

Blockchain technology set to revolutionize food safety

Blockchain is an open, distributed ledger that can record transactions between two or more parties efficiently and in a verifiable and permanent way. It is the technology at the heart of bitcoin and other virtual currencies¹, but it also has a huge potential in a variety of other industries.

Global supply chains, which are actually often complex networks spanning several legislations, connecting numerous partners with often opposing interests, are among the best-suited industries for large-scale blockchain adoption. Cryptographically secured blockchain-based network, where no single party can control the ledger, provides a neutral and trusted way to record all the transactions from the supply chain on a single but decentralised network. By doing that, it brings a new aspect and a holistic approach to supply chain visibility which is especially relevant in food supply chains.

Challenges in global supply chains

Globalization of trade brought increasing complexity to supply chains. This, in turn, increases the amount of information asymmetry - such that information is unevenly distributed among participating stakeholders within a supply chain. When participating stakeholders have misaligned incentives, such as the case in which participating stakeholders are different companies, there is no incentive to provide complete information which contributes further to information asymmetry.²

As a result, end-buyers of products have no economical way of authenticating what they are purchasing, which creates ideal conditions for moral hazard and fraudulent behaviour. Manifestations of such phenomena are the flood of counterfeit goods in the market (e.g., US\$200 billion in cost to legitimate businesses in the United States³), safety issues, violations of labour standards, just to name a few. Stakeholders at greatest risk are end-buyers, consumers, the environment, workers and companies involved in sustainable production and honest practices.

There are two key factors impeding data collection and sharing in supply chains:

1. Data is fragmented. Data silos and low data interoperability exist across the supply chain in both multi-organisation and single-organisation supply chains. There is a crucial technical challenge for various IT providers for supply chains (software and IoT) that need to be resolved in order to collaborate and establish full supply chain transparency;
2. There is no suitable decentralised solution for supply chain data. There are no solutions that can provide the needed level of performance, scalability and trust for interconnected data in supply chains while at the same time are cost-effective. Current blockchain and decentralised solutions are prohibitively costly, do not provide advanced data relational functionalities, and also have scaling issues.

¹ Iansiti, Marco; Lakhani, Karim R. (January 2017). "The Truth About Blockchain". Harvard Business Review. Harvard University. Archived from the original on 18 January 2017. Retrieved 2 October 2019 <https://web.archive.org/web/20170118052537/https://hbr.org/2017/01/the-truth-about-blockchain>

² Rakic, B., et al. *OriginTrail White Paper*. Retrieved 2 October 2019 <https://origintrail.io/storage/documents/OriginTrail-White-Paper.pdf>

³ <https://www.ipwatchdog.com/2010/08/30/counterfeiting-costs-us-businesses/id=12336/>

Nevertheless, all stakeholders have the same goal - being a member of the chain and improvement of the whole process regarding volume and efficiency.

Fragmentation of data and opacity of supply chains

The current state of supply chain data management solutions involves a number of localized information systems, enterprise resource planning (ERP) systems and custom solutions. In order for them to communicate, custom integrations need to be implemented. Often referred to as "data silos", these centralized systems lack a common technical environment, security, and exchange protocols to facilitate data sharing.

Because of this low interoperability of data and other technical hurdles (e.g., different security policies, separate infrastructures and environments), useful real time knowledge on supply chain product context has not been available to interested stakeholders (e.g., consumers, certification and governmental bodies, and operating companies in the supply chain). With each stakeholder in the supply chain receiving and sending data about product attributes only "one step back, one step forward" (which is a legal requirement in the European Union), trust is easily broken and value chains integrity compromised.

Many organizations today aim to bring more order and integrity to complex supply chains, including global standard providers in supply chains (e.g., GS1), certification organizations (e.g. Global GAP, ISEAL, Rainforest Alliance, Bureau Veritas) and information systems providers (e.g. IBM). Yet, none of these organizations can ensure entire chain integrity by creating a stand-alone solution due to centralized logic of data collection and sharing. Typically, only parts of global supply chains get audited and involved which leads to partial data collection, poor verifiability of collected data, and eventually diminished trust.

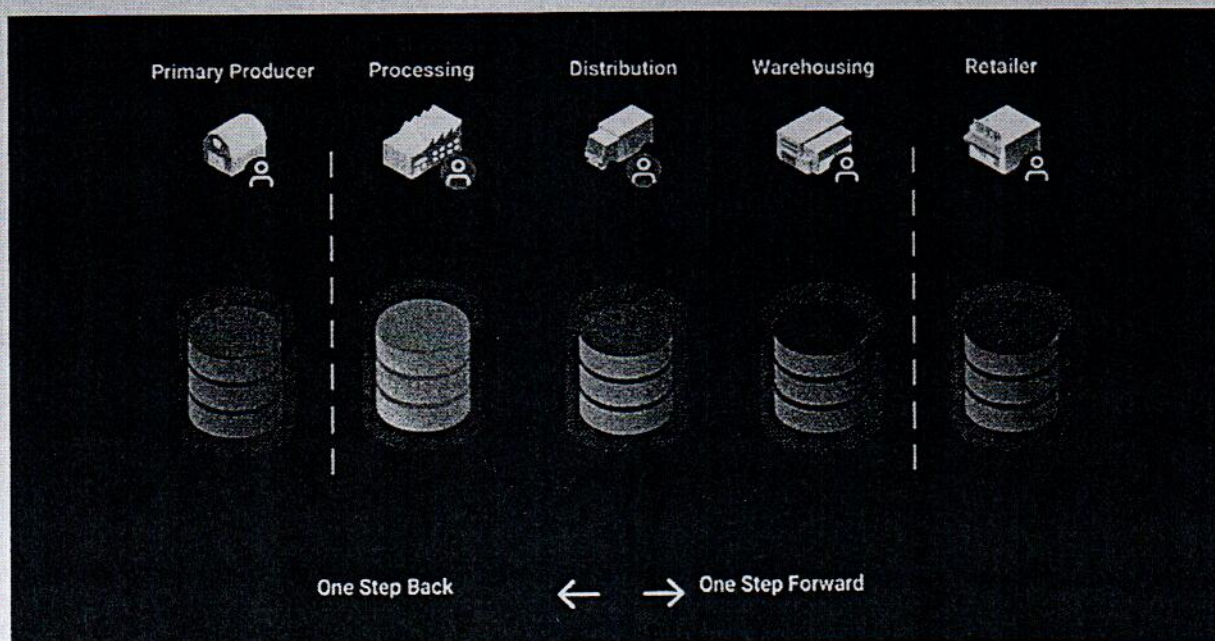


Figure 1: Fragmentation of data in silos

Shortfalls of blockchain technology

Blockchain-based, open and decentralized solutions are highly compatible technologies to overcome the above mentioned challenges for supply chain. However, blockchain was initially designed for financial transactions, not for vast amounts of data that are generated in modern supply chains and that contain larger sets of data for a number of products: such are master data, production date, shipment date, volume, transportation date ... Additional data that could also be incorporated includes data from IoT-connected sensors, cameras, and more.

Since blockchains require vast computing power to maintain and update the ledger on a large number of nodes in a distributed network, storing data directly on the blockchain is costly and not efficient. Blockchain is a ledger - not a fully functional database. To make the most out of the comprehensive supply chain data, additional functions are needed for advanced search, cumulative analysis and flexibility in handling interconnected data, which is currently in the domain of professional database solutions.

A protocol for trusted data exchange

To address these challenges - and based on the core team's prior experience of implementing traceability systems to international food supply chains in Southeast Europe - OriginTrail protocol was purposefully created for use of the blockchain in supply chains. OriginTrail is an open source protocol solution allowing IT providers to easily set up blockchain supported data sharing in supply chains. It enables building transparency and tracking beyond the "one step down, one step up" principle, protecting brands from fraudulent behaviour and driving efficiencies for all stakeholders.

Input and sharing data with OriginTrail is based on a common set of data standards (GS1 business data standards, Web of Things and others) which allow multiple organizations (companies involved in production, distribution or retail of goods) to exchange data.

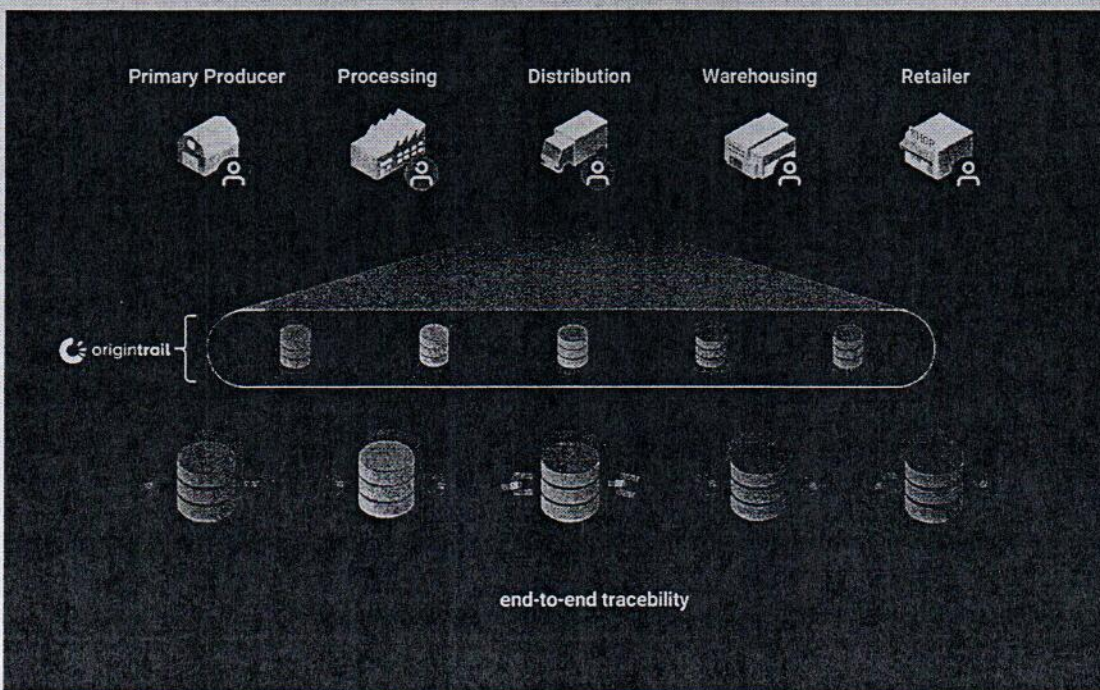


Figure 2: Data interoperability

In order to optimize the use of blockchain, the OriginTrail protocol runs on an off-chain decentralized peer-to-peer network, called the OriginTrail Decentralised Network (ODN). It enables peers on the network to negotiate services, transfer, process and retrieve data, verify its integrity and availability and reimburse the provider nodes. This solution minimizes the amount of data stored on the blockchain in order to reduce cost and inefficiency. ODN is based on a graph database, providing more flexibility in terms of adding data from various sources - thereby also ensuring interoperability between different datasets.

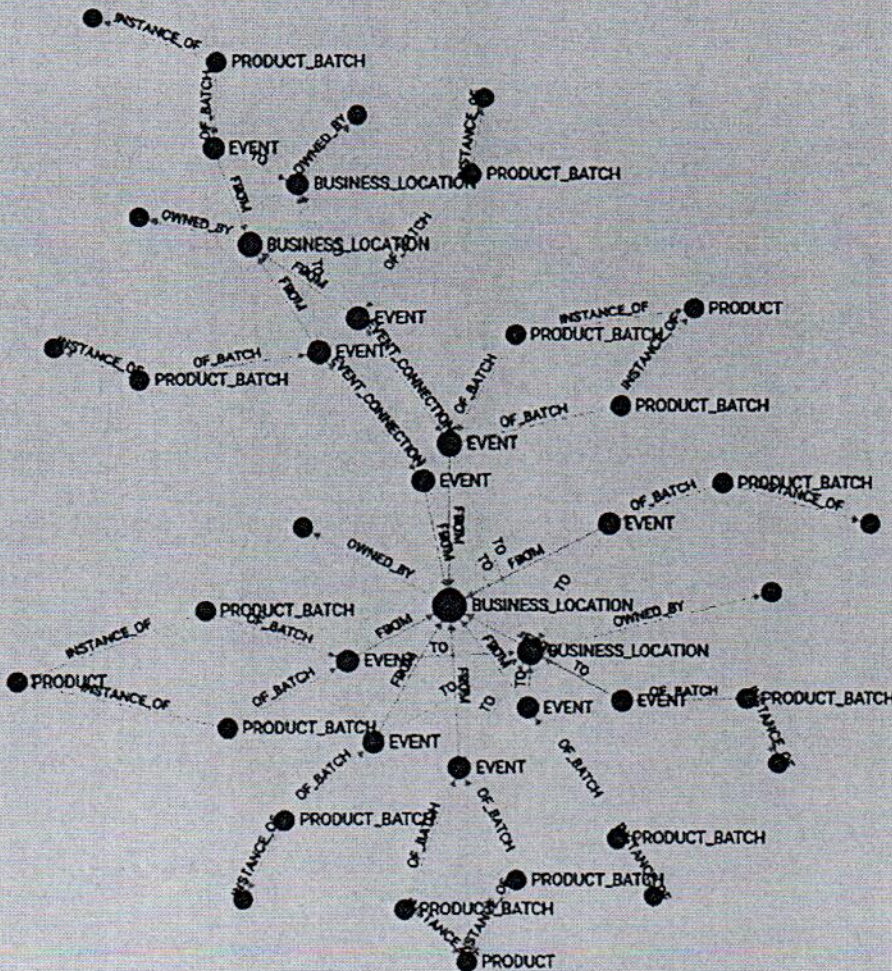


Figure 3: Example of interconnected data graph from food supply chain

Graph databases provide highly performant traversing, high flexibility in terms of data models and thus high agility when it comes to development. Furthermore, supply chain information is inherently graph-like, both in terms of the flow of products as well as connections that this data forms. Using a decentralized graph database is therefore what provides great conditions for:

- interoperability, as graphs can be extended and modified easily with low operational cost;
- high performance, as graph databases are great for quick traversal and connection forming;
- high availability, because of distribution.

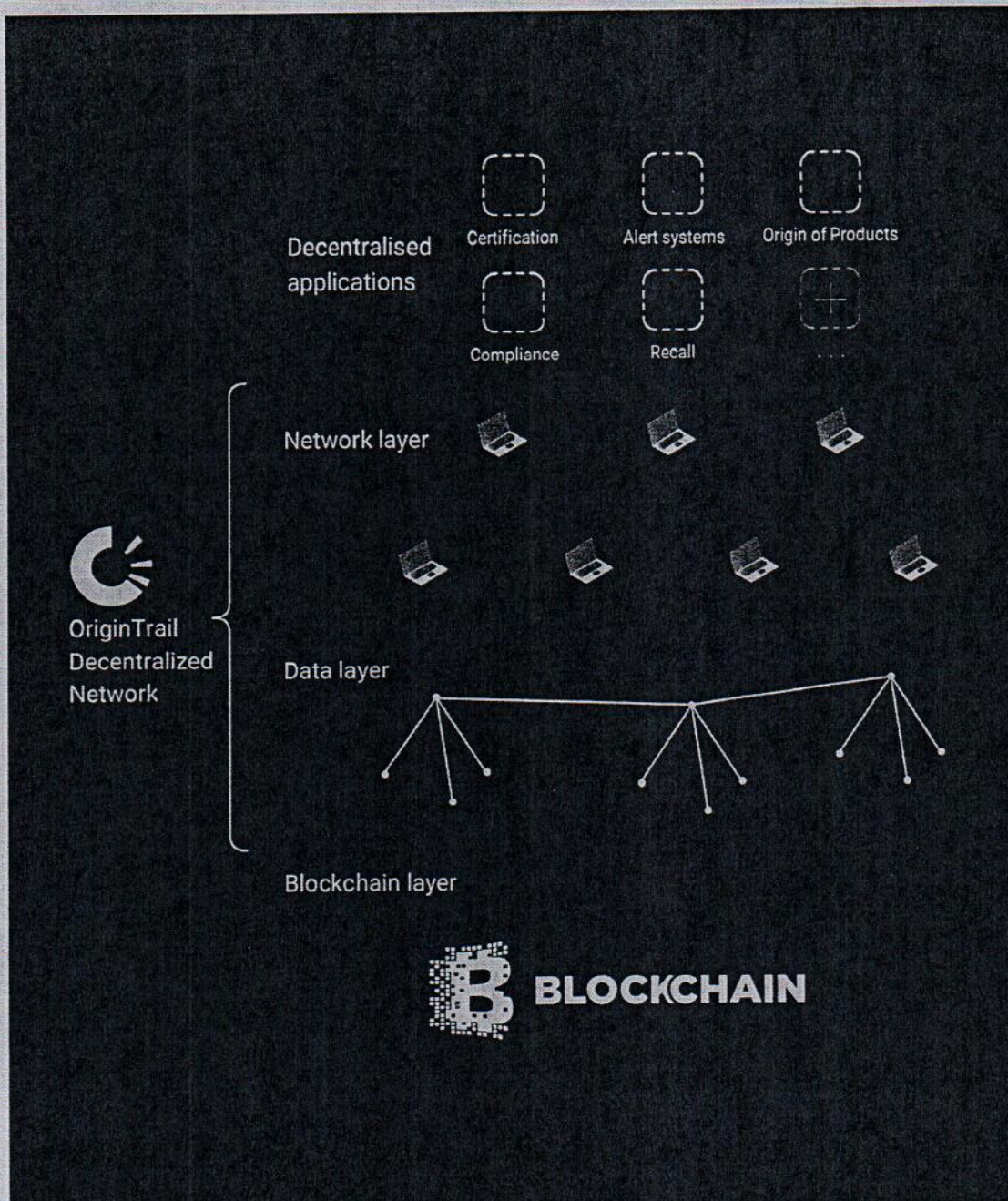


Figure 4: OriginTrail protocol solution stack

OriginTrail incorporates blockchain as the platform to ensure data integrity. For all the information that gets included in the system, a tamper proof "fingerprint" (a cryptographic hash) is generated and stored on the blockchain at the time of arrival. The cryptographic hash is commonly used to prove the received data has not been modified in any way, and having the hash immutable in blockchain as a reference to the original input completes this mechanism. If there is a need to check if data was tampered with, a simple hash comparison between the stored hash in the blockchain and the newly generated hash from the same data in ODN shows if changes have been made.

OriginTrail protocol is blockchain-agnostic and can connect with multiple blockchains, depending on the requirements of a use case. Existing implementations use Ethereum and Hyperledger blockchains.

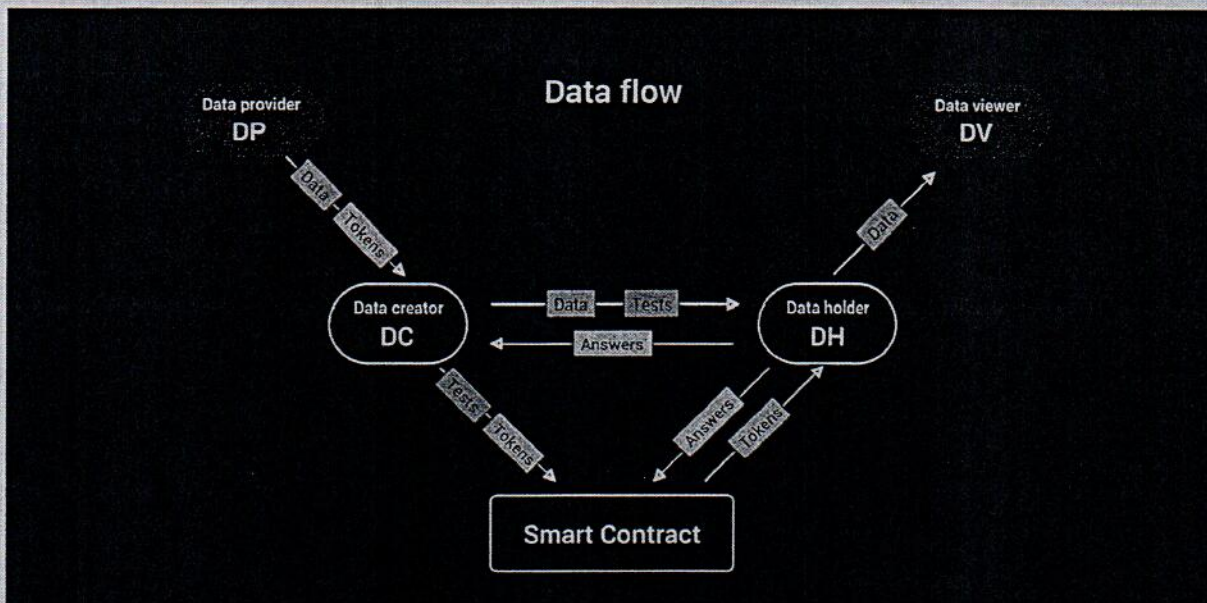


Figure 5: Data flows in the OriginTrail protocol

Private vs. public networks

One of the questions that arise when businesses plan their blockchain-based data sharing implementation is to what extent the data can be shared on a public network. As the World Economic Forum's white paper⁴ suggests, it is important that the industry moves past the public-versus-private debate to one focused more keenly on deploying solutions where enterprise-specific requirements can be met. This requires a flexible way of providing integrity based data exchanges.⁵

There are types of data that require the highest possible integrity in the business context, so it makes sense that they are published on a public network. Some of such data sets include:

- Claims towards the wider public (any claim that a company needs to verify for their consumers or partners that is not (yet) connected to the network) — such datasets should be shared in full on the ODN;
- Metadata and publicly verifiable proofs (utilising the ODN to keep proofs of privately kept data);
- Data for public use (open data requiring long-term integrity).

Applications for the supply chain and food safety

Food safety is an increasingly important issue and especially in emerging markets - with some high-level scandals in recent years - a pressing topic for public health officials and consumer trust. Examples of blockchain-based technologies that can help mitigate risks take advantage of trusted data to provide business or consumer applications for track-and-trace, provenance, fraud protection, and more.

⁴ World Economic Forum. (2019). Retrieved 2 October 2019

http://www3.weforum.org/docs/WEF_Inclusive_Deploymentof_Blockchain_for_Supply_Chains.pdf

⁵ Levak, T. Can We Transition Enterprises from Private Data Silos to Collaborative Data Sharing?. Forkast News. Retrieved 2 October 2019 <https://forkast.news/2019/08/20/opinion-can-we-transition-enterprises-from-private-data-silos-to-collaborative-data-sharing/>

Traceability applications on the blockchain are enabling end-to-end visibility of product movements across all supply chain partners. These solutions increase the efficiency compared to traditional solutions by identifying and reconciling discrepancies in real time, automating the flow of product documentation across supply chain partners, and by simplifying internal and external compliance processes.⁶

Additional possible use cases that also touch food safety are:

- advanced business intelligence (informed decision making based on complete and structured data with integrity);
- audit and risk management (efficient, secure and privacy-enabled audit and compliance management from a single interface);
- trade finance (automated flow of supporting documentation in cross-border trade);
- anti-counterfeiting (an efficient and effective way of ensuring product authenticity across industries).

Companies around the world are already implementing pilot projects with the blockchain technologies. According to Deloitte's 2019 blockchain survey⁷, 53 percent of leaders say that blockchain technology has become a critical priority for their organizations in 2019 - a 10-point increase over the year before. 40 percent of surveyed organizations with more than 500 million USD in revenue plan to invest at least 5 million USD in blockchain in the next 12 months.

Let's take a look at two case studies of how blockchain-based collaboration is already transforming our approach to food safety,

Case study 1: Organic beef production and carbon neutrality

Organic grass fed beef is a rapidly growing category worldwide. However, since intensive cattle farming leads to vast carbon emissions, there are increased concerns about the environmental impact of beef production. Cattle farming contributes to 40 percent of global methane emissions⁸ which leads to consumers questioning their choices.

OriginTrail protocol enables full traceability of food supply chains. In organic beef production, which is a premium consumer segment, there is an opportunity to present consumers with a traceability application that would enable them insight into the supply chains and also into the activities producers are leading to offset that impact and achieve the carbon neutrality of their supply chains. We invite the scientific community to contribute their insights on calculations relevant for this goal.

Network Operating System, a layer on top of OriginTrail protocol developed for business users, is a single platform for sharing data right along the supply chain. It enables cooperation between stakeholders in the supply chain. Producers, as well as certification and other agencies can safely exchange data, leading to increased efficiency, transparency, integrity and productivity. A "Track and Trace" application based on OriginTrail protocol show parts of data to relevant supply chain partners.

⁶ Traceability. <https://tracelabs.io/traceability>

⁷ Deloitte. https://www2.deloitte.com/content/dam/insights/us/articles/2019-global-blockchain-survey/DI_2019-global-blockchain-survey.pdf

⁸ National Geographic: nationalgeographic.com/environment/global-warming/methane/

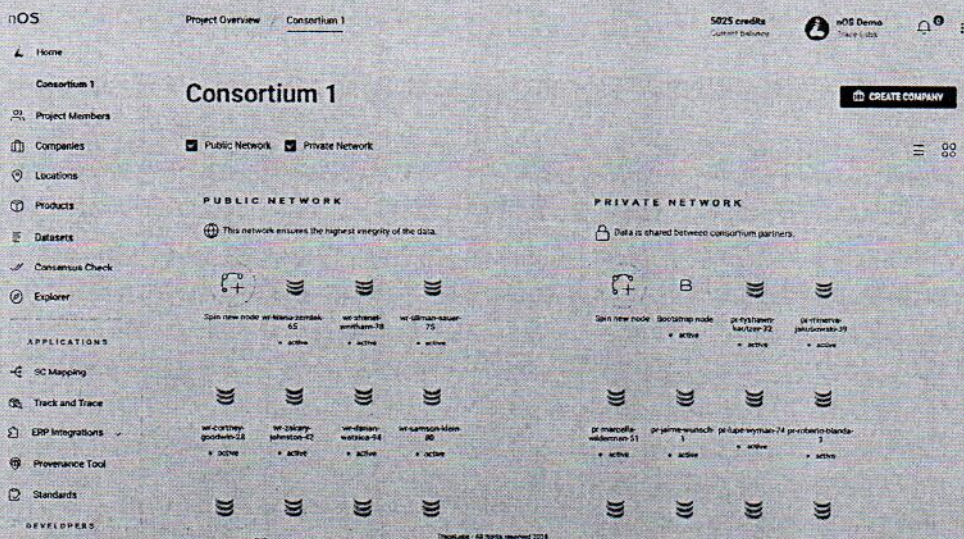


Figure 6: Example of an interface for implementation of the OriginTrail protocol

Case study 2: Product provenance with isotopic data

Another interesting field for blockchain implementation related to food safety is in scientific laboratories which play an important role in ensuring the integrity of food and non-food products in global supply chains⁹. Their capabilities include testing water, soil and air for farms and factories, validating nutrient content and potential allergens in products, and testing for the presence of heavy metals and pathogens.

In a pilot project with Source Certain International from Australia, OriginTrail decentralized protocol was used for food certification and validation purposes. It was the world's first case of connecting and integrating key scientific information, and, where relevant, laboratory information management systems (LIMS), with the blockchain. In such case, OriginTrail protocol acts as the infrastructure for integrating and distributing data and reports to the laboratories' clients, extending traceability and providing an additional layer of transparency and trust.

Conclusion

Blockchain technology is available here and now, but it is a highly technical field. The industry is still in search for viable mass-scale applications that will be both cost and time efficient. Our team is tackling this with a purpose-built OriginTrail protocol. Input of the scientific community is highly valuable and will contribute to a strong foundation to bring the future of safe food supply chains closer to everyday reality.

Mr. Tomaz Levak (tomaz.levak@origin-trail.com) is co-founder and managing director of Trace Labs – OriginTrail Core Developers, a company developing blockchain-powered data exchange protocol for supply chains. He founded Trace Labs in 2013 with the mission to bring transparency to supply chains and has led the implementation of several traceability projects around the world. Open-source OriginTrail protocol for data exchange in global supply chains is enabling businesses to speak the same language. He is an authority on the topics of data integrity and using blockchain for solving supply chain challenges; and he is also an established speaker at events around the globe, sharing his first-hand experience from implementation of blockchain technology in practice.

⁹ OriginTrail Blog: <https://medium.com/origintrail/origintrail-now-integrates-data-from-forensic-laboratories-with-the-blockchain-1e635eb54350>