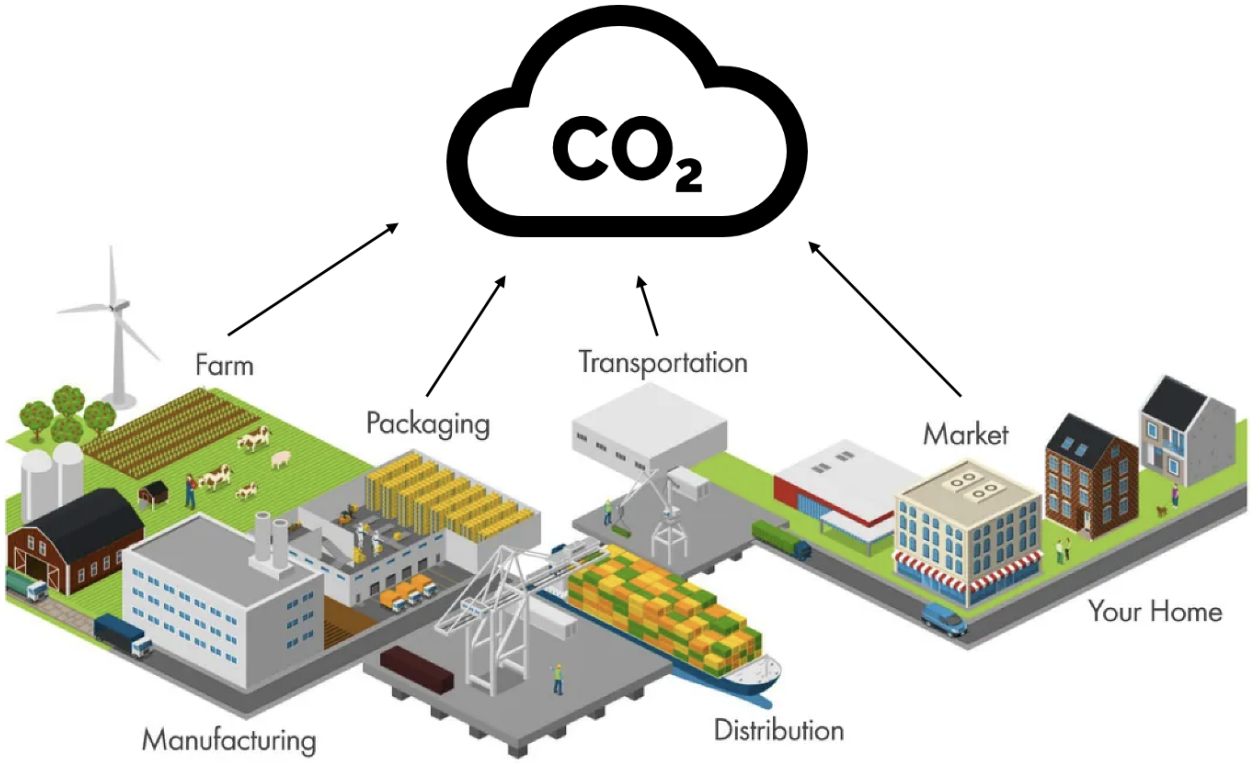
Providing a Trust Layer for Agricultural Process Chains using DLT

With use-case focus on AgriChain carbon footprint analysis



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INTRODUCTION

The agricultural sector is an essential fundament of modern industry, relying on complex supply chain networks and facing ever-changing requirements and demands. Involved parties have a need for comprehensive data, spanning the entire breadth of the diverse AgriFood product chain, while also possessing a need for data privacy and compliance. Various digital solutions exist, aiming to nullify many of the pain points plaguing parties involved in this industry. However, these solutions present key weaknesses due to their monolithic, centralized nature.
In this report, we provide an overview of the current agribusiness digitalization landscape as a whole, later honing in on the specific challenge of inter-chain CO2 footprint analysis for agricultural food products. Further, we analyze the different parties involved and take a look at their needs, along with how distributed ledger technologies might be uniquely suited to address them. Finally, we present use cases for our prototype and go into detail on some of the many decisions involved with the implementation thereof.

ANALYSIS OF CURRENT SITUATION

Demands Faced by Agribusinesses

Agribusinesses are facing more, and more complex demands than ever before. The main parties to consider here, are regulators, customers, and the agribusinesses themselves. We will provide an overview of these parties and some of their requirements that are currently most relevant to agribusinesses.

Regulatory Demands

Regulation has a tendency to increase over time. This is especially apparent in the agricultural industry. While rising regulatory standards have allowed consumers to become evermore trusting of the products they consume, and have forced production practices to become evermore ethical and sustainable, this has come at the cost of the high degree of complexity that is now involved in satisfying regulatory standards.
For example, regulators are quite interested in the kind of nutrition that animals receive, as this has a great impact on animal wellbeing and the quality of animal-derived products. Regulators also require a thorough quality analysis of animal products, which is especially focused on asserting that the products are not tainted and are safe to

consume. Lastly, there are more and more regulations pertaining to production practices. These are mainly concerned with ensuring environmental sustainability and, especially in the case of animal products, with ensuring some adherence to ethical standards.
All in all, regulators present rather complex requirements that have to be met by every Agribusiness.

Customer Demands

Driven by growing sophistication and purchasing power, Customers have developed growing expectations towards food products they consume, and are more willing and able to let these expectations influence their purchases than ever before. The main concerns of customers are related to the "healthiness" of the products, along with the ethicality and sustainability of the processes used to create them.
Furthermore, consumers are becoming more aware and suspicious of common marketing practices aimed at conveying false senses of quality or sustainability such as introducing meaningless award symbols on the packaging and making use of greenwashing practices. This has led to falling customer trust, necessitating trustworthy, verifiable quality, sustainability, and ethicality claims.

Agribusiness Demands

One party whose demands for data and process information should not be underestimated is the agribusinesses themselves. A highly competitive landscape with a paper-thin margin has created the need for highly efficient operational practices, requiring vast amounts of accurate data from a myriad of sources.
The conventional image of farmers as largely relying on 20th-century technology is quite outdated. Farmers these days rely on a number of high-tech solutions such as automated vehicles and UAV imaging. All these new approaches both require and produce large amounts of information which, in turn, introduce new challenges regarding data storage, processing, and analysis.

Limitations of Current Agribusiness Digitalisation Solutions

There have long existed various tools and systems providing solutions to different specific challenges faced by agribusinesses. These range from software applications allowing operational control via tablets, to IoT systems for the gathering of crop and animal data, to data analysis software aiming to turn data into actionable

recommendations. However, due to these systems largely being monolithic, closed, and centralized, they present some key systematic limitations which will we will now briefly highlight.

Low Cross-System Compatibility

The various digital solutions offered to agribusinesses are usually tailored to a very specific use case and have little concern with enabling interactions with outside systems. Data and control flows remain mostly hidden and inaccessible, with small parts of the system being exposed to the outside world only through the interfaces that the developers envisioned to be relevant to the specific use case.
Compare this with the smart home device landscape for instance, in which many devices, very diverse in form and function can, nonetheless, be easily added to an existing system and then made to cooperate in as many ways as the user's imagination allows though generalized interfaces.
Such compatibility issues greatly limit the usefulness and knowledge that can be drawn from operational data and constitute a real limitation on operational efficacy.

Isolated Digital Markets

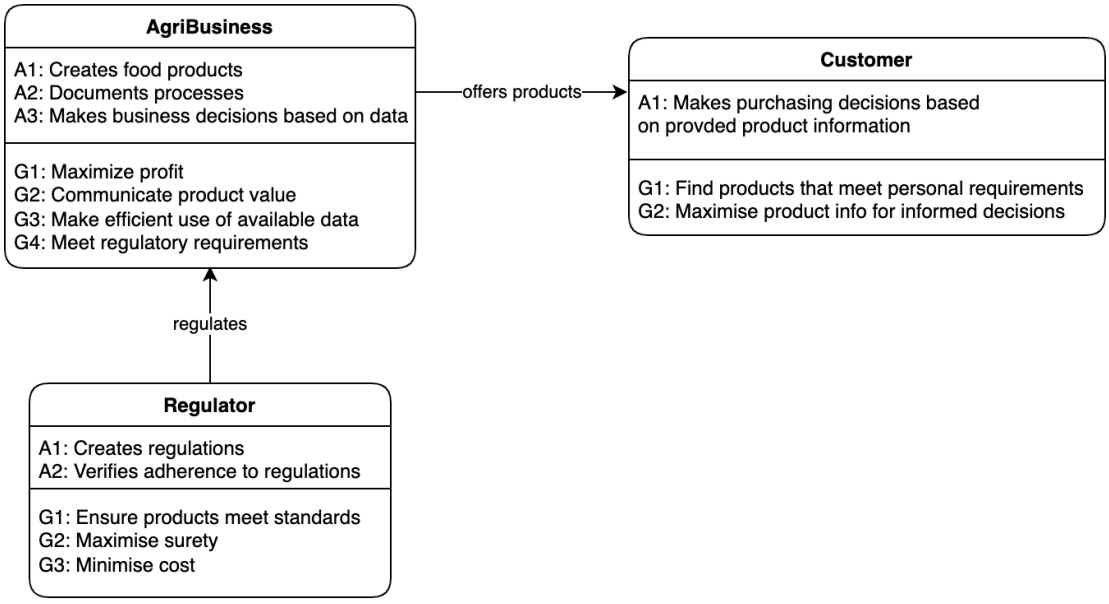
This point can best be explained by first considering the properties of the gigantic smartphone app ecosystem that allows app developers to reach a huge amount of users, and users to be offered a vast selection of high-quality applications.
The key here is that developers need not develop their applications to be compatible with a myriad of underlying software or hardware infrastructures, since this complex challenge is already handled by the IOS or Android operating systems. Any app compatible with IOS immediately gains the potential customer base of the billion iPhone users existing worldwide.
Unfortunately the same cannot be said for the software ecosystem of the agricultural industry. Here, we have the situation where there exists no inherent compatibility layer, no standardized “farm operating system” so to speak, that would allow developers to reach a large number of users in a short amount of time. Instead, new applications must be tailored to, and only remain compatible with, specific systems, drastically shrinking the user-base of any potential new product and leaving agribusinesses with very few options to choose from.
Any kind of standardized compatibility layer for agribusinesses could have a great impact on the agribusiness software ecosystem as a whole.

Lack of System Integration Across Process Chain Network Participants

Agribusinesses and their operations are inherently networked. Processing, packaging, transportation, and distribution are only some of the many steps agricultural products undergo on their journey from the farm to the customer, most of which are performed by different parties in different locations. However, this networked nature of agricultural production processes is not reflected in any interconnectedness between the systems of the different network participants. System networking is limited to the minimum necessary that ensures products end up where they are needed. Data generated during process steps are largely left behind once the product moves on to the next party. Customers might judge themselves lucky if they are provided with such basic information as the rough origin of the product they are considering purchasing, but information regarding processing, packaging, and transportation, for example, has been lost.

All this leaves the customer with little to go on when making purchasing decisions and also makes it more difficult to troubleshoot any issues with the products or their supply chain.

STAKEHOLDER NEED ANALYSIS



Having analyzed the current state of agribusiness digitalization and the limitations of current solutions, we present a stakeholder need analysis of the three key parties involved, namely agribusinesses, regulators, and customers. The need analysis we

present is simple but contains all the insights we need to consider whether DLT systems may offer a feasible improvement over the current situation. We will see that, while all parties have their own interests, all parties would gain from reducing costs and, especially, from improving transparency.

Agribusinesses

As is the case for most businesses, maximizing profit is agribusinesses' foremost goal. To this end, they offer products to customers and other agribusinesses. If they want these other parties to buy their products, they need to convince them by somehow communicating product value.
Maximizing profit entails minimizing costs, which is done by generating, collecting, and analyzing data in order to optimize processes and make well-informed business decisions.
All this must be done while not only fulfilling the hard requirements imposed by regulators but also believably communicating this regulatory adherence to the regulators.

Regulators

Being largely governmental entities, regulators are not concerned with profit but with fulfilling their main purpose at minimal cost. Their main purpose being ensuring agribusinesses meet sustainability and ethicality standards.
Regulators want to be as certain as possible regarding the adherence of agribusinesses to their standards, but need to take into account the fact that the more certain they wish to be (for example by doing more onsite inspections), the higher the costs they incur.

Customers

Customers are always looking to find products that meet their requirements at minimal cost. Here, the requirements may be ethical, sustainable, or nutritional in nature.
While most customers may be content believing and making use only of the information provided on product packaging, others may wish to go further and conduct extra research online or elsewhere.
Customers vary greatly in their requirements and willingness to spend, opening the doors to products with different approaches to the many tradeoffs regarding cost, quality, ethicality, and sustainability.

WHY DLT

We believe distributed ledger technologies offer uniquely feasible solutions to many of the requirements and limitations highlighted in the previous sections. We will now highlight the key properties of DLT solutions and the opportunities they may offer the agribusiness digitalization landscape.

Interoperability

Owing in part to their decentralized nature, DLT systems are built with interconnectivity in mind, allowing different parties network access and participation in data exchange. This functionality is provided by the use of easy-to-implement, non-proprietary connection interfaces.
While each entity interfacing with a system may choose to come up with its own approach to network interaction, it may prove valuable for groups of parties with similar needs and use-cases, such as agribusinesses, regulators, and customers, to use shared clients that address their specific needs. For highly complex and performant clients, a client market might even emerge, in which software engineers offer interface clients to user groups with highly specific requirements.
As hinted to with the idea of a connection client market, it is the standardized open-access nature of DLT systems that may enable the establishment of a common application ecosystem in which app developers can easily reach a huge userbase of Agribusinesses or consumers, thus providing great incentive for creating innovative applications.

Trustlessness

As the system we envision would require the participation of many parties with sometimes conflicting interests, and, as these parties would sometimes be exposing sensitive data, the only way such a system could find wide adoption is if all the parties involved trusted its integrity, or even better: if they didn't need to trust it.
It would be hard to imagine all these organizations trusting any central system belonging to a third party with their data. Therefore, trustlessness is in fact a key requirement of any system aiming to act as a trust layer for agricultural process chains.
DLT systems meet this requirement and even allow any interested parties to participate in ensuring network integrity themselves by running their own validation nodes.

Transparency

As we could see in our stakeholder need analysis, improving intraorganizational and interorganizational transparency is in the interest of every party involved in the agricultural process chain. As such, the transparent nature of DLT systems is a key feature, making DLT systems especially attractive for this use case.
For regulators improved transparency would mean quicker, cheaper, and more sure verification of regulatory adherence. For agribusinesses, it would mean an easier time communicating product value, ethicality and sustainability to customers. And for customers, more transparency would mean more trustable data on which to base buying decisions.
All in all, more transparency would enable a more even playing field, inviting competition and empowering customers.

OUR USE-CASE: DLT FOR CO2 FOOTPRINT ANALYSIS

We have decided to choose cross-process-chain emission tracking as the use case for our implementation. Several factors informed this decision.
Climate change is an era-defining challenge that should be impacting business decisions in every industry. As such, improving emission measurability and accountability is very important.
Further, consumers are as climate-conscious as ever when it comes to their purchasing decisions. This is especially true in developed nations where consumers may be willing and able to spend a little extra for a product meeting their personal sustainability standards. Therefore, improving emission tracking is highly relevant to any organization seeking to communicate its sustainable practices to consumers and increase sales.
Last but not least, interprocess emission tracking requires an integrated approach, making for an especially interesting challenge.

The system we present allows agribusinesses and logistics providers to log emission-relevant events across the process chain, finally yielding a product trail that can be used by regulators and other parties in order to calculate emissions and attribute them to specific products and organizations.

SYSTEM REQUIREMENTS

For a system to feasibly operate as described, several general and technical requirements must be considered. We will briefly list these in the following.

Permissioning

As the system may be accessed by different parties with particular use-cases, it is important that each party is only granted those usage permissions necessary for them to perform their required actions.

Modularity

Just as parties may be swapped in and out of the supply chain, parties must be able to easily connect and disconnect their systems to the network. Such plug-and-play functionality is crucial to allowing fast system adoption.

GDPR Compliance

As is the case for virtually any software system saving user data, data compliance must be assured. Specifically, there needs to be a way for data to be deleted or made inaccessible if requested. How this requirement may be made compatible with innately immutable blockchain systems is largely still an open question.

Interparty Information Hiding

As the system may be used by parties with conflicting interests such as competitors, some functionality must exist that allows some sensitive data to be shared only with a subset of parties instead of with everyone.

Compatibility with Existing Systems

Any trust layer will be expected to interface with the already-existing tech stacks of the different network participants. As such, it is vital that system interfaces are simple to understand and implement, allowing frictionless onboarding.

Access Control and Logging

For transparency, debugging and compliance reasons, access control, and logging are must-have features for any enterprise-grade data network. In the case of DLT systems, some of this functionality is implemented out of the box.

TECH FRAMEWORK CONSIDERATIONS

As blockchain technologies have already been eyed as possible innovative solutions for various supply chain challenges for a couple of years, there are a number of established systems that come into question as tech frameworks for this implementation. Among these, Corda and Hyperledger Fabric best allow us to adhere to our requirements while also being established products in this domain.
Both systems advertise compatibility with existing standards and regulations while providing deterministic transaction settlements and enterprise-grade data security.
In the context of our use case, the main difference between these systems is the way in which they handle the sharing of sensitive data among network participants.
By default, Corda only allows for data to be shared between transaction participants, walling off the rest of the network.
Hyperledger Fabric opts for a channel-based approach, in which data is shared between all members of a data channel, which can be seen a lot like a permission group.
For allowing inter-process-chain data tracking for agricultural food products, we estimated Hyperledger Fabric's channel-based data sharing approach to be more suitable. This would allow channels to be set up for groups of interacting agribusinesses or for specific product chains, alleviating the need to make data-sharing decisions for every transaction.
For this reason, we decided to use Hyperledger Fabric as the core of our system.

SYSTEM USAGE IN PRODUCTION

The main way in which our system can be used is as a trust layer, logging events occurring during product manufacture, processing, and transportation, essentially acting as a decentralized inter-organizational process mining solution, yielding data that can be acted on not only by single organizations but by the supply chain as a whole.
Further, this data-rich trust layer may serve as the foundation on which a myriad of other software solutions can be built, making use of standardized, widely-adopted interfaces enabling applications to access a huge potential user base with minimal effort.

Running validation nodes and providing onboarding services and upkeep may be required of application developers in order to be given access to this system and its potentious business opportunities, thereby creating a win-win situation for developers

and users alike.

While our prototype allows data ingress via simple client-side user interfaces. In a production environment, most data entry activities would be automated and triggered by actions such as barcode scanning and product shipment registration. Further, required data could be pulled straight out of the different organizations existing systems.

VALUE PROPOSITIONS

As we will see, our system creates powerful value propositions for every party involved, providing extrinsic motivation for adoption and further development.

Regulators

Regulators will be able to cut costs and gain extra surety.
Costs will be reduced through the standardizations and optimizations of auditing processes enabled by standardized access to production data through the trust layer. Instead of having to develop a unique audit process for every tech stack that is encountered, audits could be performed via the trust layer and perhaps even be largely automated.
In addition to audit optimizations, regulators will gain extra regulation adherence surety owing to the organization's now immutable and verifiable data entries.

Agribusinesses

For agribusinesses, our system provides value by making it easier to prove compliance with standards and regulations, by making it easier to communicate sustainable and ethical practices to customers, and by enabling a standardized agribusiness application market.

Instead of preparing reports and gathering logs for regulatory audits, agribusinesses will be able to simply grant regulators access to their blockchain data which will already encompass a large amount of the process data required.
Further, a large amount of process data stored in a standardized trust layer would allow a new wave of innovators to develop novel digital solutions and bring forth new leaps in efficiency and optimization. This would leave agribusinesses with a greater range of digital products to choose from, with each competing to offer the most attractive features at the lowest costs.

Customers

When it comes to communicating sustainable and ethical business practices to potential customers, agribusinesses have long relied on informative product packaging and advertisement. However, as grocery store aisles are becoming ever more flooded with products claiming sustainability, and as the deceptive greenwashing of some bad actors has eroded customer trust in sustainability claims, the efficacy of packaging claims has sharply declined in recent years. Our system would allow cryptographically verifiable claims supporting certain manufacturing procedures and CO2 footprints, enabling a whole new level of customer trust and manufacturer accountability.

LESSONS LEARNED

Building a concrete implementation of a distributed ledger system as a two-man team has been a very enriching experience encompassing several fields of research and tech infrastructures.
As is so often said, it once again proves to be true that one hour in extra planning may save ten hours of refactoring once the system is already built. Further, questions regarding the quality of usage guides and community support are not to be underestimated during a decision among different implementation technologies. One is used to being able to find a vast body of manuals, tutorials, and stack-overflow posts regarding any topics under the sun. However, this is not always a given when working with new, less widely adopted, and more niche systems.

CONCLUSION

In this paper we have presented findings regarding the state of agricultural supply-chain digitalization as a whole, identifying stakeholder needs and key pain points of existing solutions. We have laid out our case as to why we believe DLT systems may offer unique systematic advantages as well as benefits for every involved party.
Finally, we have remarked upon several requirements we aimed to meet through our implementation, described some resulting framework considerations, and provided an outline of how a system such as we have built may be used in practice.

In final conclusion, this exercise in research and development has provided us with new insights into the many factors surrounding DLT applicability in practice and has made us

aware of many nuances relevant to the feasible adaptation of DLT systems in different sectors.
We are very interested to see where the further development of DLT systems may lead and what DLT use cases might find a foothold in the future.