Introduction to Big Data and Analytics:

How IBM Food Trust Uses Big Data in Food Supply Chain

Chi-Yun Chen

School of Science and Applied Science, George Washington University

CSCI6444: Introduction to Big Data and Analytics

Prof. Anna M. Long

April 28, 2021

Content

How IBM Food Trust Uses Big Data in Food Supply Chain

Introduction

Food safety has always been a topic that draws much public attention in recent decades. With globalization, many problems like animal welfare, the environmental and ecological impact of food production, and agro-processing for food safety have been gradually emphasized by the customer (Lin et al., 2019; Opara & François, 2001). The impact of foodborne illnesses on the economy is big; researchers estimated that a total of $6.5 million to $33 million foodborne illnesses results in more than 9,000 deaths every year in the United States. Moreover, the cost of illnesses related to foodborne diseases ranges from five to ten billion annually. Food fraud could badly damage the company brand and injure thousands of consumers and cost the global food industry $40 billion a year (Kamathi, 2018). Therefore, the food industry has also started to invest more capital in the food traceability system to track every possible supply chain risk. However, the food supply chain's complexity makes integrating different data and platforms a problematic task than other industries (Opara & François, 2001). With the improvement of technology, there are many strategies offer by the researchers and industry. IBM Food Trust is the one this study would focus on.

What is “Food Traceability”?

Traceability is defined as the "ability to trace the history, application or location of that which is under consideration.". The International Standards Organization of System (ISO 9000) and Hazard Analysis Critical Control Points (HACCP), which is a standard quality assurance system, are the two systems that many practitioners often apply (Opara & François, 2001). This system aims to enhance general food safety and help determine cost-effectiveness by tracing the raw material to the food product in your hand.

Generally, the food supply chain involves several stakeholders, such as farmers, producers, distributors, retailers, consumers and the national government (Antonucci et al., 2019). A good food traceability system should be able to (Opara & François, 2001; Ringsberg, 2014):

- Assurance and reassurance of customers and consumers

- Regulatory compliance
- Demonstrable integrity of food supply chain
- Minimization of and transfer of risks
- Promotes the best allocation of responsibilities
- Facilitation of internal controls
- Used to validate and resolve complaints
- When hazards occur, traceability facilitates effective
- Product recall

However, the prevailing system faces the problems of trust in data records, information integration, and interoperability of different systems to achieve a good food traceability system (Ringsberg, 2014).

The Issue in Food Supply Chain

Processed food could be a highly complex product. Hundreds of food ingredients suppliers may own hundreds of systems and base knowledge. Let's take a lunch box as an example, which may have meat, various vegetables, seasoning, and food additive ingredients. Next, let's take one kind of vegetable in the lunch box as an example, such as broccoli, it could come from different farms. Even the broccoli from the same farm may be a different batch (Comba et al., 2013). Moreover, some ingredients might import from another country. That is one of the main reasons we require days or weeks to trace back a contaminated food.

What is "IBM Food Trust"?

IBM Food Trust is a blockchain-based food tracking system built by *IBM*. *IBM Food Trust* provides immediate access to actionable data and insights for users, farmers/growers, food producers, and anyone in the food supply chain. International companies like *Walmart*, *Carrefour*, and *Nestle* have adopted the *IBM Food Trust* in their food supply chain. Although it only applies to limited products, there is a significant improvement and even more benefits than the traditional system (Kamathi, 2018).

What is "blockchain"?

A blockchain is a distributed database of records, called blocks, that are linked using cryptography. Each block contains a cryptographic hash of the previous block, a timestamp, and transaction data (generally represented as a Merkle tree) (Kamilariset al., 2019). The decentralized design of blockchain contains unmodifiable information. Once recorded, the data in any given block cannot be altered retroactively without all subsequent blocks' alteration (Antonucci et al., 2019).

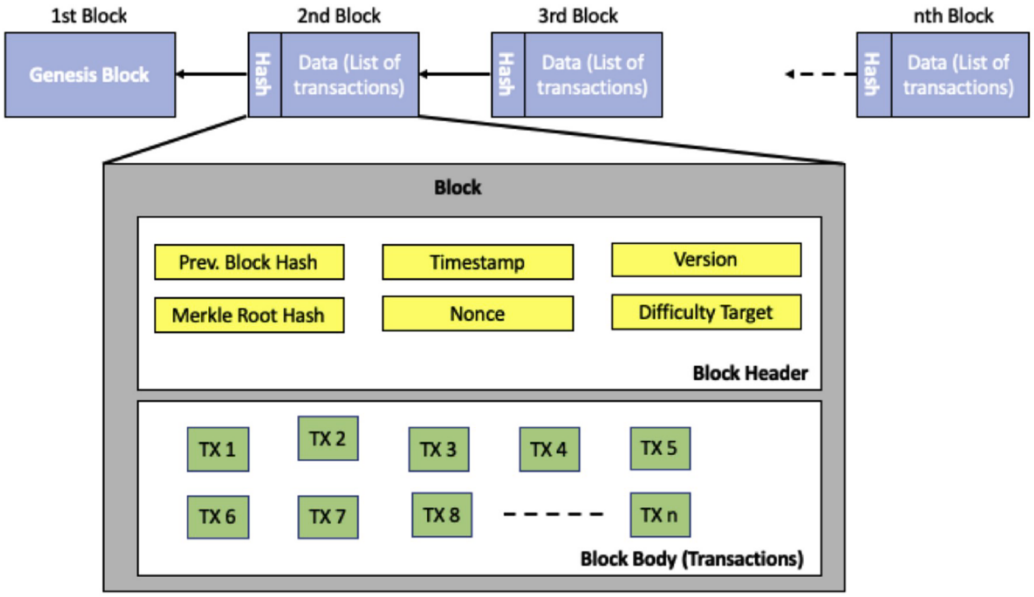

Figure 1. Example of a Blockchain containing n blocks (Kamilariset al., 2019).

Blockchain Application in Food Supply Chain

Good traceability systems should aggregate data from the extended supply chain to create a new level of visibility. Ideally, they can monitor, measure, analyze, and improve Key Performance Indicators for trading partners across the chain. We could achieve those goals through the network of sensors enabled by the Internet of Things(IoT) (Khan et al., 2020). However, trusts stand a high wall among farmers, producers, distributors, retailers, consumers and the national government. The trait of unmodifiable information in blockchain builds the communication bridge between different roles and systems.

IBM Food Trust

The current food supply chain approach as a linear model, which starts from farmer, producer to retailer. The decentralization supply chain model, like blockchain, is structured as a multi-agent system. Every role in the blockchain could record their data in the system, and through a smart contract, each layer can execute action to the products by making all the members participate (IBM, 2019).

Hyperledger Fabric established a decentralized trust in a network, and every transaction is confidential. It supports modular architecture and pluggable components rather than a one-size-fits-all approach. The smart contracts document makes it easy to get started (IBM, 2019).

A wide range of industries — finance, banking, healthcare, IoT, supply chain, manufacturing and technology — can create enterprise-grade blockchain frameworks and code bases using Hyperledger Fabric. It is an open framework built from the Linux Foundation.

Improvement

Through blockchain technology, *IBM Food Trust* provides a trustworthy and transparent platform. Moreover, they integrate different system significantly improve the efficiencies. For instance, *Walmart* is able to track its mango product from 7 days to 2.2 seconds (Kamathi, 2018). The speed of trace processing could decrease the risk in food security. Once there is any incident, we can immediately track every potential step in the supply chain, and identify specific batches and remove them rather than every suspicious product. To improve the accuracy of the data, we usually acquire

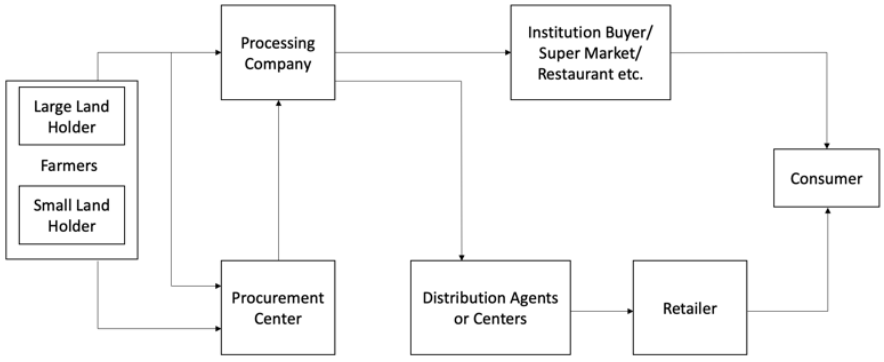

Figure 2. A general map of the traditional food supply chain (Antonucci et al., 2019).

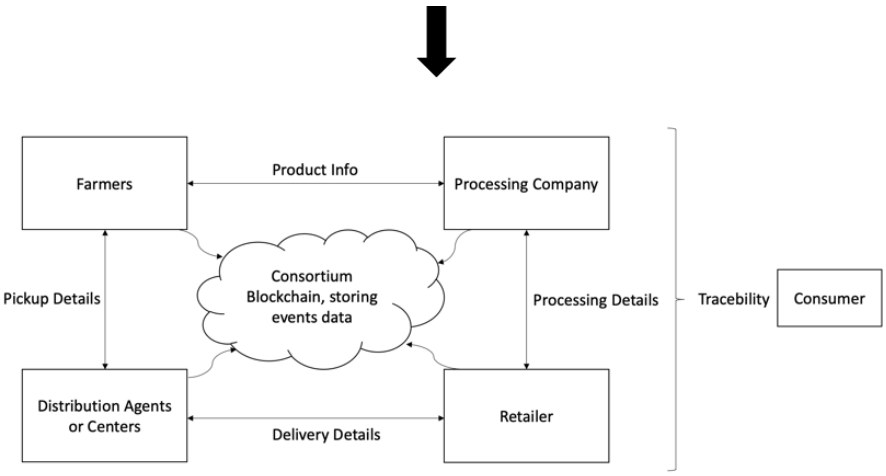

Figure 3. A map of the food supply chain that adopts blockchain (Antonucci et al., 2019).

With this tremendous amount of data, we can facilitate the supply chain and help the grower improve their products. To get accurate data in real-time, we usually need to implant many wireless sensors, which can record temperature, humidity and global positioning system (GPS) coordinates, or even more. The Internet of Things (IoT) is also helping to connect devices and sensors, and the combination of IoT and blockchain generates a large amount of data (Khan et al., 2020). With good use of those data, we may predict environmental and weather patterns or predict the product's quality.

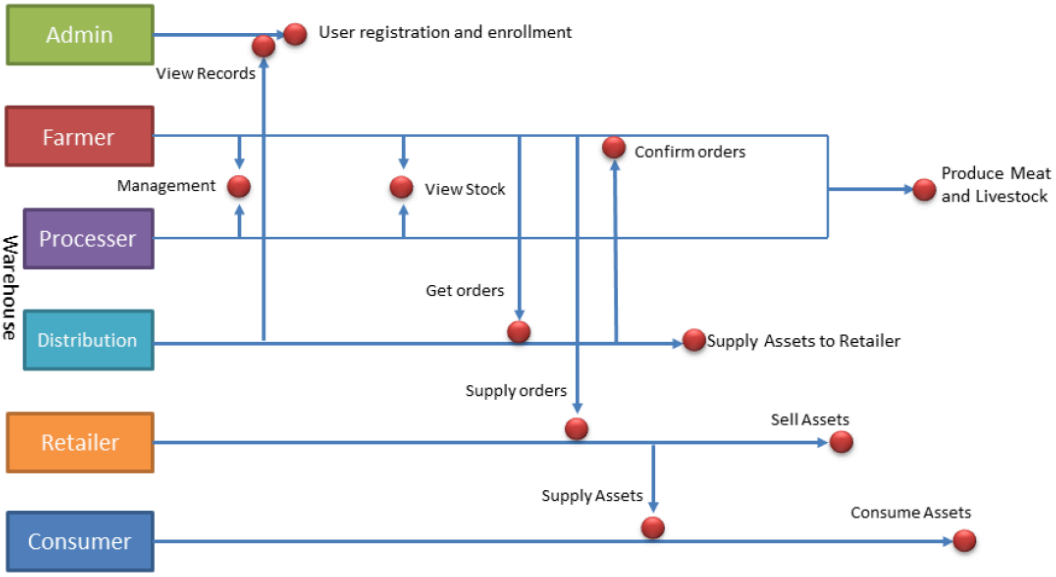

Figure 4. Designed system scenario (Khan et al., 2020).

Barcodes and Radio-frequency identification (RFID) are the technology widely used in flow control. Those technologies allow tagging on the product without invasive procedures. Combine the technologies with blockchain, the tag could be a unique digital cryptographic identifier linking the physical items to their virtual identity (Khan et al., 2020).

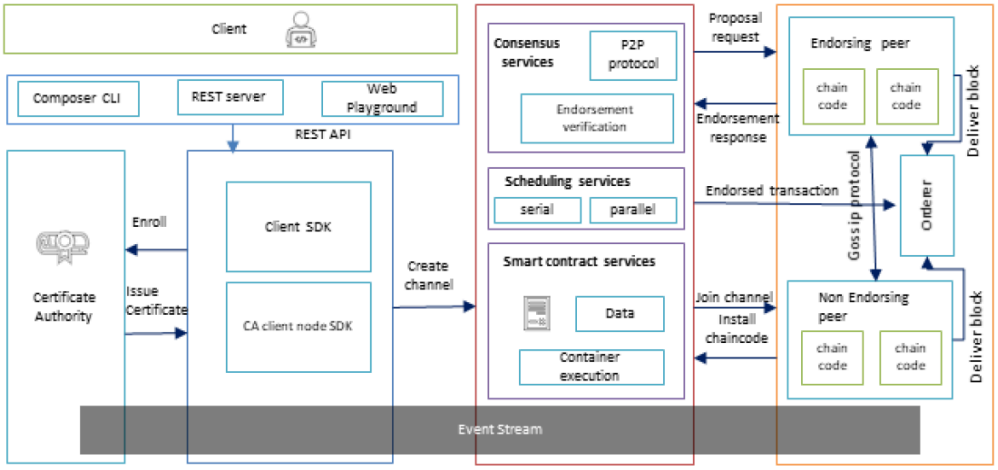

Figure 5. Architecture diagram of a private blockchain (Khan et al., 2020).

Challenges

The transparency of IoT blockchain and advanced technology devices provides an essential communication linkage between various food supply chain players and fix the pain point – Trust Issue. However, the complexity of food products is still a big challenge. From a supply chain perspective, how to integers such a complicated industry is a challenge. Companies like Walmart may begin to implement IBM Food Trust or other blockchain technology, but only on the products with simple ingredients (Kamathi, 2018).

From the data management perspective, the most significant challenges with the data generated along the food supply chain are related to issues of data fairness (i.e., Findability, Accessibility, Interoperability, and Reusability (FAIR)), data quality, data explosion, and lack of standardization (Jin et al., 2020). Nowadays, agriculture is still small-scale and predominantly at the subsistence level in many countries. They may lack resources on the IoT sensor devices.

Any insecure IoT nodes along the food supply chain can be a vulnerable point for the security of the entire IoT system and for the rest of the internet, such as inadequate hardware and software security.

Moreover, handling a tremendous amount of data is a time-consuming task that requires a large computational infrastructure to ensure successful data processing and analysis in a reasonable time. The ownership of the maintenance duty of the infrastructure may fall on big corporations' hands. Data explosion is one of the issues for them. Additionally, they might lead to the distribution of the advantages generated, damaging small and medium enterprises, self-owned farms, and developing countries (Lin et al., 2019).

From the lead company perspective, a different standard of regulation and governments' policy is the obstacle across the national and regional border in the food supply chain. With the growth of globalization, more and more countries involve the flow of food products. Blockchain technology may become a niche for the world to develop international traceability standards and harmonize regulatory frameworks. Still, a country's agriculture usually depends on the government's guide (Opara & François, 2001); therefore, engaging local government is also the challenge that IBM Food trust may counter.

Conclusion

Advantages

From the study of the implementation of IBM Food Trust in the food supply chain, Blockchain technology has already been used in many projects. Moreover, before that, a sound IoT traceability system has built the foundation for the implementation of blockchain technology. IoT traceability systems improve the efficiency of the traditional food supply chain through an internet connection and smart sensors. Blockchain, however, take it to the next level.

From the industry perspective, the decentralization system decreases the processing time significantly and distributes the product wisely. Waste of the product, inventory level/cost, and time variance are all reduced by the application of Blockchain technology. The considerable collection of the dataset allows the industry to ameliorate product production and food safety over time. Furthermore, the knowledge built by big data could renovate agriculture.

From the consumer perspective, the transparency of the food product processing could offer awareness and empowerment (Kamilariset al., 2019). Consumers now demand assurances on the quality and safety of food products and assurances of minimal impact on the environment and ecology (Opara & François, 2001).

From the government perspective, illnesses and deaths due to foodborne hazards represent a major cost to the public health system. With the help of technology, not only can reduce social cost, any related certification and inspection work would be more accessible for the auditing authorities and government departments (Galvez et al., 2018).

Disadvantages

Although there are many advantages to adopting IBM Food Trust Blockchain technology into the food traceability system, we must take some challenges seriously. The integrated system for every food product traceability system just began. The responsibility of the infrastructure in the future is still under discussion. Moreover, the controversy of how the distribution algorithm impacts the economics of small and medium enterprises, self-owned farms, and developing countries is what we need to pay attention to.

These are many aspects that should be deepened in the food sector to facilitate blockchain architecture. Finally, adopting Blockchain technology in food traceability systems and the food supply chain is very promising.

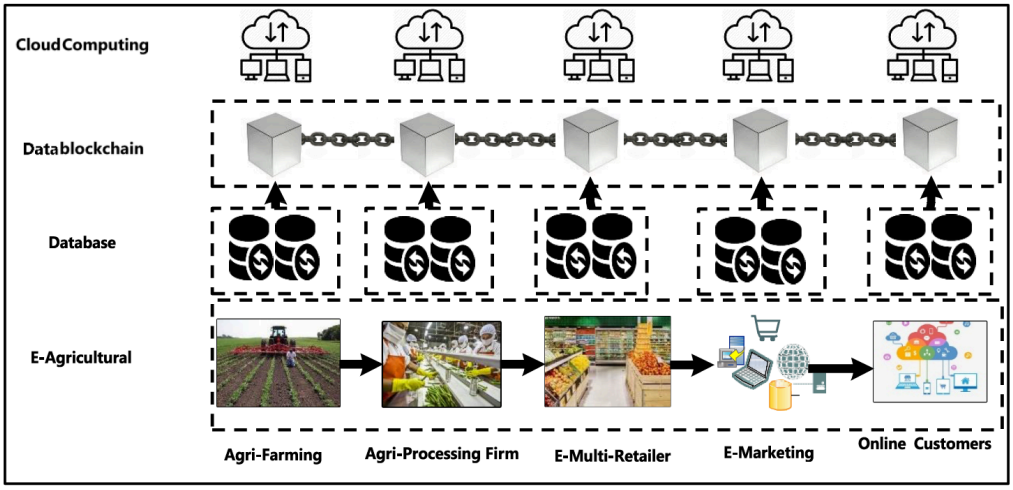

Figure 6. Flow diagram of cooperative e-agricultural supply chain management considering blockchain technology for digital marketing (Alkahtani et al., 2021).

References

Alkahtani, M., Khalid, Q.S., Jalees, M., Omair, M., Hussain, G., Pruncu, CI. (2021). E-Agricultural Supply Chain Management Coupled with Blockchain Effect and Cooperative Strategies. *Sustainability*. 13(2), 816. https://doi.org/10.3390/su13020816

Antonucci, F., Figorilli, S., Costa, C. Pallottino, F., Raso, L., Menesattiin, P. (2019) A review on blockchain applications in the agri-food sector. *Journal of the Science of Food and Agriculture. 99(14), 6129-6138.* https://doi.org/10.1002/jsfa.9912

Comba, L., Dabbene, F., Gay, P., Tortia C. (2013). Open problems in traceability: from raw materials to finished food products. Journal of Agricultural Engineering. 44(s2), 154-157. https://doi.org/10.4081/jae.2013.272

Galvez, J.F., Mejuto, J.C., Simal-Gandarac, J. (2018). Future challenges on the use of blockchain for food traceability analysis. *TrAC Trends in Analytical Chemistry.* 107, 222-232. https://doi.org/0.1016/j.trac.2018.08.011

IBM (2019)., Blockchain Public Regulation Fabric-Food , *GitHub repository*. https://github.com/IBM/BlockchainPublicRegulationFabric-Food

Jin, C., Bouzembrak, Y., Zhou, J., Liang, Q., van den Bulk, L.M., Gavai, A., Liu, N., van den Heuvel, L.J., Hoenderdaal, W., Marvin, H.J.P. (2020). Big Data in food safety- A review. *Current Opinion in Food Science.* 36, 24-32. https://doi.org/10.1016/j.cofs.2020.11.006

Kamath, R. (2018). Food Traceability on Blockchain: Walmart's Pork and Mango Pilots with IBM. *The Journal of British Blockchain Association.* 1(1), 1-12. https://doi.org/10.31585/jbba-1-1-(10)2018

Kamilaris, A., Fonts, A. Prenafeta-Boldú, F.X. (2019). The rise of blockchain technology in agriculture and food supply chains. *Trends in Food Science & Technology. 91, 640-652.* https://doi.org/10.1016/j.tifs.2019.07.034

Khan, P.W., Byun, Y.C., Park, N. (2020). IoT-Blockchain Enabled Optimized Provenance System for Food Industry 4.0 Using Advanced Deep Learning. *Sensors.* 20(10), 2990. https://doi.org/10.3390/s20102990

Lin, Q., Wang, H., Pei, X., Wang, J. (2019). Food Safety Traceability System Based on Blockchain and EPCIS. *IEEE Access. 7, 20698-20707.* https://doi.org/10.1109/ACCESS.2019.2897792

Opara, L.U., François, M. (2001). Food Traceability from Field to Plate. *Outlook on Agriculture*, 30(4), 239-247. https://doi.org/10.5367/000000001101293724

Ringsberg, H. (2014). Perspectives on food traceability: a systematic literature review. *Supply Chain Management: An International Journal*, 19(5/6), 558-576. https://doi.org/10.1108/SCM-01-2014-0026