Blockchain Applications in Shipping, Transportation, Logistics, and Supply Chain

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Abstract

Blockchain, as a new technology, has aroused wide attention from industry and academia in recent years. There are a huge number of articles and news reports about blockchain applications in shipping, transportation, logistics, and supply chain. This short tutorial aims to clarify (i) the key characteristics of blockchain that enable its use in shipping, transportation, logistics, and supply chain, and (ii) how these key characteristics are applied. The key characteristics are decentralization, open data, and authenticity of data. The applications include smart contract, fast payment, information sharing, track and trace, and supply chain finance. We hope this tutorial can provide introductory knowledge to practitioners in shipping, transportation, logistics, and supply chain who are layman in blockchain.

1. Introduction

Most people have heard the buzz words 'bitcoin' and 'blockchain'. Bitcoin is one of the earliest, and perhaps the most important to date, application of blockchain. Nowadays, the production and distribution network is globalized and of high complexity, which requires new innovations to address the challenges therein. Blockchain is one of such new innovations. There have been a number of blockchain applications in shipping, transportation, logistics, and supply chain. There were 89 million Google pages when searching 'blockchain AND shipping OR transportation OR logistics OR 'supply chain'' on 25 December 2018.

Blockchain is a distributed digital ledger system. First, blockchain is a ledger system, a system that records the transactions. It should be noted that here transactions do not necessarily involve money. A transaction in blockchain should be understood as a new piece of information, e.g., an arrival of truck to a warehouse and a recording of inner temperature of a refrigerated container. Second, blockchain is a digital system. This is easy to understand: blockchain

involves a huge number of transactions and many players, and a paper-based system cannot work. Third, blockchain is a distributed system. There are many players but there is no central agency that controls or coordinates the players, such as a bank.

Blockchain can be considered as a WhatsApp (or WeChat) group, where (i) all relevant players are in the group, (ii) each player will post in the group all relevant transaction information, (iii) all players will download all the chat records to local disk, and Facebook (or Tencent) does not interfere with the chat in the group. By likening blockchain to a WhatsApp group, we can understand the following three key characteristics that enable blockchain to be applied in shipping, transportation, logistics, and supply chain.

- Decentralization: All the players can communicate directly with each other (note that we have assumed Facebook (or Tencent) does not interfere).
- Open data: All the transaction information is in the chat history of the group, and all the players can access the information.
- Authenticity of data: No player can modify his historical chat records or fake the other players' chat records.

2. Overview of Blockchain Applications

We summarize the blockchain applications in shipping, transportation, logistics, and supply chain in Table 1. The applications are classified into several categories, including smart contract, fast payment, information sharing, track and trace, and loan from bank. We provide a few examples for each category and these examples will be explained in subsequent sections. We also list the techniques that enable each application, including workflow management, Internet-of-Things (IoT), the decentralization (D) characteristic of blockchain, the open data (O) characteristic, and the authenticity of data (A) characteristic.

Application	Examples	Workflow	IoT	Decentralization	Open data	Authenticity of data
Smart contract	Automatic delivery	√				
Fast payment	Bitcoin			√		
Information sharing	US truck companies				√	
Track: transport stage	Maersk Line	√	√			
Track: environment	Cold chain		√			√
Track: process	Odometer		√			√

Trace: authenticity	Luxury products					√
Trace: illegal	Ivory products					√
Trace: unethical	Diamond					√
Trace: unsustainable	Plastics					√
Trace: quality management	Walmart					√
Supply chain finance	Loan from bank					√

Table 1. Overview of blockchain applications.

3. Smart Contract: Workflow Management instead of Blockchain

DHL reported that 10% of freight invoices contain errors and a reduction of 5% transport cost reduction can be achieved by eliminating the errors [1]. Winnesota estimated that $140 billion is associated with disputes in payment in the transport industry [2]. Winnesota further stated that 20% of transportation costs are related to reliance on paperwork [2]. Smart contract can significantly reduce bureaucracy and paperwork. An example of a smart contract is that once payment is received, the delivery of product is automatically triggered. Another example is that once the freight is received, payment is automatically triggered. A related application is that shipping company ZIM digitalizes the bill of lading in its trial of a blockchain based system.

Smart contract is often quoted as an advantage of blockchain. However, smart contract is not the innovation of blockchain. Smart contract is part of workflow management, which appeared much earlier than blockchain. Although smart contract can be integrated into blockchain, it is not a characteristic of blockchain.

4. Fast Payment

Winnesota estimated that on average it takes a company 42 days to receive payment [2]. Using blockchain, payment can be done much faster, say, in 1 hour. Australian car maker Tomcar uses bitcoin to pay some of its suppliers. The fast payment is enabled by the decentralization characteristic of blockchain, eliminating the central agency that is slow. (It should be noted that there are disadvantaged of payment using bitcoin, which will not be discussed in the paper.)

5. Information Sharing

DHL estimated that there are over 500,000 trucking companies in the US [1]. Winnesota estimated that 90% of the trucking companies have at most six trucks [2]. Because of spatial and temporal transport demand unbalance, these companies have low truck utilization in less-than-container-load (LCL) transport. Winnesota estimated that trucks travel 29 billion miles per year with partial or empty loads [2].

Blockchain in Transport Alliance (BiTA) is an organization that aims to improve trucking efficiency using blockchain. By sharing truck and cargo information, trucking companies can reduce empty trips and decrease their costs. This application is enabled by the open data characteristic of blockchain. It should be noted that a third-party platform may also function in a similar way. The disadvantages of a third-part platform, compared with blockchain, include: the former may seek to make a profit and hence distort the market (e.g., by prioritizing the trucking companies that pay more to the platform) and the former may be the target of cyber-attack while blockchain has much higher cyber security.

6. Track and Trace

The track and trace functions are arguably the most importance applications of blockchain. 'Track' means monitoring the process and 'trace' means uncover the origin. Track and trace utilize the authenticity of data characteristic of blockchain. The tracking applications and the tracing applications are elaborated below.

6.1. Track

Maersk Line established a global blockchain-based system to track container shipment. Similar to smart contract, this type of tracking application is not the innovation of blockchain, either. It should be noted that the tracking of transport stages may need other technologies in IoT, such as radio-frequency identification (RFID) tags.

A very important application is tracking the environment while a product (e.g., food, flower, medicine) is in transit. Winnesota estimated that 8.5% of sensitive pharmaceutical products are discarded due to exposure to unacceptable temperatures in transit [2]. Blockchain can integrate IoT technologies, that is, sensors measuring temperature, humidity, vibration, and other items of interest. The recordings of the sensors can be stored on blockchain and hence are tamper free and open to all players. Figure 1 shows a refrigerator of products and the display of the temperature. If the sensors for temperature are operated by a third party and the temperature is regularly stored on a blockchain, then customers can be confident that the products have been stored in appropriate conditions. Depending on the deviation from the required range of parameters of the

environment, actions triggered by the deviation may include adjustment of the environment settings, changing the expiry date of the product, declaring the product is unfit, and applying penalties to the player that is in charge of ensuring an agreed environment.

Figure 1. A refrigerator in Korea Market, New Zealand.

A third application of blockchain is to track the process to make the tampering of results impossible or at least more costly. DHL estimated the odometers of one third of second-hand cars in Germany have been illegal manipulated [1]. Bosch and TÜV Rheinland created a blockchain-based system with an in-car sensor to regularly record the mileage of each vehicle. The recorded data are stored on a blockchain.

6.2. Trace

Tracing the origin of a product, or the origins of the raw materials, components, and sub-assemblies of a product, brings in a number of benefits. (i) Tracing the origin can ensure the authenticity of a product, especially for expensive products such as diamond, handbags, and pharmaceutical products. (ii) Tracing the origin can ensure that a product is legally manufactured. For instance, the trade of

elephant ivory is generally illegal but the trade of the ivory from the tusks of dead woolly mammoths frozen in the tundra is legal. (iii) Tracing the origin can ensure ethical activities. For example, De Beers uses blockchain technology to track stones from the point they are mined all the way to the point when they are sold to consumers to avoid 'blood diamonds'. (iv) Tracing the origin can promote the use of sustainable products. Figure 2 shows a bottle of laundry liquid in a supermarket with the tag 'All our bottles are made from sugar plastics! 100% kerbside recyclable'. If the origin of the bottles is authentic and stored on a blockchain, then environment-conscious customers will buy more of this brand of laundry liquid. (v) Tracing the origin can assist quality management. Walmart uses blockchain to track sales of pork meat and checks where each piece of meat comes from, its processing and storage, and its sale to customers.

Figure 2. A bottle of laundry liquid in a PAK'nSAVE supermarket, New Zealand.

7.   Supply Chain Finance

Many supermarkets adopt the vendor-managed-inventory (VMI) policy, that is, the products belong to the supplier of the supermarkets before they are sold. With blockchain, banks can be sure that the products indeed belong to the supplier, and

hence the products can serve as warrant for the supplier to take a loan from banks. Logistics transactions are often paid monthly or quarterly. Therefore, a company may have a huge amount of money to receive. With blockchain, the money to be received can be guaranteed, and this facilitates the company to borrow money.

8. References

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