

“Tracified”: Integrating Blockchain with Crypto-economy for Commodified Traceability

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Traceability is now a trending buzz word in many premium product markets across the world. However, the existing supply chain management systems are finding it impossible to cater to the increasing demand for traceability by the modern consumers, due to the distributed nature of the information. “Tracified” powered by blockchain technology facilitates a platform which streamlines the data flow in a supply chain and introduces a novel crypto-economic model to minimize manipulation of the system based on a reward/penalty concept, ensuring fair distribution of gains across the chain. The originality of the solution is further enhanced by its immense focus on the end consumers while also ensuring easy access to administrative traceability to players involved throughout the supply chain.

1. Blockchain

1.1 Introduction

Blockchain is a shared, distributed ledger that facilitates the process of recording transactions and tracking assets in a business network. An asset can be a house, a car, cash, land or intangible like intellectual property, such as patents, copyrights, or branding. Virtually anything of value can be tracked and traded on a blockchain network, reducing risk and cutting costs for all involved.

Blockchain was developed to fulfill the need for an efficient, cost-effective, reliable, and secure system for conducting and recording financial transactions [1].

1.2 The Emergence of Bitcoin

The blockchain offers a different approach bitcoin –a digital currency protocol launched in 2009 by Satoshi Nakamoto, the pseudonymous creator of bitcoin to solve the ‘double spend’ problem: the issue that digital information can easily be copied, and therefore a centralized authority was

previously required to reflect where funds were located.

Unlike traditional currencies, which are issued by central banks, bitcoin has no central monetary authority and no one is controlling. Bitcoins aren’t printed like dollars or euros; they’re “mined” by people and increasingly by businesses, running computers all around the world, using software that solves mathematical puzzles.

The decentralized structure of the blockchain brings several key features such as,

- Transparency: it is possible for anyone to track the movement of funds from one account to another.
- Immutability: once confirmed, a transaction cannot be reversed. No one can interfere with a completed transfer.
- Low cost: transaction fees are minimal.
- Cross-border: funds can be sent as easily to someone on the other side of the world as they can to someone in the next room.

- Speed: due to the flat and transparent nature of the blockchain, transfers show up almost instantly and are typically confirmed in minutes, rather than hours or days [2].

2. Traceability

2.1 Overview

Traceability helps the end Consumers to have a better understanding on a product's origins, its healthiness and sustainability by providing the ability to identify and trace the history, distribution, location, and application of products, parts, materials, and services.

Traceability is a data recording & fact proving system supporting Claimed Quality. Fact proving is when a product processes through the supply chain, the facts which were entered before could be verified or conflicted.

2.1.1 Quality

Quality is an aspect of a product carrying a direct relationship with the product's perceived value in the mind of a customer (when quality is increased perceived value goes up).

In addition quality may permit a product to surpass entry barriers into certain markets (certifications, approvals required).

2.1.2 Claimed Quality

Claimed Quality is the level of quality promised to have been added / maintained by a Quality Custodian.

2.1.3 Ultimate Quality

Ultimate Quality is the level of quality agreed upon by the majority of stakeholders (including end customer) according to a predefined consensus mechanism.

In case of a false response from a stakeholder a penalty would be applied.

2.1.4 Transparency

Transparency is the attitude of making visible all sources and processes involved in making of a product so that the end customer is empowered to make an informed decision.

2.2 Participants in a Traceability Community (TC)

2.2.1 Traceability Advocate (TA)

Typically there will be only one participant (company) in the Traceability Community that will promote traceability within the community. This is probably the company that owns the brand and the end customer. This participant is known as the Traceability Advocate. In rare cases Traceability Advocate can represent more than one company.

2.2.2 Quality Custodian (QC)

A value chain will consist of several stages. In every stage the product / part will be under the custody of one participant. This participant will be adding more to the product / part which will have implications on traceability. This participant is known as the Quality Custodian. There can be many Quality Custodians in a Traceability Community. Traceability Advocate can be a Quality Custodian too.

Example: In an organic vegetables business Farmer would be the QC during farming stage while the warehousing company would be the QC during warehousing

2.2.3 Oracle

There will be participants that just add some traceability data about the product / part at a stage without being a Quality Custodian.

These type of participants are known as Oracles.

Example 1: A lab conducting tests- This is an Oracle that adds in-custody traceability. There can be Oracles that add some traceability without having the product / part in their custody.

Example 2: An example would be a field officer who visits a farm and reports certain information regarding farming. In this case the product is under the custody of the farmer.

2.2.4 Authority

Example for an authority is Control Union that examines vegetables and provide certifications. Authorities are much like Oracles in the sense that they report traceability data without adding any value to the product. They are different in that their traceability input can open or close doors for the product to enter into certain markets. Oracles can be hired by participants in a Traceability Community but Authorities cannot be.

2.2.5 End Customer

The customer who buys the end product. His/her feedback will be instrumental in evaluating the authenticity of traceability data added by participants

3. Tracified

3.1 Overview

Knowing the origin and authenticity of the consumer's purchase online, is crucial today, with so many suppliers in the market. As such, consumers are faced with the challenge of identifying the trusted supplier, whilst suppliers need to be able to prove to

consumers that they are the most transparent in practice.

Tracified bridge this gap, through allowing suppliers to provide transparency of their product lifecycle and practices, which in turn will gain consumers trust.

Tracified will integrate with the businesses available data sources, i.e. internal systems, IoT devices etc. while verifying the data through block-chain technology by allowing more secure transactions and more advantages, and display it to give businesses' clear visibility of the entire value chain.

3.2 Building Blocks of Traceability Economy

3.2.1 TraceProof (TF)

It is required that each Traceability Data items should undergoes one or more Test, to prove its authenticity, satisfying the constraint that the Test itself carries an empirical capability to falsify the Traceability Data. Test context should not controllable by the Traceability Community who owns it, so that, it is done by either another party which is out of control by Traceability Community, or otherwise, by the Traceability Community using an Oracle which cannot be influenced.

TraceProof (TF) provides the measurement of how many times Traceability Data is proven to be authentic by a particular test. The proofs by test will positively contribute to the TracePower, otherwise it will contribute negatively.

3.2.2 TraceValue(TV)

TraceValue indicates degree of contribution from Traceability Data for the accepted quality. It can be calculated by opinions

collected by the participants in the Traceability Community.

Example 1: Traceability Advocate set TraceValue based on subjective judgement

Example 2: Perform Online or face-to-face surveys with customers to calculate TraceValue

3.2.3 Traceability Strength (TS)

Traceability Strength is a metric calculated by the system to indicate that to what extent a particular product is traced. It can be calculated using TraceValue (TV) and TraceProof(TF) for each Traceability Data (TD).

$$TS = \text{Aggregate}(f(TV, TF)) \quad (3.1)$$

Example: The aggregate function can be use as follows.

$$TS = \sum_{\forall TD} TS \times TF \quad (3.2)$$

The aggregation function must be reverse-assignable, so that, it should be able to calculate what fraction of Traceability Strength is contributed by each Quality Custodian.

Assumption: Accepted Quality will have direct relationship with Traceability Strength, as depicted in Equation 3.3, where g is an increasing function.

$$AG = g(TS) \quad (3.3)$$

3.2.4 TracePower (TP)

TracePower denotes the reputation of a participant in a Traceability Community. TracePower affects participants based on their role in the community. For Quality Custodian, more TracePower indicates improved TraceProof for his Traceability Data. A Quality Custodian with high TracePower will get more TracePower for his

Traceability Data even with no proof by any Oracles.

For Traceability Advocate, TracePower will provide improved power in influencing decisions. In Customer context having more TracePower will provide ability to make more influential complaints regarding the product quality. In order to ask for a probe into a perceived quality deficiency, the customer should have sufficient TracePower.

3.2.4.1 Earning and Spending TracePower

At the point of initializing the Traceability Community, all Traceability Advocates will be given a predefined amount of TracePower, and a certain amount of it will distribute to each Quality Custodian. When Traceability Advocate influences a decision, a predefined TracePower is used.

For Quality Custodian adding Traceability Data will consume a predefined amount of TracePower, which will eventually credited again in steps once the Traceability Data is proved to be correct by oracles. When the End Customer accepts the Traceability data, the Quality Custodian is guaranteed to get all debited TracePower with additional increment as an appreciation. If Quality Custodian has run out of TracePower, he has to obtain a TraceCoin loan, which will carry an interest rate.

When End Customer purchase products, he will earn TracePower, which can spend for enforcing a probe into a suspected quality breach. Such complaints by customers with higher TracePower, will be considered as higher priority. The customer will get a TracePower bounty when the Traceability Community confirms the validity of a complaint he made.

3.2.4.2 Overall TracePower

Initially, all TracePower of a Traceability Community will be equal to the aggregate TracePower assigned to all Traceability Advocates. The overall TracePower will increase when an end customer confirms the validity of Traceability Data or an Authority confirms the validity of Traceability Data. Overall TracePower will decrease when an End Customer's disapproval of Traceability Data is confirmed via Traceability Community Consensus or an Authority disapproves a Trace Data.

3.2.5 TraceCoin (TI)

The Crypto unit of value within the Tracified is known as TraceCoin. It will not have an intrinsic value, so that its value will go up when the demand increases. When a Traceability Custodian wants to join Tracified, Traceability Advocate will have to purchase some TraceCoins which will then be converted to TracePower. TraceCoin will be publicly tradable, but also possible to run without allowing to trade publicly.

3.2.6 TracePower and TraceCoin

When participant gets new TraceCoin and attempts to convert it to TracePower, the corresponding TraceCoin value of that TracePower will remain the same while the power of TracePower increase over time, i.e. fresh TracePower is less powerful initially. TraceCoin can be converted to TracePower instantly, but conversion of TracePower to TraceCoin requires to be happen throughout a tenure via installments, to make sure that the participants are committed to the Tracified ecosystem.

In cases such as, TracePower returned after a security hold (i.e. quality claim of a Quality Custodian, Complaint Probe initiated by a

customer) will be assigned same power as it is used to have just before being taken to the security, so that, it will not be considered as fresh TracePower.

3.3 Participant Characteristics

3.3.1 Traceability Advocate (TA)

Traceability Advocate will be the participant in a Traceability Community who will own the brand. Therefore Traceability Advocate will have a vested interest on customer satisfaction. He will also be able to protect the Traceability Community from attacks and will try to improve the accepted quality by avoiding malicious customer input through consensus. Traceability Advocate would see the supply chain as a competitor advantage, hence he will try to protect it by hiding supply chain stakeholder identities from competitors and keeping supply chain stakeholders satisfied by making sure that they perceive that they get a fair share of traceability gains.

3.3.2 Quality Custodian

Quality Custodian may not have the same level of care on end customer satisfaction as Traceability Advocate. Traceability Advocate might enforce Quality Custodian to add certain traceability data. Quality Custodian will have a vested interest on accepted quality on his part as it brings him the reward. Whenever Quality Custodian genuinely adds quality he will make an attempt to prove it by reporting corresponding traceability data if the expected reward is higher than cost of reporting traceability data. Quality Custodian will make an attempt to get his genuinely added traceability data verified as early as possible because it improves his reward.

Quality Custodian may attempt to report malicious traceability data either by adding it himself or bribing an oracle that it supposed to report it in case he recognizes a loophole in the system.

3.3.3 Oracles

Oracles can be believed to report traceability data genuinely when they do not get any advantage of cheating. Oracles can be malicious humans or instruments controlled by malicious humans. Oracles can be bribed by competitors, Quality Advocates or even Traceability Advocates. Oracles may also have physical limitations leading to error prone outputs. Representation of an oracle in the system should encompass physical capabilities/limitations of the oracle, intentions of the participant that controls the oracle and degree of fidelity of the oracle to get bribed. Reputation of a traceability data added by an oracle will be proportional to the trace power it possesses.

3.3.4 Authority

Authorities will be considered to be perfect oracles. They cannot be controlled by any participant in the traceability community and they will not cheat.

3.3.5 End Customer

End customer's goal will be to consume a product with provable high quality. He will be ready to pay an extra for the provability of quality. End customer will appreciate insights into product quality, facts for proving those insights, the ability to provide feedback on quality aspects, the ability to communicate frustrations using the product

to the business and the power to ask for a probe into low quality.

3.4 Participant Perspectives

3.4.1 Traceability Advocate (TA)

Customer satisfaction can only be improved by motivating all participants to add quality and report truthfully. In the perspective of Traceability Advocate, he has to make sure that every participant has enough TracePower to add Traceability Data. Traceability Advocate should invest on educating other participants about best practices, rewards and penalties that associates with the system.

3.4.2 Quality Custodian (QC)

Quality Custodian holds the responsibility of reporting truthfully to avoid high penalties otherwise. When Quality Custodian has the ability to report Traceability Data regarding some quality he added previously, it is always better to add it even by acquiring a loan.

3.4.3 Oracle

In Oracle's perspective, he holds the responsibility of adding the Traceability Data about a product at as stage, with aspects, either product in-custody, otherwise not.

3.5 Adding traceability data to the system

Traceability data at a particular stage in the value chain can be an input by the Quality Custodian or by an Oracle. An example for input by Oracle would be a warehouse entering the temperature values under which the products are kept. An instance of Quality Custodian engaging adding Traceability Data to the system would be a field officer who

visits to observe a farm entering a soil quality report.

Traceability Data can be categorized in terms of the way they added to the system, as in,

1. One-off Data
2. Stream Data

When data added as one element, it is considered as One-off Data, whereas most data is expected to be of this type, for example, harvest date. Stream Data is which added as a stream of values, for example, temperature profile during the transport.

In considering, how Traceability Data digested by the system, it can also classify into two types.

1. Semantic Data
2. Plain Data

In Semantic Data, it can be further processed to extract a meaning, for example, a temperature value. Plain Data cannot be semantically processed further, for example, a custom report that is added in pdf format.

4. Conclusion

The blockchain based design for Tracified involves a mathematical model that extends traditional supply chain modeling techniques into a reward/penalty based economic model which is well aligned with the crypto-economic model offered by blockchain. Tracified is built on plug and play concept, with ability to use with existing data and integrates with existing web shop. Hence, Tracified is a complete solution for traceability of high end premier products which ensures fair distribution of benefits among all entities in supply chain.

References

- [1] C. Trew, G. Brandon and N. Dorier, "Stratis Blockchain Solutions".
- [2] M. Gupta, Blockchain Dummies, NJ: John Wiley & Sons, Inc., 2017.