A NEW ERA OF FOOD TRANSPARENCY POWERED BY BLOCKCHAIN

FRANK YIANNAS

For the past ten years, I have had the privilege of serving as vice president of food safety at Walmart. I am responsible for overseeing the delivery of safe foods to 260 million customers every week across 28 countries and nearly 12,000 stores. At Walmart, we strive every day to help our customers save money so they can live better. However, when it comes to food, operating in so many countries around the world presents a daunting challenge. Our customers rely on Walmart to act as their trusted buying agent, which means that they trust—and indeed expect—that we know as much as possible about the food we sell in our stores and online. To honor that trust, we are always looking for ways to advance food safety and improve public health.

People often talk about the food supply chain, but in reality it isn't a chain at all. The food system today—that is, the way we get our food from farm to table—has evolved into a complex network that is interdependent on many entities. And while there is no question that today's food system provides consumers with a more diverse, convenient, and economical source of food, it also presents new challenges. For example, in today's food system, the output from one ingredient producer could end up in thousands of products on a grocery store shelf. We saw evidence of this during the peanut butter Salmonella outbreak in 2008 and the E. coli illnesses caused by contaminated flour in 2016.

Today there is no widely adopted industry standard for how each segment of the food system (farmer, processor, distributor, retailer, etc.) tracks and records data for food traceability purposes. Many simply record their data on paper, and while some are using digital methods, these methods do not enable communication with other parties in the food system. Thus, the system is limited to

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traceability capabilities that are often described as "one step forward and one step back." Piecing together traceability data by sifting through hundreds or even thousands of documents during a foodborne outbreak can be slow and complicated, and it all too often is not an effective way of identifying and informing action through lessons learned to prevent future outbreaks. These inefficiencies and complexities are one of many reasons we at Walmart were looking for a technological solution to help us achieve enhanced food traceability and transparency.

An outbreak of E. coli 0157:H7 in the United States back in 2006 that was caused by contaminated spinach was an example, and a warning, of the need for better traceability capabilities within the food system. As I am writing this, another multistate outbreak of E. coli involving leafy greens, this time romaine lettuce, is being investigated, and it is clear that not much has changed in regard to food traceability since 2006. The FDA stated in its update on the recent romaine outbreak that "FDA scientists and investigators are working with federal and state partners and companies as quickly as possible to collect, review and analyze hundreds of records in an attempt to trace back the source of the contaminated romaine lettuce."[1.] In the same update, the FDA claimed that people fell ill beginning on March 13. However, the CDC did not issue the first public advisory informing consumers and retailers not to consume or sell romaine lettuce from the Yuma, Arizona, region until April 13. In 2006, it took the FDA approximately two weeks to trace the issue back to the source. As of this writing, it has been over two months since the first CDC advisory but a definitive source or sources of the illness has not yet been identified. The current E. coli outbreak suggests that, in the 12 years since the spinach outbreak, our food system's traceability capabilities have not significantly improved or kept up with the digital modernization that has happened in the world around us. These statements are not a criticism of the good work our nation's health officials do on a daily basis; they are, however, a critique on the food system's ability to track

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and trace food—and an urgent call to action.

Further illustrating the need for improvement is the fact that more and more food product recalls in recent years have been caused by a single ingredient. These ingredient-driven recalls can last a month or more, due to inefficient and disparate traceability systems that do not have set standards and do not communicate with each other. The 2009 outbreak, which was caused by peanut paste produced by the Peanut Corporation of America (PCA), lasted for months as suppliers slowly became aware that their products contained PCA's peanut paste. In the end, nearly 4,000 food items were recalled. A digital, transparent food traceability system could have identified where PCA's ingredients had been used in much less time.

Creating a digitized farm-to-fork industry standard enabled by blockchain would likely enhance, accelerate, and optimize food traceability throughout the entire food supply.

BLOCKCHAIN TECHNOLOGY AND FOOD

Blockchain is a technology that enables the creation of a decentralized, distributed, and trusted digital ledger that can be used to record transactions from multiple entities across a complex network. A record on a blockchain cannot be altered retroactively without the alteration of all preceding blocks and the consensus of the network.

How to enhance food traceability and transparency for our customers is one challenge that Walmart has been working on. Blockchain is often associated with cryptocurrency, but it is being looked at more and more as a solution to food-supply problems that will enhance trust and transparency. Walmart believes that using blockchain could usher in a new era of food traceability, and that it could benefit areas beyond food safety, such as improving sustainability by reducing waste and lowering costs by eliminating food system efficiencies. Moreover, using blockchain could enable the capture of data beyond mere traceability attributes (where and when), including those that promote greater transparency (How was a food produced? Was it sustainably grown?).

Having worked in the food profession for more than 30 years, I have to be candid. I've been pursuing better traceability systems for many years, and when I first heard about blockchain and considered the role it might play in enhancing food traceability, I was a bit skeptical. It was only after I started learning more about blockchain, such as how it digitizes information, and more about its unique features (immutability, consensus, etc.) that I started to change my mind. After we successfully piloted the technology, I moved from being a blockchain skeptic to a blockchain believer.

While you usually hear about blockchain technologies that are implemented for cryptocurrencies like Bitcoin, the truth is that enterprise-level blockchain networks are starting to emerge that have a wide range of use cases in the private and public sectors. For example, financial institutions are evaluating blockchain to improve the tracking and tracing of real currencies; transportation and logistics industries can use it to improve tracking of containers or packages; and regulatory agencies can use it to improve import control efficiency. Blockchain also can free up capital flows, improve efficiencies, reduce costs, and build trust across a broad range of stakeholders and ecosystems.

Why do I believe that it is time for a technology like blockchain to transform the food sector and usher in a new era of transparency? First, I know it can improve our ability to definitively link

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WHY BLOCKCHAIN?

A blockchain-based ledger is a shared digital ledger used to record the history of transactions, which cannot be altered. In a typical transactional relationship, multiple parties are involved in the transactions along a supply chain, and every party typically has their own version of the truth. This environment is fraught with errors, duplication, and redundancies that create inefficiencies along the supply chain. This is especially true in the food sector, where there are many small to mid-sized enterprises that even today maintain paper-based records. A single shared ledger that is tamper evident alleviates many of these inefficiencies and allows all parties participating in the series of transactions to have a view into one version of the truth. There are elements that are unique to blockchain networks that make the technology a game-changer in terms of promoting greater trust and transparency in food. These elements are:

Decentralized: In a blockchain network, multiple nodes hold a copy of the same data, which eliminates the risk of a single point of failure in the network. This is a key difference between a blockchain network and a centralized repository (or authority) of data.

Immutable: By using cryptographic hashes and encryption, data is written onto the blockchain in a way that cannot be altered without detection. Not only does this increase confidence in the data itself, it also incentivizes all stakeholders responsible for putting their data on the blockchain to ensure the accuracy of that data the first time and every time it is uploaded.

Consensus: To write data onto the blockchain requires consensus from all parties involved in a transaction. This ensures that a single entity does not control the blockchain and also allows for the permissioning of data to meet the business needs of the blockchain participants.

Democratic: The governance of the blockchain can be implemented and enforced in a democratic and transparent manner, whereby a diverse group of stakeholders participating in the blockchain network have an equal voice on issues such as data ownership, rights, data sharing, and protection. In addition, as opposed to a central governing authority benefiting from the insights, all participants in a blockchain system can get smarter together, thereby creating what we refer to as shared value.

foodborne outbreaks to their causative food vehicle, which could result in fewer and smaller outbreaks and fewer people harmed. It could allow for more efficient analysis to determine the root cause of an outbreak, which also would inform future prevention efforts. The U.S. Centers for Disease Control and Prevention estimates that 48 million consumers get sick from foodborne illnesses each year. The global estimates by the World Health Organization are even more concerning. Moreover, the economic impact of such outbreaks in the United States alone ranges from $55 billion to $93 billion (Scharf, 2012). The inability to track and trace food efficiently back to the source of the contamination is one main factor contributing to these statistics.

Food fraud is another growing concern across the global food industry. From counterfeit olive oil to adulterated milk, it has been estimated that food fraud incidents cost the industry between $10 billion and $15 billion annually. (Johnson, 2014). One reason for this is

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that the supply chain is only as secure as its weakest link, and cargo theft is on the rise. One of the reasons unscrupulous suppliers are willing to commit food fraud is because they do not fear being caught, due to the anonymity of how food is produced and where it comes from. Having a digital, real-time ability to monitor and trace food as it flows from farm to store will be a strong deterrent for such fraudulent activities, as it will create a digital footprint that leads back to a fraudster's door.

Food-safety regulations are becoming more stringent across the globe. For example, the U.S. Food Safety Modernization Act established additional record-keeping requirements, including a section on enhancing the tracking and tracing of foods. This will inevitably raise the bar on the minimum expectations for food traceability in the coming years.

From a sustainability perspective, greater traceability and transparency would likely allow food system participants to optimize supply chains and reduce food waste. The current estimate is that nearly one-third of the food produced globally goes to waste. In the U.S., the amount of food waste each year equals $161.1 billion (EPA). We know we can do better. We know we must do better. By having more targeted recalls, we can both reduce the amount of unaffected food we discard and protect public health more effectively. By having longer shelf-life and providing the consumer with clearer messages about the safety and quality of food, we can reduce post-purchase consumer waste.

Ultimately, blockchain-enabled traceability will create greater food transparency, which will lead to greater accountability and incentivize every stakeholder in the food system to do the right thing every time. Greater accountability will in turn encourage stakeholders to take greater responsibility for food safety, which will promote greater trust within the supply chain. Consumers are already demanding this, and it's up to the industry to step up to meet this challenge.

WALMART'S PROOF OF CONCEPTS

In October 2016, Walmart and IBM announced two proof of concepts (POCs) to demonstrate that blockchain technology provides a viable way to trace and authenticate food from farm to store with speed and precision. The POCs focused on two elements of the blockchain solution: traceability and authenticity.

Mangoes and Traceability

Consider a typical mango supply chain, starting with the seedling that takes five to eight years to mature. Once the mango is harvested, it is sorted and containerized before being loaded on a truck and shipped, often across borders. The mango then gets further processed—cleaned, sometimes sliced, and put into a clamshell—before being palletized, put on a Walmart truck, and shipped to a Walmart store. At the store, our customer will pick up the mango, check out, and take the fruit home to enjoy. Even for a fairly simple food product like a mango, you can see that it's a long and complicated supply chain with many stakeholders involved.

I wanted to find out what it would take to identify the grower of a single package of sliced mangoes offered at one of our stores. So, I bought a package of mangoes at a local Walmart store in northwestern Arkansas, and during a meeting with my leadership team I asked them to find out which farm those particular mangoes came from. I told them that I was going to time them. They began by calling our immediate supplier to see if this information was readily available. In

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Figure 1. Life of a Mango

today's regulatory environment, the expectation is that stakeholders maintain records for one step up and one step down. This means that each stakeholder in the mango supply chain had to work with the next node in the chain to identify the provenance of my mangoes. It took us 6 days, 18 hours, and 26 minutes to identify the farm that harvested those mangoes! While this was pretty good by industry standards, where an average traceback can take weeks or even months, in today's digital age, where information is available at our fingertips, this was unacceptable for Walmart.

One of the key advantages of blockchain that Walmart and IBM wanted to prove was its ability to provide product visibility from farm to store. The spinach outbreak was evidence that alerting stores in a matter of seconds that they needed to remove a product would be invaluable to public safety. To prove this feature, Walmart and IBM used blockchain technology to trace mangoes from farms in Mexico to two stores in North America. For this test, each stakeholder in the supply chain, including farms, packing houses, transportation companies, importers/exporters, processing facilities, distribution centers, and stores, put data on the blockchain. The blockchain then linked the datasets together to tell the story of the journey this mango took from farm to store. The result was a steep reduction in the time it took to trace mangoes—from 7 days to 2.2 seconds! That is what I have referred to as "food traceability @ the speed of thought."

We used mangoes for two reasons. First, the produce supply chain is one of the most complicated in the food system. Second, even though the produce supply chain is very safe when one considers per-capita consumption rates, when a foodborne illness does occur, produce is one of the most frequent causes. The ability to

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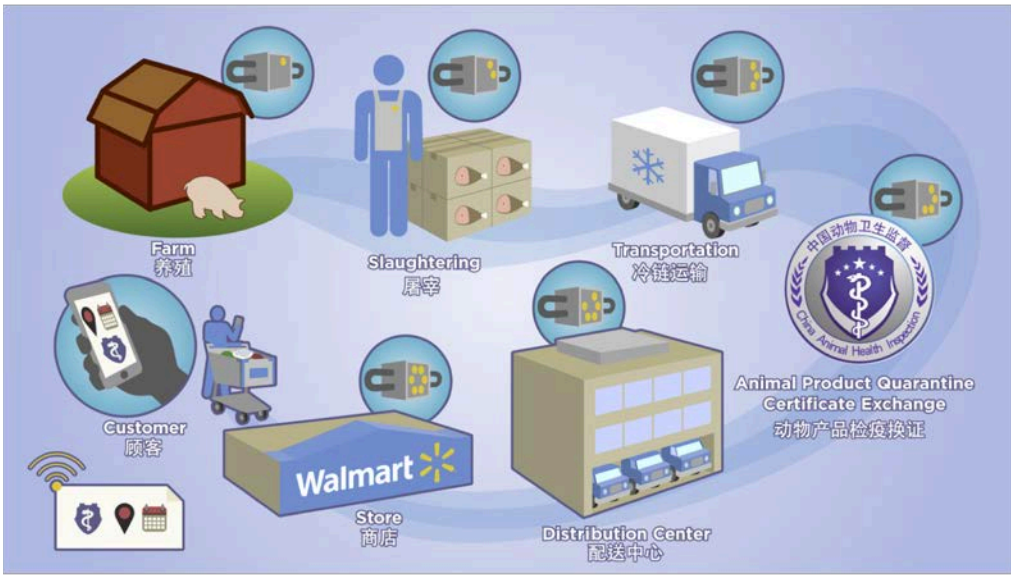


Figure 2. Pork Supply Chain in China

pinpoint and remove a product from the shelves immediately after becoming aware of a food safety issue could prevent illnesses, and also reduce the likelihood that the wrong sources will be erroneously implicated.

The amazing power of this innovation is that, once the foundational infrastructure enabling greater transparency and traceability is built, it is relatively easy to leverage the same infrastructure to collect additional data about the food, from time-temperature tracking for improved freshness to tracking certificates for food safety audits.

Another benefit we observed during the mango POC was increased visibility into the speed at which food flows through the supply chain. For example, it is easy to blame the farmer for the poor quality or lower shelf life of foods that reach our stores. However, during this POC, we learned that the mangoes sat at border control for four days before reaching our direct supplier. That's four additional days of shelf life we could give back to our customers, resulting in better quality products and less food waste. Using blockchain will allow us to identify where in our supply chain we can improve efficiencies and to do more "fact-finding" than "fault-finding" when issues do arise.

Pork and Authenticity

Food fraud is being identified increasingly and consumers are aware of this trend. Proving that blockchain could be used to build confidence in the authenticity of our products was as important as proving traceability. We wanted to demonstrate that blockchain could be used to do more than trace food and we wanted to engage our international partners as well. So, in addition to our "mango POC," we conducted a POC to trace pork from farms in China to a Walmart store, also in China.

We began by collecting information about the animals at the farm in China, then at the slaughterhouse, and on through their transport and the Animal Product Quarantine Certificate Exchange. Prior to conducting the POC, a label was placed on each case of pork at the pro-

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cessing facility, but it contained minimal information. For the POC we added a QR code (barcode) to each case, which allowed any trusted user to verify the traceability and authenticity of the product at any point between packaging the product into the case and its arrival at our stores. Our Walmart associates could scan the label in the distribution center to digitally view the purchase order and shipment details, and thereby verify that the product was flowing through the correct distribution center. Our associates previously had to verify the details on paper, which made us vulnerable to errors.

Even more exciting is that the veterinary certificates were scanned to blockchain, rather than physical copies being handed to a truck driver. The certificates were stored on the blockchain as an immutable digital copy that was accessible to any trusted user on the network. Permissioned food safety professionals in our organization had instant access to the veterinary certificates at any time, which eliminated having to chase down paper records. In the POC we reduced the amount of time it took to access the certificates and increased confidence in those records. In China, where trust and authenticity are serious issues, we brought trust to the food system.

FOUNDATION PROGRAM

Over the summer of 2017, after demonstrating that blockchain was a viable way to trace and authenticate food, we realized that if we sought to build a proprietary system unique to Walmart and our supply chains, we would fail. The power of blockchain networks comes from collaborative ecosystems that enable a diverse group of stakeholders to participate in the network. No single retailer or single food company, regardless of size, can (or should?) do this alone. We understood that these were still the early days of blockchain technologies being applied in an enterprise environment and that we needed to encourage innovation in this space rather than stifle it.

Therefore, CEO Doug McMillon, contacted the leaders of some of the world's most influential food companies to inform them of our accomplishments and ask them to participate in additional testing and scaling of the solution. Partnership was critical to creating an open, collaborative solution that would work for everyone. If each company attempted to create solutions in isolation we would end up right back where we started on this journey, with systems that don't talk to each other and datasets that cannot be linked across the supply chain. We recognized early on that pre-competitive collaboration was essential in this space if we were to deliver a safer, smarter, and more transparent food system to our customers. For this reason, we invited even our competitors to join us in scaling this innovation. Moreover, it would have been cost-prohibitive for each supplier to implement and participate in a separate blockchain network for each retailer with whom they conduct business.

Today we have a coalition of ten Foundation Partners comprised of both suppliers and retailers, which include Walmart, Kroger, Wegmans, Tyson, Driscolls, Nestle, Unilever, Danone, McCormick, and Dole. It was equally important to ensure that the self-governance structure we built around the blockchain network to resolve issues such as data ownership, privacy, and access rights was done collaboratively with the Foundation Partners in order to prevent any one stakeholder, like Walmart or our solution provider IBM, unequal authority to make decisions.

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GUIDING PRINCIPLES FOR THE DEVELOPMENT OF BLOCKCHAIN SOLUTIONS

To promote a more collaborative approach to blockchain food applications, reduce duplication of effort, and promote more efficient and interoperable solutions, Walmart has developed the following guiding principles on how we believe blockchain solutions should develop for food.

Solve for a Business Case: When pursuing a new technology application, we believe there should be a clear business case for doing so. Don't chase blockchain but consider when it is deemed more effective than existing technologies or approaches. This also means that one should begin with the business problem that is being addressed in mind—not the technology.

Collaborate: As the food system is complex and interdependent on numerous stakeholders, we believe the development of blockchain solutions should be collaborative efforts, as no single company or sector can digitize the food system alone. Working together, we can reduce duplication of effort, redundancies, and gain food system efficiencies by promoting more effective and interoperable solutions.

Interoperate: A collaborative, digital traceability network does not exist today, because companies have digitized their areas of the food system in isolation and created digital information silos. To prevent a repeat of the past, we believe blockchain food networks must be designed so that they are interoperable with legacy systems as well as other blockchain networks, and are based on existing standards, such as GS1.

Create Shared Value: One beneficial feature of blockchain is that it democratizes information. In order to take advantage of this feature, blockchain solutions should be designed and operated in a way that provides benefits and adds value to all stakeholders in the food continuum (farmers, processors, distributions, retailers, etc.). Making sure that all stakeholders benefit is critical to creating a blockchain ecosystem that participants want to join and participate in voluntarily. It will also allow the entire food system to get better together, rather than individual entities getting better alone.

Leverage: Whenever possible, blockchain solutions within an organization should utilize and build on existing technologies, processes, standards (such as GS1), and investment should be made in digitizing the food system. This will allow blockchain solutions to develop in a cost-effective and less disruptive manner.

Establish Strong Governance: As blockchain solutions are less reliant on a central authority, blockchain networks must clearly establish rules for self-governance, including membership, data ownership, rules of conduct, and privacy. Blockchain is about trust.

Make It Affordable: During these challenging economic times, consumers worldwide are trying to make their food dollar go farther so they can feed their families and loved ones. As advocates for the customer, we believe blockchain solutions should always undergo a thorough cost-benefit analysis to ensure that they truly deliver benefits while protecting against ineffectiveness and unnecessary cost. In addition, we believe blockchain solutions should have little to no cost to use, and that any amount users pay to participate are proportional to the benefits they derive from the solution.

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Scaling Trust

Walmart, IBM, and the Foundation Partners have moved rapidly to scale, test, and implement blockchain-enabled traceability on a number of strategically selected SKUs, including both private and supplier brands. As of May 2018, Walmart has already tracked nearly two dozen SKUs involving 2.6 million food packages across 166,000 traceability events on the blockchain. Furthermore, we have achieved this in a production environment—that is, beyond proof of concepts or pilots. After hearing about the Foundation's successes to date, many companies across the globe have reached out to us saying that they want to learn about our approach and participate in our initiative.

I truly believe that blockchain could enable a level of transparency in the food supply chains that has not existed before. It will allow us to move from a food system that has operated with a lot of anonymity and create an environment of accountability that enables and scales trust. For Walmart, the end goal is to leverage this transparency to create a safer, smarter, and more sustainable food system that benefits people and the planet. Ultimately, this will benefit our customers, whether it helps them make a better decision while shopping at our stores or allows them to scan a QR code on the package to learn everything they would like to know about the food they are purchasing—from the farmer or fisherman through each step it took in the journey from farm to store.

Potential Impact of the Innovation

A digital food system enabled by blockchain could enable more than just traceability and safety. It could lay the groundwork for benefits such as the following:

Transparency: Transparency is the food system's desired state, one in which a food's attributes are easily accessible to all stakeholders, including consumers, so that decisions made at every level can be more informed.

Enhanced Food Flow: Blockchain will enable instant access to large amounts of data that was not previously available. This means that the best decisions about how food flows from farm to our stores will be not only possible but automated.

Reduced Food Waste: One outcome of using blockchain could be a vast reduction in food waste. This aligns with Walmart's commitment to achieve zero waste to landfill in key markets by 2025, and to sell more sustainably produced products while maintaining the low prices customers expect.

Deterring Food Fraud: Enhanced transparency will shine a light on each actor in the food system, which we believe will discourage unscrupulous behaviors and deter food fraud.

New Model for Scaling Trust in Food: Given recent and well-publicized food scares and data scandals, some consumers have lost trust in both private and public institutions and large central authorities. This trend is not unique to food and it has broader societal implications. Some believe that a new form of distributed, digital trust that is dependent on better checks and balances is emerging. Because blockchain protocols are based on decentralization and consensus, it could help food system stakeholders restore and scale consumer confidence in food, and in the institutions that are part of the nation's food supply.

Walmart and the Foundation Partners have moved rapidly to scale, test, and implement blockchain-enabled traceability on a number of strategically selected SKUs. Right now we are on the verge

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of demonstrating complete farm-to-store traceability for many more.

As our global community becomes smaller, the business of moving food from the farm to the dinner table has become increasingly complex. Food is being distributed farther than ever before, sometimes from one distant country to another, and foodborne disease outbreaks could become more widespread. As long as foodborne outbreaks exist somewhere in the world, they can exist anywhere in the world. Today's food system requires more interdependence on multiple stakeholders than ever before. In fact, collaborative solutions have never been as important as they are today. No single food retailer can mandate better food traceability, food manufacturers in one country can't do it alone, nor can any single country's regulatory agencies. Better food traceability requires collaboration, and it must be people led and technology enabled.

While we are starting with food traceability, our ultimate goal is greater food transparency, which will benefit all food system stakeholders. It will benefit food producers along the entire food continuum. It will benefit regulatory officials and NGOs. But, ultimately, enhanced food transparency will benefit our customers. By getting rid of the anonymity that exists in the current food system, blockchain technology will shine a light along every step of the way in the life of our food products to help create a safer, smarter, and more sustainable food system so that our customers can save money and live better.

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