TECHNICAL MEMORANDUM

A Dual Use Case for Blockchain: Infrastructure Delivery Method and Stable Store of Value

PREPARED FOR:	Integrated Engineering Blockchain Consortium (IEBC)
PREPARED BY:	Thomas Wendling P.E./CH2M, Daniel Robles P.E./IEBC
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Abstract

An application of blockchain technology is proposed as an improved delivery method for aging infrastructure repair & replacement while simultaneously creating a useful virtual currency, which can be used as a stable store of value. Delivery methods concern the source of funding for activities such as design, construction, operation, and maintenance. Maintenance requires funding for unscheduled repairs and replacements of obsolescing physical assets. Current funding models usually involve saving, debt financing, or simple deferral of work until such funds become available. According to Wendling (2015) there is an optimum time for replacement that is usually deferred, mostly due to a short-term lack of funds. The lifecycle inefficiencies resulting from systemic deferral in a portfolio of assets can be significant.

The measure of any currency is its usefulness as a unit of account, a medium of exchange and a store of value. This paper describes a use case for storing value in infrastructure while altering market incentives to produce optimized decisions by a decentralized network of engineers. A blockchain application will create a cryptographic token that unlocks reserve funds corresponding to adjudicated events for future replacements. Time release of these tokens would be constrained by adjudication through a distributed organization of technical experts. Governance of funds would be coded to smart contracts on the blockchain, and would be written to create an insurance-like restriction of liquidity to focus on long-term maintenance needs and simultaneously create currency stability. The novel Blockchain application provides immutable record keeping, unit of account, and the ability to scramble adjudicators making the reserve funds immune from corruption, misallocation, or unnecessary expenditure.

Advantages to the owner of aging assets are as follows:

- Availability of funds for repairs and replacements at the right time and pre-paid expert advice on replacement timing
- Contractor Statement of work and bidding may be standardized

- Property appreciation, property liquidity, insurability, and financing will yield significant gains over a comparable structure of lesser market transparency.
- The value of the cryptographic currency will be inversely proportional to operation risk of the asset.
- The decision to maintain vs. replace will be optimized by game mechanics and easy to project on to future cash flows.
- Moral hazards may be mitigated and catastrophic failures may be avoided thereby lessening punitive exposures.
- Signals the construction markets to increase quality of products and services

1.0 Introduction

Physical assets in the sectors of transportation, energy, power, water supply, healthcare, and communications make up the infrastructure that allows economies to thrive. Machines, vehicles, and buildings, are produced at great expense, then age with ever increasing opportunity costs relative to advancing replacement technology. Eventually the economic advantages of a newer asset become so great that they force a replacement investment. Saving for future repairs and replacements is difficult in a business climate focused on short-term financial performance or in a highly inflationary economy.

Resources to manufacture and operate physical assets are scarce, yet represent the vast proportion of all materials and energy consumed by society. Potentially significant creation and destruction of wealth are at stake in the critical timing of asset replacement, and lifecycle costs of aging infrastructure can be minimized if obsolescence is handled as an insurable event (Wendling 2017). However, an insurance company or captive created for this purpose would be prohibitively expensive because of overhead and administrative costs.

Blockchain technology could allow the development of an autonomous organization with the essential functionality of an insurance product, but without the corporate expense of a third-party insurance company. Repair and replacement risk exposures would be identified by qualified engineers, pooled by actuarial data, and mitigated by smart contract. Improved information, reporting, and transparency will increase the efficiency of associated markets.

2.0 Virtual Currency

Blockchain applications and virtual currencies are connected. The currency is the fuel and lubricant of the blockchain, acting to incentivize the optimum behavior of all participants. The blockchain tracks system change and the currency tracks system incentives - each are functions of the other and therefore constitute integral halves of the system. The application is explicitly defined by smart contract and can affect the behavior of the underlying currency, and the behavior of the currency can likewise affect the ability of the smart contract to fulfill its purpose. The fitness of the resulting system to achieve its purpose depends on the fiscal policy designed for the system.

Most virtual currencies are established primarily as a medium of exchange and as a way to compensate miners to maintain the system. Unfortunately, such currencies often become the subject of speculation more suited for long-term storage of value. The resulting high volatility reduces the likelihood of widespread reciprocity in a market for goods and services – two mutually exclusive conditions

The most effective way to stabilize such currencies is to assign them intrinsic value. By attaching the currency to a known physical event such as aggregate productivity of a physical asset, the currency is essentially "marked to market" for the asset. Whereas the asset may be illiquid, scripts may be written against the asset which are highly liquid and stable.

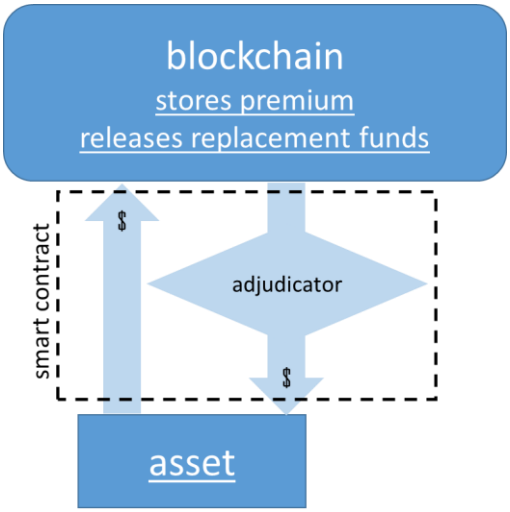
In Robles 2016, Quant, a currency which memorializes the intrinsic value of engineering work, is proposed as the primary blockchain. Intrinsic value in a currency is desirable and can dampen price volatility. A general theory is proposed (Robles 2016) that by mimicking the Bitcoin protocol, specifically the mining function, and replacing Bitcoin's trivial proof-of work with Quant's intrinsic proof-of-real work, the proofing algorithm will transfer intrinsic value to the resulting tokens. Quant, or a Quant derivative token may be created for any project that would enjoy widespread reciprocity because it represents a claim against a real asset.

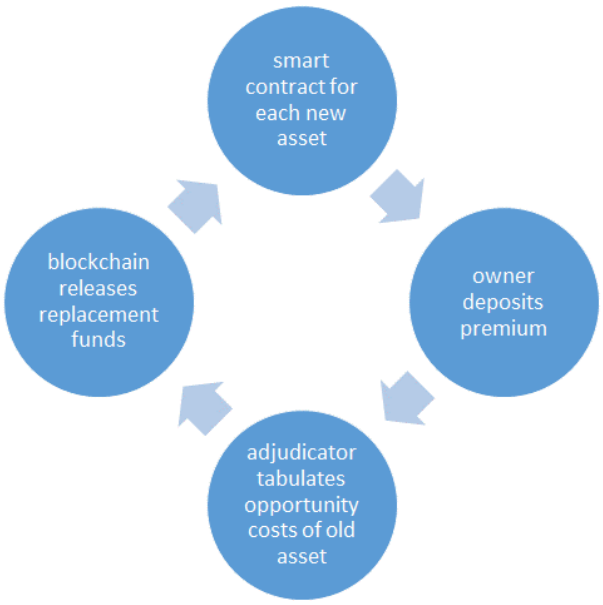
It will be possible to realize the intrinsic value of engineering works in the currency. Quant would have stability because of its actual usefulness integrally tied to the currency mining process itself. What follows describes a concrete implementation of this general theory.

3.0 Asset Registry

In this proposal, a Quant derived smart contract would be written for each physical asset to create an immutable asset registry. Each contract and asset has its own hash identifier, and currency would be securely transferred to or received from a contract by digital wallet.

Funds would be earmarked for the specific asset corresponding to the contract. Payout is time released through adjudication performed by a distributed panel of technical experts who are paid in Quant and incentivized to produce quality opinions.





This system would assure that funds are not comingled with those from other asset owners or even other assets. It would be a self-insurance model using blockchain automation for third party administration. A suicide function coded with each contract would allow liquidation and return of the currency if high-level owner authorization were given; however, such action would be registered in an immutable record and may impact the value of the asset. Market losses may possibly exceed the short-term gains of liquidating the fund, in any case, market efficiency is increased. The asset owner would be able to store as much premium as desired depending on expectations of currency value appreciation over time, and the knowledge of when the funds would be needed for repairs or replacements. Actuarial help in these determinations could also be made part of the governance structure.

4.0 Governance of Funds

A panel of prequalified adjudicators would normally specify the release of funds. The rules for adjudication should be resistant to attack. An attack would be defined as any attempt to trigger a payment of Quant to an adjudicator without performing the required work for the intended purpose. The rules for adjudication should also incentivize high quality technical opinions.

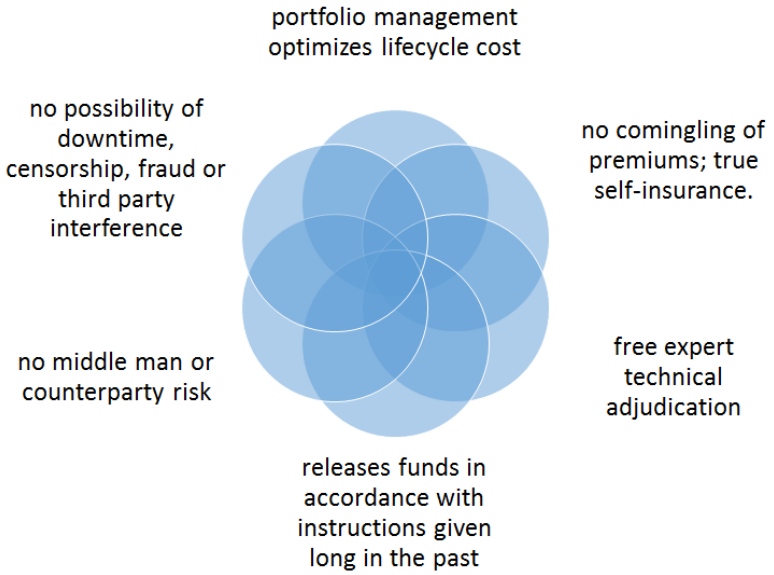
Defensive mechanisms can include randomization of adjudicator so that an owner or contractor would not be able determine which adjudicator will make a determination making them unable to corrupt or deliver retribution against an unfavorable expenditure. The adjudicators may also work in a double blind format to not be able to identify or communicate with each other in order to act collectively in a way that circumvents the intent of the smart contract architecture. Other methods such as a byzantine fault tolerant strategy may be employed where two or more adjudicators vote on an observation and then vote on the vote. If the second vote is not unanimous, a null condition is triggered by smart contract until the discrepancy may be determined.

- As an example of adjudication for the release of funds: An asset owner makes a replacement claim in the case of an aging asset; an odd number of panelists is randomly selected from a prequalified pool of engineering experts; a vote is taken for the release of funds once the technical claim information is disclosed; only experts in the majority would earn a fixed amount of Quant commensurate with the work performed.

- Another governance model example would involve the calculation of opportunity costs *M(t)* associated with an asset replacement decision as described in Wendling 2015. A panel of experts would be randomly selected. The engineer panelist who calculates the value closest to the median of the collected panel values would win a fixed amount of Quant while the outliers would be rejected. This creates a negative incentive for an adjudicator to act incompetently or encumbered by conflict of interest.

- A final example of fund governance involves actuarial help in determining the correct amount of premium to store in the contract, as well as determining the benchmark threshold value of asset opportunity costs for asset replacement described in Wendling 2017. The actuary panelist who calculates the value closest to the mean of the collected panel values would win a fixed amount of Quant. The ability to create an autonomous decision optimization engine is novel and unique to this proposal.

The above examples are proof-of-work analogs to blockchain mining, incentivize accurate technical opinions by a quorum of decentralized experts, and demonstrate how the asset owner could benefit from prepaid technical expertise on repair and replacement decisions.

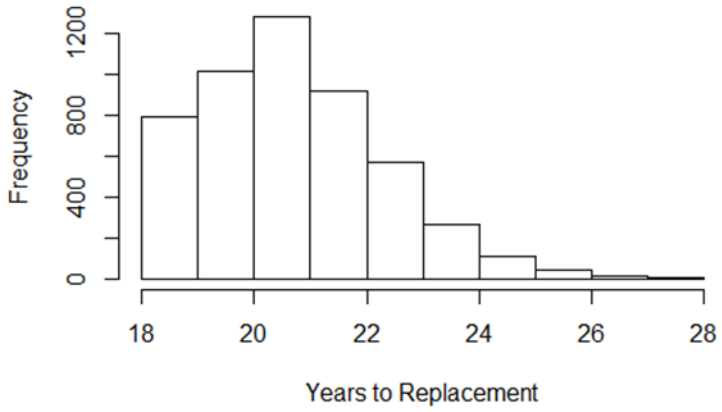


Adjudication is on an individual asset basis. Comprehensive information, such as photographs, videos, equipment specifications, power or fuel consumption, and maintenance history can be associated with the smart contract and uploaded to the Blockchain just prior to the owner's call for adjudication. In this way, adjudicators can be truly distributed and are not geographically constrained to the asset.

5.0 Open Data Structure

Insurance products rely on historical data analysis for ratemaking and reserving. The final governance example given above requires actuaries to participate for this purpose. A distributed ledger is the ideal environment to immutably store asset longevity and repair cost data that can be classified and organized according to an open taxonomy that can be modified by its users. Actuaries would use this data to accurately price the risk of asset mortality (obsolescence) and morbidity (the rate of growth of opportunity costs of not replacing the aging asset, such as increasing repairs or the advent of newer technology).

For example, longevity data on a sample population of standby power generators between 400kW and 500kW would be useful in the actuarial determination of optimal replacement timing of an aging generator of the same classification:



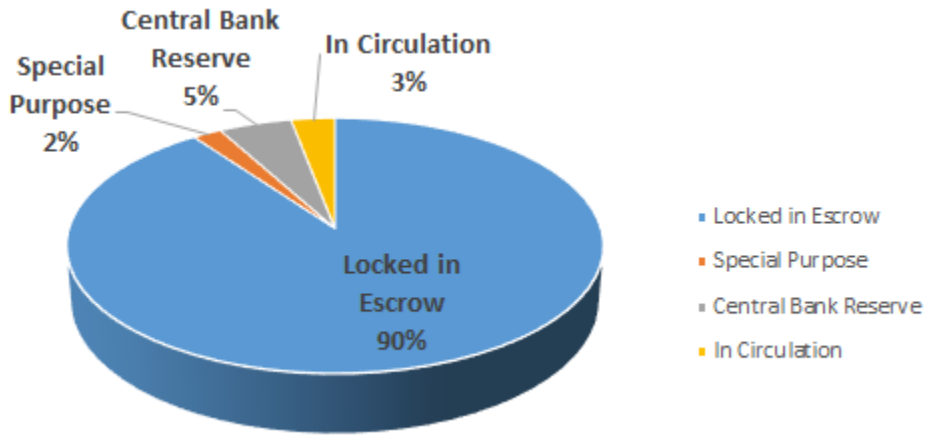
The intent of this application is to create an accumulating body of open data that is self-generating simply through the routine governance actions taken by the adjudicators. This valuable data would form the basis of an actuarial life cycle analysis on physical assets that would span multiple industries.

Such data would normally be proprietary to a surplus lines insurance company. Blockchain technology would make this data available to all without restriction, and would create the statistical foundation to treat physical assets in the context of insurance, bringing the industry's full actuarial talent to bear on what would essentially become a ratemaking and reserving exercise to assure the appropriate portfolio treatment of pooled, homogeneously grouped physical assets treated as mortality and morbidity risks.

The impact of the decentralized database would be felt far beyond the adjudication process. The data would reward the contractors and manufacturers that increase quality, improve maintainability, and extend warranties, etc.

6.0 Stability of Currency

The aggregate value of physical assets in the world is vast. Most of the currency would be locked in an illiquid form (by design) as contractually held funds for future claims generated by the aging of physical assets. The portion of Quant actually in circulation would be small in comparison to the value of assets under management and may be comprised of contract payouts not yet reinvested, amounts held for speculation, or amounts intended purely for exchange of value. Depending on price elasticity, the market value of Quant could fluctuate relative to the velocity of engineering whereas long-term appreciation would be proportional to increasing utility of the data constantly being generated. Such data appreciation would be dominated by networks effects. In any case, the amount of Quant in circulation could be controlled through minimal intervention. A small fraction of Quant would be held in reserve for this purpose. Special purposes of Quant would involve other use cases including the compensation of the adjudicators in the above governance model.



7.0 Supply and Demand for Quant

For funds held over time, appreciation of value is an important consideration. The value of the database will increase proportional to the number of nodes (people) who access it. This is as true for insurance as it is for savings of any kind. If the currency serves a useful purpose for at least a fraction of the global population of infrastructure owners, then there will be demand for it. Even If only a small percentage of owners use it, the data would still become a benchmark for pricing outside of the network. This currency is intended to serve multiple useful purposes, and demand is an important factor in its appreciation over time.

The population of infrastructure owners is diverse. Incipient demand for Quant may originate from owners of new infrastructure with ramping repairs and replacements expected far in the future, from owners wanting to establish such funds in highly inflationary economies, or to protect such funds that are vulnerable to politically motivated liquidation to enhance short term financial performance.

Ultimately, long-term demand for Quant will be related to the recovery of lifecycle inefficiencies by mathematically balancing the massive costs of manufacturing new assets against the equally massive opportunity costs of continuing to operate aging assets. This is important to owners of asset portfolios and for the future valuation of Quant, which derives from value recoverable through a portfolio approach for optimizing the mortality cycle of the things that consume almost all of our scarce resources. The mathematical tractability and magnitude of this value are well documented in Wendling 2015 and 2017. This algorithm is executable through Quant, smart contracts, adjudication, and open data. It would not be possible without and is therefore exclusively enabled by blockchain technology.

The supply of Quant is constrained by the velocity of engineering – the mining source for Quant. To create more Quant would thus require more engineering. Also determinant would be the willingness of Quant holders to exchange their Quant for fiat currencies, so holding Quant in storage may be essential. The value of Quant will be proportional to the utility of the engineering body of knowledge largely governed by Network Effects (the exponential formula known as Metcalfe's Law).

The rate of growth of demand can be controlled through communication of the currency's useful purposes. Early movers in this model could expect to realize the most appreciation in funds as knowledge of its useful purpose becomes widespread through communication, and as the supply of liquid Quant decreases with growing storage in contracts.

8.0 Social Impacts

If widely adopted, the replacement fund governance game described above would have inevitable social impacts. Because of this system's open source, open data structure, these impacts would transcend individual enterprises and even whole industries.

There is an old saying, "only that which is measured matters". The transaction record for a certain facility may be seen as something similar to a credit score. The exception is that a credit score measures negative events, which has also spawned markets to obfuscate responsibility and minimizing market transparency. By contrast the Quant ecosystem measures positive events in the lifecycle of the asset. It can therefore be expected that a market would arise for improving information and transparency.

Due to the decentralization of adjudicators, they may not know each other and therefore cannot collude. Moral hazard may be eliminated where neither the contractor nor the owner know the adjudicators such that retribution cannot be enacted. Finally, there is no incentive to be encumbered by a conflict of interest because outlier decisions are rejected by the system at economic loss to the conflicted party.

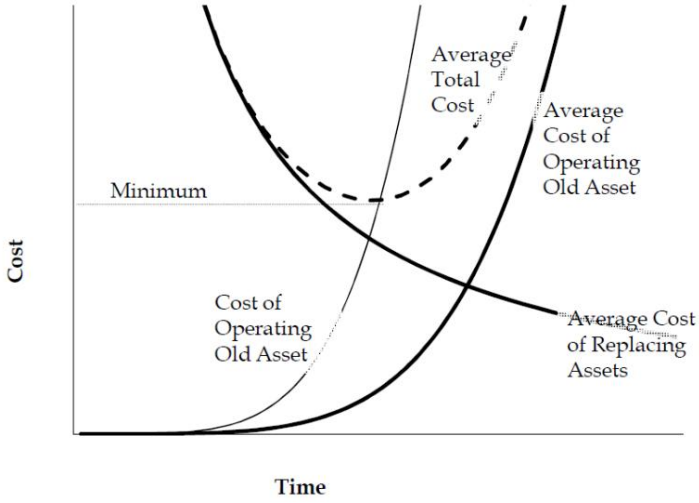
These are benefits that are normally handled through the adversarial judicial and legislation process that produces excessive regulation at great cost to society in order to perform what a simple Blockchain application can accomplish for a fraction of the cost.

8.1 Financial Stability

All financial securities must be backed by some form of physical collateral, otherwise, the security will cease to exist. While every effort is made to secure the financial industry, only the engineers can secure the collateral. Physical assets subject to resale can lose their value because markets can crash. Valuation systems may become disconnected with the reality of an asset's value, as was witnessed during the 2008 mortgage crisis. This use case provides another valuation instrument in the toolbox. An asset enrolled under this replacement insurance system could define the nominal value from which exceptions would deviate. Asset value would be pre-normalized based on its intrinsic value and denominated in a currency designed to reflect this value.

8.2 Systemic Energy and Resource Recovery

The game mathematically balances capital expenditures (CAPEX) and operating expenditures (OPEX) on a portfolio level. Recovered efficiencies represent energy, materials, and labor, which re-enter the ecosystem in a feedback loop. Growth in productivity would result at what could be a step increase in efficiency gains.



CAPEX and OPEX are the two trays of the lifecycle cost optimization scale that are being explicitly optimized by the replacement fund governance game.

8.3 Innovation Driver

If manufacturers can exploit this system to contractually & promptly obsolesce aging assets simply by developing more efficient technology, then it will accelerate research, development, and market adoption of new technology. A faster time to market would result in more of the fixed term of patents being spent on monopoly sales rather than on marketing time. This could have the potential effect of making patents more valuable, encouraging innovation, and driving long term productivity growth.

Conclusion

By simultaneously considering the complimentary purposes of the blockchain application and the virtual currency which energizes it, it is possible to establish resonance between these two integral halves of the system. Smart contract architecture can incentivize accurate lifecycle decisions on physical assets, open data, and storage of funds (savings) for future repairs and replacements. The currency which drives this behavior would benefit from intrinsic value, appreciation, and stability which would make it a general store of value undergirded by the value of the world's obsolescing and replaceable infrastructure.

Other benefits would include increased market efficiency in the design, build, operate, and maintenance industries and the shifting economic incentives towards high integrity and sustainable enterprise as the dominant game strategy for market success. Engineers can perform their objective duties with commensurate compensation without fear of reprisal or forgoing future opportunities. Finally, taking pressure off the judicial and legislative processes renders these important public resources available to better serve society in other ways.

Sources

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