing need for modernization, and an immense opportunity to create reliable, long-term funding sources” (ASCE, 2013). It is estimated that each household will lose $3,400 each year due to investment gap, with expectation of loss of $4 trillion in

GDP resulting in loss of 2.5 million jobs by 2025 (ASCE, 2016). Despite known real costs we are unable to secure long term investments to offset these trends.

It is well known that the civil engineering discipline risks commoditization through low-bid procurement methods and difficulties in aligning qualifications to the best life-cycle option (ASCE, 2006). These conditions promote competition over collaboration and regulation over innovation. These themes undercut the boundless foundational knowledge of civil engineers threatening dire circumstances to our profession and our society.

The Flint River lead drinking water crisis exposed the dangers in making major policy changes without continually monitoring water chemistry data already being collected by the agency (Torrice, 2016). 43 lives were lost in the landslides of Oso Washington when development was permitted in a known slide area (Cornwell, 2014). The Gulf of Mexico BP Oil spill has been attributed to a series of cost-cutting decisions by management (Goldenberg, 2011). Each of these tragedies can be traced to the marginalization of the civil engineering profession.

The public stands to gain immensely with civil engineers contributing to the proposed Quant ecosystem. The scope, scale, and purpose for civil engineering are well-aligned with the proposed decentralized engineering body of knowledge. There is no question civil engineers deliver tangible value to public. But why is this value so difficult to convey on the balance sheet? Civil engineering projects are often designed with consideration for long service life and high consequence of failure. These unique projects involve multidisciplinary coordination and interact with both public and private sectors. These factors make the investment and true asset value difficult to track which erodes reliable funding sources and compensation of services. The Quant brilliantly addresses this problem by translating engineering interactions in terms the market can understand.

The possible incorporation of Quant into new civil engineering business methods are too numerous to express here; however, the following illustrative concepts may help to illustrate the how the Quant cryptocurrency ecosystem may aid the profession in positioning engineers more effectively to serve the society at large.

Internet of Things

The "Internet of things" (IoT) is an idea floating around the big data crowd that suggests we put billions of sensors on everything from toasters to bridges and collect tons of data, stir in some artificial intelligence and make important financial decisions.

However, someone needs to invent the sensor, locate the sensor, secure the sensor, isolate it, calibrate it, maintain it, replace it, etc. Data needs to be interpreted, verified,

and synthesized appropriately before any decisions should be made. This is the exclusive domain of engineering. Without an engineer, data is just data.

Through smart contracts, these IoT sensors can be programmed through the Blockchain to deliver Quant micropayments back to the engineer that supports the system every time the sensor operates correctly. Interpretations made on sensor data could be verified by other engineers translating into full-fledged verified conclusions. Quant helps incentivize engineers across public and private sectors to develop high quality sensors, share data, and develop innovative solutions collaboratively.

This will introduce an industry of IoT adjudication for engineers, compensated for their long-term sensor performance and verified data delivery. This application translates to anything where a complex network of sensors is needed. Potential applications include earthquake early warning systems, drinking water quality monitoring for lead contaminants, or any number of emerging “Smart City” initiatives.

Asset Valuation

Real Estate valuation systems such as Zillow, RedFin, Trulia and others will place a valuation of an individual’s most valuable asset by scraping public records. These valuations do not take into account any physical site visits or engineering assessments and are only as accurate as the available public records.

These estimates can vary well beyond the oft-cited +/- 10% median error for such services (O’Brien, 2007). In other words, a citizen’s net worth can be understated by 10%, 20% or even 30% by a glorified search engine. The 2008 Financial crisis was triggered by the inability to determine the actual value of real estate used as collateral on loans. The crisis demonstrates the dependence of the economy on the involvement of qualified engineering-based appraisals. Consider the appraisal implications of known landslides, traffic studies, seismic retrofits, additions, soil conditions, or any number of other valuable engineering assessments.

Quant allows for an engineer to assess the condition of a property (or any other type of asset) and post the assessment to a decentralized ledger, which can be made accessible to big data search engines. Since the engineer is certified and the database is immutable, the data can be verified and utilized to increase accuracy of the estimates.

Implications for Society

The proposed engineering cryptocurrency powered by the Blockchain and incentivized with smart contracts scales to numerous other civil engineering applications. Connecting engineers in this way shows great promise in asset management, asset valuation, system optimization, and even innovative procurement strategies.

In order to reduce life cycle costs 50% by 2025, bold strategies are needed to reconcile the fundamental problem of lost engineering value. While grand in scale, the initial steps are easily identified, measureable, and actionable. The purpose of a network is to find each other. The proposed network encourages global engineers to interact with one another- to teach, to learn from, and to certify each other in various skills on an immutable, decentralized, and time-stamped ledger. Eventually, the value of engineering cryptocurrency would reflect the true value of engineering interaction. The storage of intrinsic engineering value will directly interface with existing financial instruments in banking and insurance. The result is a more stable economy, capable of delivering impactful long term infrastructure investments and a higher quality of life.

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