CASE STUDY

Logistics and Asset Management
Intel IoT

Tracking Perishable Goods with Blockchain and the Intel® Connected Logistics Platform

Intel partnered with a leading blueberry supplier to show how using blockchain technology in the supply chain can help farmers deliver fresh produce to market in prime condition

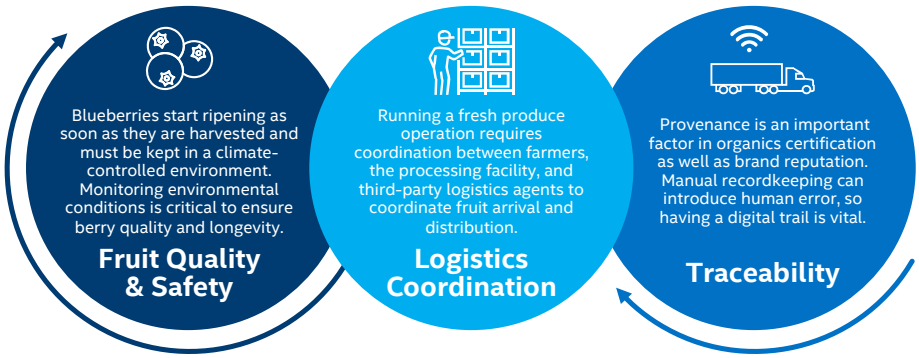
Executive Summary: Berries and Blockchain

Growing concerns with food safety in recent years have created a demand in both private and public sectors for greater food supply chain traceability and improved quality controls. Consumers and distributors alike have begun to demand products that have proven quality, safety and provenance (such as organics certifications) for perishable goods.

In July 2018, Intel teamed up with Curry & Company, a large independent fruit distributor in Oregon, to assess how an innovative supply-chain solution could help to address one of Curry's most pressing business challenges: harvesting and transporting freshly picked blueberries while maintaining optimal environmental conditions and providing top-notch quality assurance to their customers.

Oregon is one of the largest blueberry growing regions in the United States, and the Pacific Northwest climate offers optimal growing conditions; more than 100 million pounds[1] of blueberries are harvested in Oregon each year. Oregon farmers grow more than 20 varieties of blueberries, which are highly valued because of their taste, appearance, and health benefits. Like other fresh fruits, however, blueberries begin to ripen as soon as they are harvested, creating an environment for microbial growth and other quality deviations such as discoloration. Blueberries and other produce are very sensitive to temperature and handling processes, which can negatively affect fruit quality and reduce customer satisfaction.

Blueberry harvests typically take place in the morning. After the ripe berries are manually (or mechanically) removed from the blueberry bushes, the standard process is to chill the blueberries almost immediately to just above freezing, 34°-35°F. This slows the respiration rate[2] of the blueberries and lengthens the shelf life of the fruit from days to weeks. Once the berries have been chilled, they are



processed and inspected, and any damaged or defective berries are removed. After processing, the blueberries are then sorted and packaged into pint-sized plastic containers, arranged in flats that can be stacked into shipping pallets, and stored in a refrigerated environment to await customer orders.

Challenges with Fresh Fruit

Many produce distribution companies still use human operators to perform a number of essential tasks. Environmental data, inventory management, product inspection, and processing are just a few examples of operations and data capture tasks that many firms still perform manually—an error-prone method that increases the risks and challenges of processing and distributing fresh fruit.

Driving Innovation in Agriculture

The State of Oregon Department of Agriculture, recognizing a need for innovation in the agriculture industry, has partnered with local businesses and city commissions, such as Curry & Company and the City of Independence, to facilitate innovative projects to improve the quality of products grown in Oregon. Curry & Co., a locally owned and operated company in Oregon's Willamette Valley, is a leading blueberry supplier. To help farmers address the challenges of a finite harvest season and getting fresh fruit safely to market and in prime condition, Intel and Curry & Co. partnered to pilot a project aimed at monitoring blueberry harvests, tracking location, and incorporating blockchain technology in the supply chain.

Benefits of Blockchain in the Produce Industry

Intel worked with Curry & Co. to employ an integrated blockchain-based IoT solution to help the company solve several business problems. There are many benefits to using blockchain in a perishable goods supply chain, including:

- **Provenance:** stronger assurance of the origin and chain of custody of blueberries throughout the supply chain, which in turn reinforces brand reputation
- **Food Safety:** allows for near real-time monitoring of fruit, leading to a more proactive approach in terms of safety, quality and recalls while minimizing food waste
- **Distributed Ledger:** transforms manual recordkeeping to digital and establishes a trustworthy exchange of data across supply-chain partners. The blockchain acts as a record of financial transactions, events, or even environmental data capture.
- **Security:** Blockchain technology ensures that data cannot be tampered with or modified.
- **Supply Chain Network Optimization:** better visibility into the supply chain network might allow Curry & Co. to improve their logistics network and inventory turnover.

What is Blockchain?

Blockchain is a distributed ledger technology that has the potential to transform the way enterprises, governments, and consumers exchange data. By eliminating the need for a central authority, blockchain technology simplifies transactions, mitigates transaction risk, and increases efficiency and transparency. The technology is based on an open source, fully distributed network, enabling pure peer-to-peer communication. Transactional information is stored in a publicly distributed ledger, which is arranged in blocks. Each block is then connected (chained) to the previous block and has a cryptographic signature that is dependent on all the previous blocks.

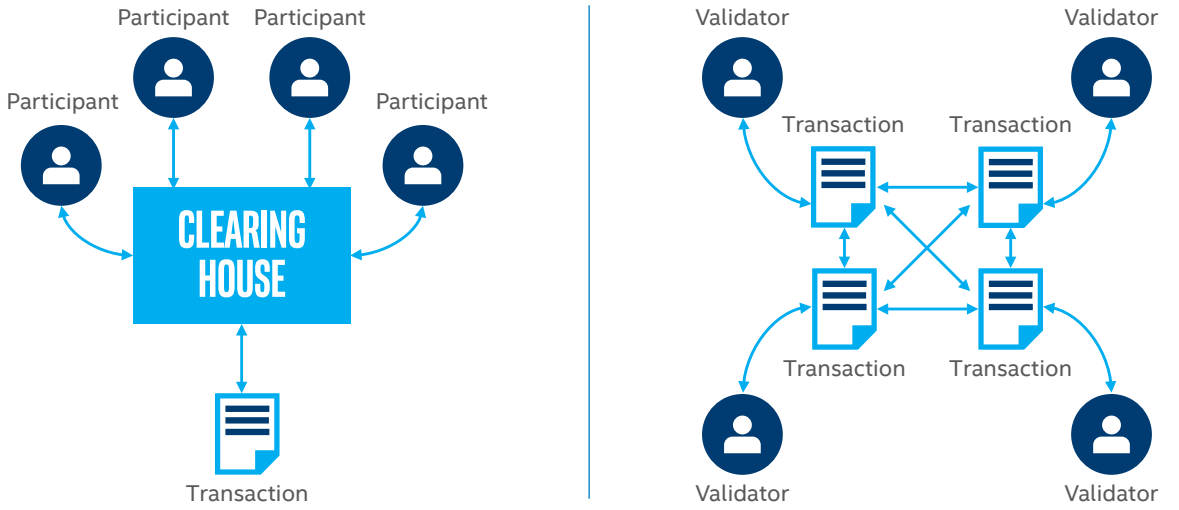


Figure 1. Traditional systems (diagram on left) rely on a .... on behalf of participants. Blockchain systems (diagram on right) operate with no central clearinghouse, but rather rely on distributed ledgers maintained by each participant, which are automatically updated with each transaction.

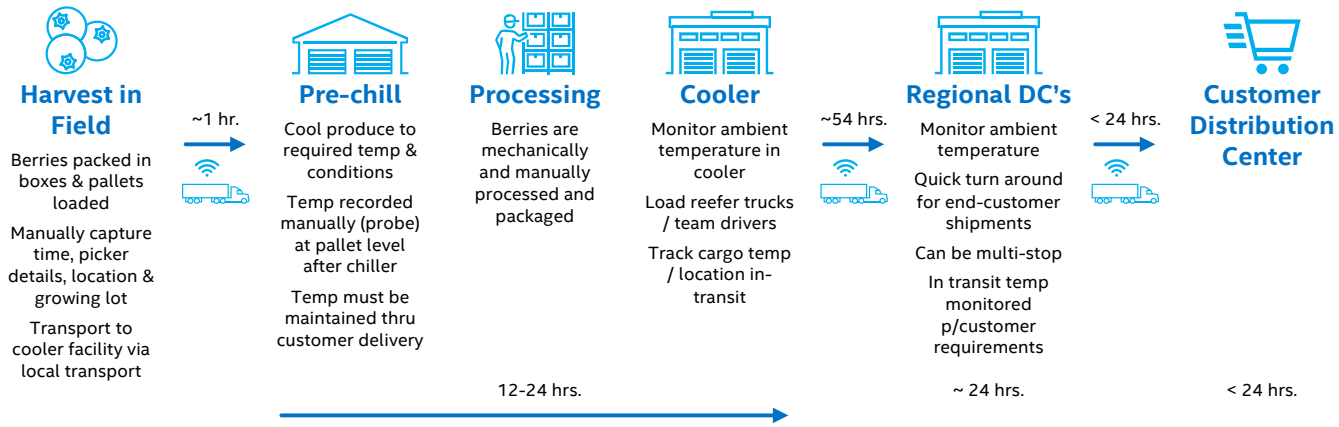


Figure 2: Blueberry Process Flow

The Solution

Intel piloted an integrated IoT solution with capabilities that directly address and help mitigate the challenges associated with shipping perishable goods, by using the Intel® Connected Logistics Platform (ICLP) and Intel's Hyperledger Sawtooth* Blockchain, and Microsoft Azure*, to create a connected supply chain. The ICLP enables the monitoring and tracking of environmental conditions for a variety of products, such as produce, and ensures that items arrive at their destination in optimal condition. The ICLP communicates live data to the cloud while simultaneously creating an immutable record on the blockchain. Read more in this whitepaper about how to implement a solution using ICLP.

Among its many features, the ICLP:

- Allows near real-time monitoring of environmental data, including temperature, humidity, light, tilt, shock, and location with a tag/gateway sensor solution.
- Enables pallet-level monitoring of shipped goods to facilitate course correction as needed.
- Delivers near real-time location tracking and programmable notifications (i.e., for temperature excursions).
- Collects all of this information and pushes it to the blockchain to establish supply-chain transparency and create an immutable digital "trail" for the fruit each step of the way, from harvest to distribution.

Proof-of-Concept Study

Intel piloted an integrated end-to-end IoT solution to track and trace the blueberry supply chain at Curry & Co. This pilot monitored a truck of berries from harvest at a local farm in Salem, Oregon, to storage and processing at the Curry & Co. facility in Brooks, Oregon, also including the delivery to the customer-distribution center in Portland, Oregon.

Step 1: Harvest in the Field

For the pilot, blueberries were harvested at a farm near Salem, Oregon. After they had been placed on pallets and weighed, the ICLP sensors were activated and placed on the pallets with the fruit so they could begin collecting data and enabling the blockchain for real-time monitoring. With the sensors in place, the harvest was ready to begin its journey from the farm to the storage and processing facility in Brooks, Oregon.

Explaining the Data: On the day of the pilot, it was sunny in Oregon, therefore the data collected by the ICLP sensors in the field aligned with the weather from that morning during the harvest. The dark blue shaded area in Figure 3 shows the temperature and humidity environment around the berries while tracking them from the farm to the Curry & Co. processing site in Brooks, Oregon.

Step 2: Pre-Chilling

Once the truck arrives at the Curry & Co. facility, the blueberries are immediately unloaded and staged in a "pre-chiller" where they are cooled prior to processing. Here they are staged until the ICLP sensors indicate the berries have reached the correct temperature and the processing line is freed up.

Explaining the Data: The light blue shaded section of Figure 3 displays data from the ICLP sensors in the pre-chiller, showing temperatures dropping below 45°F, which is the desired condition for blueberry storage.

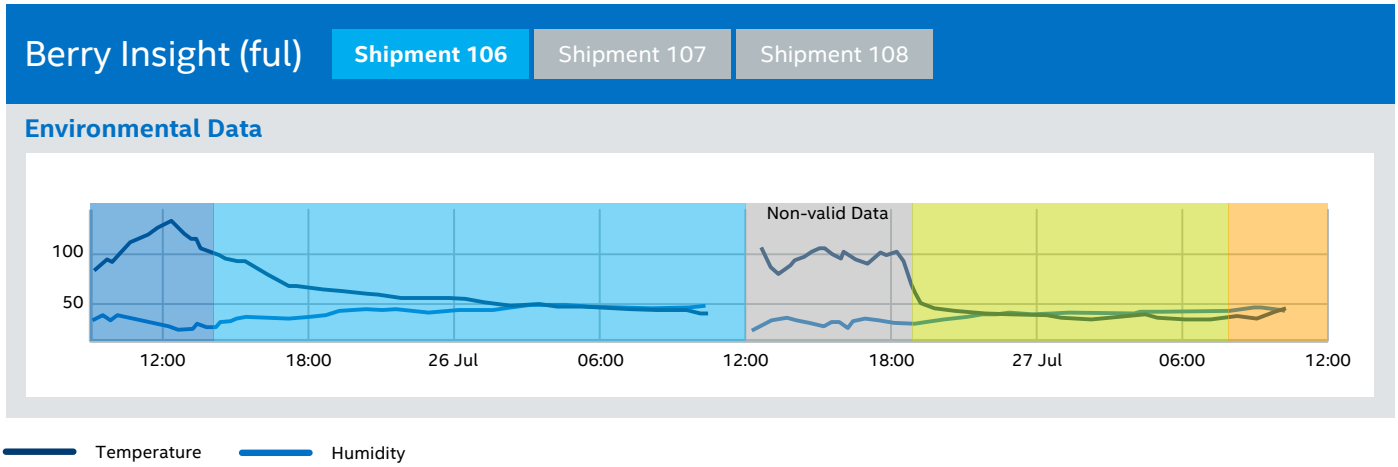


Figure 3: Sensor data from the pilot showing the berries' temperature (top line) and humidity (bottom line) from harvest through delivery.

Step 3: Processing and Storage

Once the queue in the processing facility is freed up, berries are moved pallet-by-pallet from the pre-chiller to processing, where automated and manual methods are used to remove fruit that falls outside the standard quality specifications. During this stage, the blueberries are also packaged in plastic clamshell boxes, arranged on finished-goods pallets, and then placed in a chiller, where they are kept until a customer order signals a pull. During the pilot, these blueberries were processed the day after harvest.

Explaining the Data: At one stage during the pilot, the team had to remove the ICLP sensors from the fruit to avoid interfering with the standard processing steps. So even though the ICLP sensors continued to collect and transmit data, the data was not associated with the blueberries at this stage and did not accurately reflect the temperature of the berries (see the gray section in Figure 4). Once processing was complete, the ICLP sensors were added back to the finished-goods pallets, which were then placed in the cold-storage facility, and the sensors resumed collecting and transmitting data specifically related to the blueberries and their environment.

Step 4: Delivery/Transport

Once an order is placed, the berries are pulled from cold storage and staged on the dock for pickup by the second-party logistics (2PL) transportation agent. This order of blueberries was destined for a fruit-distribution center (DC) in Portland. The day after processing, the Intel team followed the driver from the dock at Curry & Co. to the DC and confirmed delivery of the blueberries.

Explaining the Data: The sensors' GPS signals match the route that the 2PL transport agent took on his route from the Curry & Co. facility in Brooks, Oregon to the customer DC in Portland. As shown in the orange shaded area, the temperature sensors also indicated a slight elevation in temperature once the berries were being unloaded at the dock.

Summary: Connecting Physical to Digital

This pilot was instrumental in connecting the physical world, using ICLP, to the digital one, with the Hyperledger Sawtooth blockchain. Through the use of Intel's technology, Curry & Co. was able to gain insights into their existing supply chain, including real-time environmental and transit monitoring, paving the way for a smarter supply chain.

The Value of a Connected Supply Chain

By providing greater immediacy, accuracy and transparency than manual processes, a connected supply chain increases food safety and improves both the logistics and traceability of perishable goods such as fresh fruit.

Live Tracking with the Intel Connected Logistics Platform

Live tracking of multiple elements such as temperature, humidity, and GPS at the pallet level means that companies can make real-time adjustments when the unexpected occurs. Live tracking is a standard focus for business-to-customer shipping but hasn't been integrated into systems that support the food and beverage industry. For companies like Curry & Co., real-time tracking means better control, higher quality, and reduced spoilage.

Companies like Curry & Co. that ship goods regularly already have well-defined shipping processes, and Intel realized it was important not to complicate or disrupt existing workflows and supply-chain processes. Intel also recognized that companies with less shipping infrastructure must also be able to understand and use the technology with ease.

Supply Chain Transparency on the Blockchain

The blockchain provides peace of mind for consumers, who know that they can verify how their products were handled and by whom. With increasing concern about issues related to food safety, blockchain adds another layer of security by making it easy to verify the history of products and improve trust with end consumers. Other benefits of the blockchain include:

- **Enabling a supply-chain network** that connects suppliers, customers, original device manufacturers (ODMs), third-party logistics (3PL) transport agents, retailers and end consumers: the network will enable sensors to directly and seamlessly connect with any potential partner and will drive supply-chain efficiencies.
- **Establishing new business models** enabled by joint process ownership across partners or even competitors, by improving collaboration and trust.
- **Achieving better decision making** and enabling further AI applications with the data integrity and reliability provided by the blockchain.

About Curry & Company

Curry & Company is an independent produce distributor based in Oregon, celebrating 50 years of providing the highest quality produce with superior service. Their produce includes onions and blueberries along with seasonal blackberries and sweet carrots.

Appendix

Helpful links about the blockchain pilot project:

- https://www.intel.com/supplychainiot
- https://www.intel.com/blockchain
- https://www.intel.com/iot
- https://www.curryandco.com

[1] Oregon Blueberry Industry, Oregon AgLink (Reference: https://oregonfresh.net/education/oregon-agriculture-production/oregon-blueberry-industry/)

[2] Postharvest Cooling and Handling of Blueberries, North Carolina State Extension, Aug. 1, 1993 (Reference: https://content.ces.ncsu.edu/postharvest-cooling-and-handling-of-blueberries)