A Review of Blockchain Applications from the Perspective of Traceability

Nan Liu (17238744)

**Abstract**

The purpose of this paper is to review the current researches of blockchain applications from the perspective of traceability. Blockchain technology is developed from the first decentralised cryptocurrency—bitcoin. As the emergence of smart contract, blockchain has inspired much more extensive applications far beyond digital coin domain. This paper collects the researches about these extensive applications and analyzes how the traceability of blockchain contributes. Our objective is to demonstrate the relationship between the traceability and blockchain applications. By doing this, future research directions and novel ideas can be inspired for people who are interested in exploiting the traceability using blockchain technology.

**keywords**：blockchain characteristics, traceability, blockchain applications

**I Introduction**

Blockchain’s development can be divided into three generations [1]. The first one is bitcoin or other virtual currency [2] which is used with a decentralised network distinguished from traditional currencies with central banks. This design is to fight against inflation, to reduce the transaction fees and to improve anonymity [3]. The second generation is still in the financial market but with wider instruments not just payments and transfers. This came with the advancement of smart contrast [12] which is a self-conducting program in the network replacing the traditional off-line contract [4]. The most famous application in this generation is Ethereum [5]. The third one is beyond financial area expanding to industries like health, supply chain, identity, communication, governance, etc. This paper will review the researches in the context of the third generation.

## Background

Why trace is important? In food industry, traceability is often associated with food’s quality and safety in consumers’ perspective (Van Rijswijk, Frewer, Menozzi, & Faioli, 2008) . Traceability system can be used as a method of guaranteeing credence of a food product (Myae & Goddard, 2012) . On an even wider extent, traceability means good control ability in any manufacturing management (Cheng & Simmons, 1994).

Blockchain is a distributed peer-to-peer network system based on a trustworthy collaboration mechanism without an authorized intermediary (Drescher, 2017) .On blockchain, each transaction which can be seen as a data block is linked with its prier one through a hash reference . When a transaction happens, it has to be verified by the majority users on the blockchain network before it can be added to the public ledger. In the meanwhile, that whether the existing public ledger is forged is detected, too. After the proof-of-work (Nakamoto, 2008) has been done, the up-to-date ledger is synchronized to every node on the chain. Figure 1 shows a simple model of blockchain. However, in real life, it is more complicated that one block contains more than one transaction using Merkle tree (Li, Lu, Zhou, Yang, & Shen, 2014) hash model.



Figure1. a simple model of blockchain

Blockchain’s structure has inherently tracing character that from each block of the chain we can track all the way back to the first one (Yli-Huumo, Ko, Choi, Park, & Smolander, 2016) . There are other properties of blockchain technology which can enhance its reliability of tracing.

Firstly, the transactions are recorded with timestamps on blockchain. DDT (Decentralized Trusted Timestamping) technology can be used which can enhance believability of the existence of a transaction (Breitinger & Gipp, 2017). Secondly, blockchain is a trusted which is hard to cheat (Lemieux, 2016). The validity of historical state of activities is crucial for traceability. If the data is monopolistic and easy to change, tracing on it pales into insignificance. Thirdly, blockchain is a peer to peer network which means there is no central host and any nodes can get the access that makes tracing feasible (Swartz, 2017). Moreover, the private key and public key structure of blockchain can prove the ownership (Underwood, 2016). That means after many transactions we can still easily find the provenance of something (Bateman, 2015).

Blockchain has been reviewed in one industry or comprehensive industries (Sharma, 2017) (Tama, Kweka, Park, & Rhee, 2017) (Rabah, 2018) (Ghuli, Kumar, & Shettar, 2017) or in the view of blockchain itself without applications (Seebacher & Schüritz, 2017) (Yli-Huumo et al., 2016). However, blockchain is developed into a very macro concept compared with bitcoin, even the review in one particular industry, it is easy to get lost and cannot set up a structured and clear understanding of Blockchain.

In this paper, we will analyze the resent application researches linking with traceability and illustrate how traceability is utilized through blockchain in those applications. Most of these applications are not incentive to trace something. Actually, their initiatives mainly about bitcoin’s decentralization, autonomy and privacy (Swartz, 2017). However, whether their implementations are relevant to the traceability of blockchain provides a new look at blockchain and its potentials.

The rest of the paper is organized as follows. Section II will explain the strategy for searching materials. While in section III, we will recognise the tracking points of each application and analyse how they are implement through blockchain by giving the linking map. The last section is the conclusion.

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2 A sequential chain

as a timestamp using the DTT (Decentralised Trusted Timestamping) technology (C. Breitinger & B. Gipp, 2017) that enhances the believability of the existence of a transaction. (Ahmed Kosba∗, Andrew Miller\*, et al. 2016) An online ideas sharing application uses the trusted timestamp as a traceable evidence in a blockchain to identify the original ideas [7][13].

# Methodology

There are several limitations about carrying on this research:

1. That traceability is not the key word or key point in most of the blockchain applications makes it challenging to define the research scope. I have to dive into the journals to extract the ideas of tracing something, sometimes nothing can be found.
2. Most of the blockchain applications are just theoretical that makes it difficult to analyze how they implement traceability.
3. Blockchain is a new research domain and developing exponentially which makes it difficult to cover the newest journals. During my research cycle, new ideas of blockchain applications may be published.

**II methodology**

Our focus is the traceability of blockchain and its applications, so I use following keywords to search on google scholar:

Blockchain trace/tract, blockchain applications, blockchain potential applications, traceability of blockchain, blockchain traceability, blockchain review.

The blockchain articles contain not only above keywords, but I found most resent results of those keywords overlap with each other at a quite high rate. I can rarely find new articles when I search with the last several terms which means the articles searched with the above terms can be sufficient.

My target articles are about the resent researches beyond the digital coin, relevant to traceability. So I narrowed down the searching results first by years: latest 2years: 2016, 2017, 2018, since the concept of blockchain we discussed here is the third generation blockchain technology which just develops in recent years, then by topics (application), contents (choose the ones have functions about traceability), and by the quality of the source. Therefore, we have 80 articles left [6] [14].

# Traceability of Blockchain Literature

## How is blockchain used for tracking in supply chain?

The manufacturing industry becomes more and more complex since that one product can be produced in several countries for different production phases. This makes meeting quality demands more challenging. The supply chain management is always struggling to trace the product during its life circle, especially when consumers have more concerns about product’s quality and security issues nowadays. The launch of blockchain technology can be an ideal improvement for the situation (Petersen & Jansson, 2017) .

Feng (2016) mentioned a traceability system for food-supply chain in 2016, in order to change the situation of Chinese food safety. By using blockchain technology and the application of RFID (Radio Frequency Identification), the framework of the system can solve the trust issue in the traditional supply chain traceability system which is based on the sharing information from supply members. The blockchain is used as a trusted and transparent database for that the validity of the data is proved by the majority nodes on the network so that there will be no cheating. Besides, it is accessibly by any member of the system.

In pharmaceutical manufacturing, there are tracing or tracking needs as well (Biggs, Hinish, Natale, & Patronick, 2017). Blockchain technology is recommended to be the supply network linking all the participants. Because of its immutable transaction data, to be accessible by any participant, mechanism of linking blocks which allows the network nodes track the date from any point along the chain, the pharmaceutical industry can be improved.

## In healthcare industry

In healthcare domain, an App called Healthcare Data Gateway (HGD) was proposed in 2016 (Yue, Wang, Jin, Li, & Jiang). In this system, healthcare data is seen as an asset of the patient. All the pieces of patient’s data, like a blood test result etc... are blocks linking to a blockchain cloud (the public ledger). HGD strictly controls the access of each block by getting the permission of the asset’s owner but uses some secure functions to analyze and query the whole blockchain cloud without any patient’s permission. By these functions the patients’ privacy can be protected and the hospitals, or other organizations in healthcare area can get what their need freely. The Blockchain is used as a trusted datacenter which can be tracked block by block. In addition, its specific structure can help keeping patients’ privacy that distinguishes it from traditional healthcare data system.

Another application uses blockchain to track users’ actions, like getting the access of the medical data or contribution to the medical data, making the sharing of data in a more secure manner (Xia, Sifah, Smahi, Amofa, & Zhang, 2017). The users are verified then given several keys which are used in the cryptographic processes. The request itself is a block recording the user’s information and purpose. Once it is granted it will be transferred form a requests pool to the blockchain with several timestamps recording every step, like when the request was sent, last entry time, and the time of the closure of this block, etc.

## In network media/idea sharing industry

In a blockchain based intellectual property rights management design (Xu, Zhang, Zhao, & Peng, 2017), blockchain technology is used to trace the qualities of network media as one part of the copyrights management scheme.

An VirtualPatent platform was introduced in 2017 (Breitinger & Gipp) to help the researchers share their novel ideas freely before published. By using trusted-timestamp created on blockchain, which is called Decentralized Trusted Timestamping(DDT) methodology, the original owners can keep their credits of the novel idea credit on such platforms without warring about being tampered which is the problem on existing social media or idea sharing websites. (track idea’s owner)

## In e-government

An blockchain e-government project is undertaken in a city of China (Hou, 2017). One system of that project is to improve individual credits by taking advantage of traceability of blockchain. One scenario is individual identity management. Once a person’s identity is generated as an original block, all the other things happened to this person and recorded in the blockchain can be traced back. For example, his marriage records, education records, employment records etc. can be linked to his identity. Because of the reliability and consensus of blockchain, he does not need other organizations to get the authenticity of his individual records and can collect all the records at one time.

## In energy industry

An energy transaction scheme(Wang, Wang, Zhou, & Chi, 2017) and a small scale energy trading system(Mengelkamp, Notheisen, Beer, Dauer, & Weinhardt, 2018) based on blockchain technology connect the consumers and the energy suppliers directly without the traditional centralized organization. Similar with the bitcoin transaction (Nakamoto, 2008), we need to trace the input of a transaction, which is the energy to be transferred here, to determine whether it can be transferred legally. Blockchain’s structure allows every node on the network to trace an input to its provenance which has to be the output of the previous transaction.

For most application researches in energy industry, no matter it is machine-to-machine market (Sikorski, Haughton, & Kraft, 2017) or P2P (peer to peer) network market (Hasse et al., 2016) , it is to transact solar (Rutkin, 2016) or other renewable energy trading within community energy markets (Burger, Kuhlmann, Richard, & Weinmann, 2016) (Mannaro, Pinna, & Marchesi, 2017) , they all use similar pattern as bitcoin transaction using blockchain to trace prior transaction to decide every transaction’s validity.

## In AI

A research based on blockchain to protect smart automobiles’ privacy during communicating with other participants, like manufactures, insurance companies and other smart vehicle owners is proposed in 2017 (Dorri, Steger, Kanhere, & Jurdak). They use blockchain to transfer information between nodes, such as updating the software of some vehicle units, flexible insurance dependencies, car sharing requests etc. The overlay block managers which takes charge of forwarding the information to the right recipient can verify the transaction by tracking to its previous transaction because of blockchain’s immutability and traceability.

## In education

Chen proposed that the blockchain technology can be used in educational applications for tracing the students’ development and for evaluating the education processes as well (Chen, Xu, Lu, & Chen, 2018) . For example, all the details during the process, like students’ feedbacks, discussions, progresses in researches, supervisors’ help with students’ study plan and review of student’s thesis, etc. can be stored in the blockchain ledger.

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