final report

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Evaluation of Blockchain Technology to Support Provenance

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Executive summary

Australian food exports are perceived to be clean, green and with the highest of quality. Consumers often identify with brand promises such as "Australian Grain fed Angus" with quality attributes that are communicated in packaging. Digital technology and smartphones now enable new ways for consumers to verify brand promises and product attributes.

This report details research conducted to assess how Blockchain technologies may be applied to prove the authenticity and brand qualities of Australian meat products. The research involved investigating the processes, systems and information flows in the beef supply chain from Australia through to export markets in Asia.

Blockchain is a distributed database (or ledger) shared across a public or private network of computer servers. Each computer "node" in the network holds a copy of the database simultaneously. Unlike a conventional database or website, due to having multiple copies of data, in a Blockchain network, there is no single failure point. Every piece of information is encrypted, ensuring only people with the correct permission level can view each record. In the research answers were sought to questions of how Blockchain technology could be utilised by different participants in the supply chain to satisfy the provenance lifecycle and what if any, advantages it offers over other more traditional databases.

The formal definition of Provenance is "The fact of coming from some particular source or quarter"; This definition relates to just one of the attributes of Australian Beef, namely Traceability.

Following our discussions with MLA, Stockyard, Teys and other meat industry experts, we propose that the definition of Provenance is extended to include other attributes that are equally important, and should include the following:

1. Traceability. The ability to track location and time across the Supply Chain.
2. Brand Promise. The alignment with the claims made about the product, for example "Aussie Beef" or "Queensland Organic Grass-Fed Angus".
3. Compliance. Demonstration of compliance with religious, market access and/or food safety attributes.

The conclusions in the research and the consequent opportunities identified include:

- Blockchain technologies could increase the barrier to counterfeiting Australian Beef.
- Brand promises could be verified digitally by integrating to the Blockchain data elements from existing logistics and quality systems.
- Existing systems could be integrated through text information derived from the unique identifiers in the supply chain order process.
- Unique identifiers can be extracted from the existing supply chain process to create verifiable blocks.

Traditionally, agricultural supply chain transactions are recorded in isolated data silos, owned by separate organisations. This makes it difficult and almost impossible to audit the origin of products, creating an opportunity for imitations entering a supply chain.

Blockchain technology is not owned by any single entity or organisation, it is operated by a collective. As a result, it provides neutral ground for all stakeholders in the supply chain to record interactions on a distributed ledger. Transparency and inherent resistance to tampering of a Blockchain, creates a distributed network of trust and integrity, which makes it easier for any participant in a Blockchain to check all steps in the provenance of the goods throughout the supply chain.

When it comes to food, having reliable data that shows where and how ingredients were grown, processed and distributed is essential to establishing and maintaining trust from consumers.

Blockchain offers a new competitive advantage for manufacturers and producers who can now prove claims made about their products which can be reliably and independently verified.

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1 Background

The ability to trace the origin of products has increasingly become part of expectations from consumers of products. This is of greater importance when one considers the consumption of foodstuffs and the potential of outbreaks of disease.

Australia continues to be a world leader in the traceability of red meat and is committed to food safety and the integrity and reputation of the Australian red meat industry.

Although there are numerous traceability programs in place there remains a desire for continuous improvement and a need to enhance the reputation of the red meat industry in Australia, which would enhance the reputation and competitive advantage Australia has in the global meat market thereby potentially increase the market presence of Australian produce.

The traceability and quality assurance systems already in place include:

- Property Identification Codes (PIC)
- National Livestock Identification System (NLIS)
- Livestock Production Assurance (LPA)
- National Vendor Declaration (NVD) and Waybill
- National Feedlot Accreditation Scheme (NFAS)
- National Saleyard Quality Assurance (NSQA)
- Processing protocols and labelling
- Australian Quarantine Inspection Services (AQIS) Health Certificate

All these systems could potentially form part of a centralised system. Until recently, the best and accepted practice in the IT industry was to entrust the responsibility to govern a centralised system was to a third party. This was the only way to achieve data and transaction transparency.

The reality is that no single organisation should be responsible for making data in a whole supply chain transparent. This creates a single point of weakness and makes the data vulnerable to targeted hacking, something that would have negative effect on the red meat industry of Australia, both locally and internationally.

1.1 Provenance Definition & Principles

The Oxford English Dictionary, defines provenance as (i) the pace of origin or history, esp. of a work of art etc. (ii) origin. [F f. provenir f. L prōvenīre (as PRO-, venire come]

1.1.1 Food Provenance

From meat to dairy products, the food industry has a desire to demonstrate the origin of the ingredients we purchase and eat. Many reasons drive this interest in food provenance: best and safest quality of meat from a reputable region, it is a stamp of quality. Ethical labels also guarantee that products, e.g. such as coffee, were produced under accepted working conditions, while promoting local sustainability and fair terms of trade for farmers and workers in the developing world.

Understanding the provenance of food, i.e. its origin, how it is produced, transported, and delivered to consumers, has turned into a competitive advantage by the food industry, since it allows it to demonstrate quality (in taste, in carbon foot print, or in ethics etc.).

World-wide, governments and associated regulatory authorities are interested in food safety. (Food safety refers to the conditions and practices that preserve the quality of food to prevent contamination and foodborne illnesses.) In this context, the term of choice is "traceability". Regulations, such as the EU Food law, require the traceability of food, feed, food-producing animals and any other substance intended to be, or expected to be, incorporated into a food or feed to be established at all stages of production, processing and distribution. Similar laws, such as the US Bioterrorism Act, deal with the security aspect, and deliberate contamination of food by terrorists. Whenever contaminated food is discovered, the ability to trace all its ingredients, suppliers, manufacturers, is critical, as illustrated by the food scandals that regularly show up on the front page of newspapers; for instance, the Sudan 1 scandal originated from traces of this carcinogenic dye found in spicy food; it resulted in a withdrawal of many products from supermarket shelves across Europe.

2 Project objectives

Meat & Livestock Australia (MLA) has identified the potential for Blockchain technology to ensure provenance of Australian red meat product for overseas markets. MLA has also observed that much activity regarding the application of Blockchain to Supply Chain Management is currently underway around the world but is in its infancy and has not yet been introduced as an industrialised, commercial approach. MLA seeks to investigate how Blockchain might be applied in the Australian red meat industry and identify potential benefits and challenges. This project will explore the benefits of using Blockchain as an alternative process to verify provenance within 2 beef supply chains (Teys and Stockyard).

This project explored the application of Blockchain Technology for enabling provenance of red meat in Australia. A secure flow of information enabling the full chain of custody to be accessed, including important social attributes such as farming methods and compliance data.

Building on Blockchain technology enables a peer-to-peer network to create: an open platform that can deliver neutrality, reliability and security.

- It makes it possible to avoid double-spending of certificates and claims, which is otherwise impossible without a trusted third party.
- It acts as the base layer of truth that everyone throughout the chain can refer to in a trusted way
- It allows the definition of unbreakable rules called smart contracts that will be enforced by the protocol itself

To prove the ability of Blockchain technology to support provenance, a Proof-of-Concept (PoC) was created. The PoC was developed with the assistance of two well established brands in Australia:

1. Stockyard Beef - A premium producer of high quality Angus and Wagyu.
2. Teys Australia - One of the largest meat processors and exporters in Australia.

We would like to acknowledge the assistance of both these organisations in the successful completion of the PoC.

The aim of the PoC was to prove two key concepts:

1. Blockchain can provide a transparent, trusted lineage of a value chain.
2. Blockchain technology has the potential to integrate to existing processes.

Given that this is a PoC, it was decided not to integrate with all the systems that exist across the supply chain. However, key opportunities for integration were to be identified.

3 What is Blockchain

Blockchain is a decentralised, distributed ledger technology. It provides for the creation, validation and encryption of digital transactions and record them in an immutable way. – Forbes 2018

It is a database of groups of transactions (blocks) that are linked to a previous group of transactions (the chain) and is replicated and distributed to all node participants in the network so that all copies of the database are identical. Blockchain records every transaction that happens, and no records are can be deleted.

A distributed ledger is a type of database that is shared, replicated, and synchronised among the participants/members of a network.

The distributed ledger records transactions, such as the exchange of assets or data, among the participants in the network. Participants in the network govern and agree by consensus on the updates to the records in the ledger. No central, third-party mediator, such as a financial institution or clearinghouse, is involved.

Every record in the distributed ledger has a timestamp and unique cryptographic signature, thus making the ledger an auditable history of all transactions in the network.

In short, a Blockchain can be described as a network of computers, each having an identical copy of the database (distributed) and changing its state (records) by common agreement based on pure mathematics, with no need for any central server or agent.

Blockchain technology can be used in a private or public peer-to-peer network of parties, who all participate in a given transaction. The technology uses a distributed ledger that is visible to all participants involved in the transaction. Through a consensus mechanism, the ledger is guaranteed to be consistent. Because the ledger is distributed, everyone involved can see the “world state” at any point in time and can monitor the progress of the transaction. By its very nature, Blockchain can tackle the following business issues:

- Trust – Through the use of Blockchain, all the parties involved in a transaction only must trust the Blockchain without a need for a central intermediary;

- Transparency – Because the ledger is distributed, all peers involved in the transaction network can view it subject to security rights (private Blockchain)

- Accountability – Since all parties in the transaction can view the distributed ledger, everyone can agree on how the transaction is progressing while it is ongoing, and how it went once it is complete.

So, to summarise, Blockchains are:
• Transaction ledgers
• Immutable
• Consensus-driven
• Decentralised
• Trust less (it's not based on a system of trust)
• Secured by cryptography
• Can be made public

3.1 How does Blockchain work

3.1.1 A typical Blockchain transaction works broadly as follows:

i. Transaction initiation: One party (the sender) creates a transaction and transmits it to the network. The transaction message includes details of the receiver's public address, the value of the transaction, and a cryptographic digital signature that proves the authenticity of the transaction.

ii. Transaction authentication: The nodes (computers and users) of the peer network receive the message and authenticate its validity by decrypting the digital signature. The authenticated transaction is placed in a "pool" of pending transactions.

iii. Block creation: Pending transactions are put together in an updated version of the ledger, called a block, by one of the nodes in the network. At a specific timing interval, the node broadcasts the block to the network for validation

iv. Block validation: The validator nodes of the network receive the proposed block and work to validate it through an iterative process that requires consensus from most of the network. Because all parties have the same data set, they validate by ensuring the information matches their ledgers. Given that the validation happens across multiple peers in the network that compare the information to their own data sets, fraudulent transactions are nearly impossible.

v. Block chaining: If all transactions are validated, the new block is "chained" into the Blockchain, and the new current state of the ledger is broadcast to the network. This whole process can be completed within 3 to 15 seconds or even faster as the technology advances.

vi. Document Hashing: A hash value is a number generated from a string of text. The hash is substantially smaller than the text itself and is generated using a formula in such a way that it is extremely unlikely that some other text will produce the same hash value. Hashing plays a role in security systems such as Blockchain, where they can be used to ensure that stored data or documents have not been tampered with. The document being saved generates a hash of the document, encrypts it, and stores it with the document itself in the Blockchain. A viewer would then decrypt both the document and the hash, generates another hash from the document, and compares the two hashes. If they're the same, there is a very high probability that the document is the original. Hashing is also a common method of encrypting electronic communications.

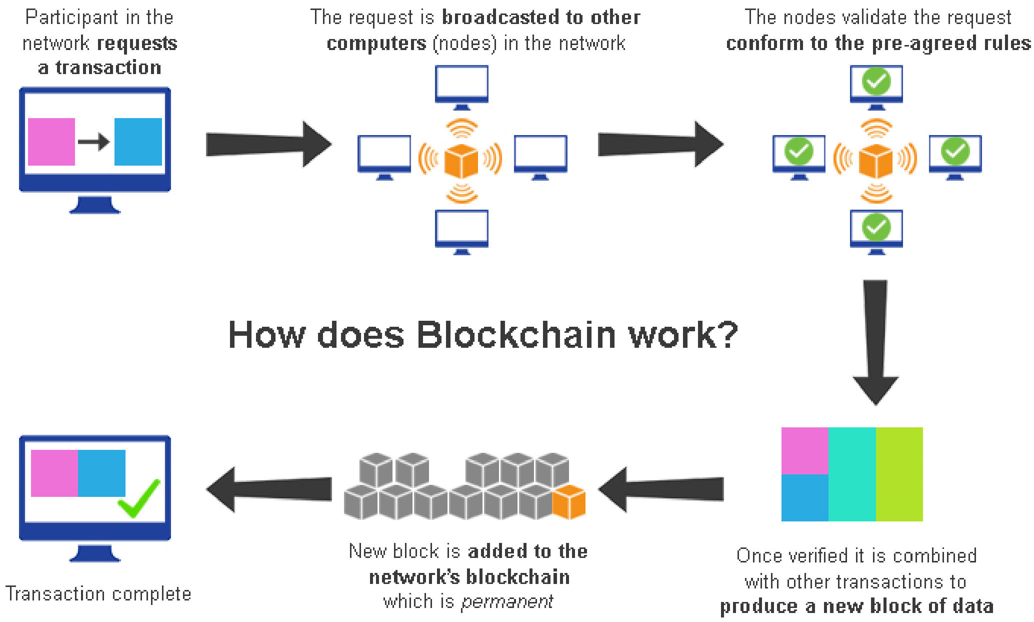

FIGURE 1 – A typical blockchain transaction. source:- http://netsend.com/blog/introduction-to-blockchain-technology/attachment/introduction-to-blockchain-technology/

3.1.2 Public Blockchains

Public Blockchains, such as Ethereum and Bitcoin, are Blockchains which are accessible by anyone. An individual can access either Blockchain and enter transactions using the Blockchain. In addition to being open access, all the data on public Blockchains is public. Anyone can access these Blockchains to see a flow of transactions if they wish to.

Advantages:

Autonomy
Autonomy is an advantage of a public Blockchain in that no one individual or company can control the information which is contained on the Blockchain or the rules governing the Blockchain. It is not possible for the "owner" of the Blockchain to change the rules of the Blockchain. The information about the transactions is authenticated by means of an agreement between the users of the Blockchain. Thus, the users of a public Blockchain do not have to place their trust in a third party to use the Blockchain. Instead, a user of a public Blockchain can trust the Blockchain itself.

Security out of publicity
Although it is possible to hide the actual identity of all associated participants on Blockchains, all data on public Blockchains is public. The security is obtained by their very publicity, where every participant can see all account balances and the info regarding all transactions.

Availability

Bitcoin, Ethereum, Hyperledger and other public Blockchains were created to be available by anyone having a computer and access to the internet.

Disadvantages:

Disadvantages of public Blockchains include lack of speed and the inability to control access to data.

3.1.3 Private Blockchains

In contrast to public Blockchains, private Blockchains are Blockchains which are operated by an organisation or consortium of organisations and which are only accessible to individuals or organisations which have been granted permission to use the Blockchain by its operator. Private Blockchains are essentially private databases which are structured as a distributed ledger.

For some companies, the private nature of a private Blockchain is a key advantage, as it maintains the confidentiality of information concerning transactions made on the Blockchain and prevents commercially sensitive information from being viewed by anyone with access to the internet.

Advantages:

The transaction speed
The transaction speed of a private Blockchain is generally faster than public Blockchain. The speed can even be the same with the speed of a normal database that is not a Blockchain. This is because there are not many cross-points all with high trust levels. There is no need for every cross-point to verify a transaction. For example, it takes upwards of 10 minutes for the Bitcoin Blockchain to confirm transactions, whereas private Blockchains are likely to have significantly quicker confirmation times as less data must be processed and transferred for transactions to be validated.

Cost of transactions
The cost of transactions in private Blockchains are generally not very expensive, they can even be free. If a company oversees all transactions and processes, it does not need to change the cost of work, even if the transaction is processed by multiple entities, such as competing banks. The transaction fees can still be very small for the same reasons that they can be so fast. Complete agreement between nodes isn't required, so fewer nodes need to do the work for any one transaction.

Disadvantages:
Flexibility
If such a need arises, a company running a private Blockchain can easily change the rules of a Blockchain, revert transactions, modify balances, etc. Of course, one can argue that one can do this on a public Blockchain by giving the government a backdoor key to a contract.

The differences between a publis and private (enterprise) Blockchain can be summarised in the table below.

	PUBLIC	ENTERPRISE
ACCESS	Open read/write	Permissioned read and/or write
SPEED	Slower	Faster
SECURITY	Open computer network	Approved participants
IDENTITY	Anonymous / Pseudonymous	Known identities
ASSET	Native assets	Any asset

Note: Some features can vary from platform to platform.

Data Source: Chain, Chris Skinner's blog

State of Blockchain Q3 2016 | 8

Figure 2: Table comparison of Private and Public Blockchains – source:- https://www.coindesk.com/research/state-of-Blockchain-q3-2016/?slide=8

3.2 What is a Smart contract

A smart contract is a piece of code stored in the Blockchain network (on each participant database). It defines the conditions on which all parties using the contract agree and certain actions described in the contract can be executed if the required conditions are met. As the smart contract is stored on every computer in the network, they all must execute it and get to the same result. This way users can be sure, that outcome is correct.

4 Application of Blockchain in a supply chain

In the Australian red meat industry, an efficient supply chain is vital to the successful movement of goods. Contracts within a supply chain are complex, dynamic, multi-party arrangements, which are constrained by regulatory and logistical influences. The products often cross jurisdictional boundaries. Information exchange in a supply chain is as important as the physical exchange of goods. For example, customs inspections are not able to begin until both the physical goods and the relevant documentation are available. If custom officials had confidence in the documentation it could expedite customs and biosecurity processes, even reduce risk and potentially reduce insurance costs.

Supply chains are a highly promising area for the application of blockchain technologies. The neutral ground provided by a Blockchain can help integrate the disparate participants in a supply chain, and the integrity and audit trail in a blockchain ledger will improve transparency and confidence across the entire supply chain.

Being able to identify how products were processed and distributed is important to establish greater confidence in food safety, creating and building high-quality brands, assisting in the prevention of fraud, and improving supply chain efficiency.

Although producers and logistics agents are likely to bear most of the total costs of deploying and operating a blockchain, these benefits may be felt by consumers globally and by producers domestically.

Although not explored in detail as an illustrative example in this PoC, the combination of distributed integrity, digital currency, and smart contracts in a blockchain may enable new kinds of "contracts" between different roles.

In a red meat supply chain there are many stakeholders, these range from producers, to transport providers, sorting/processing facilities, wholesalers, distributors, retailers, and consumers. In an international supply chain there are additional stakeholders being customs and biosecurity regulation.

4.1 Case study A: Stockyard

The PoC undertaken for Stockyard identified that a "permissioned" blockchain could be utilised to provide provenance for a meat product produced by Stockyard.

Given that distributed trust is critical in supporting the wide variety of participants in a supply chain, the Blockchain must act as a logically-centralised database of supply chain information. In the case of Stockyard, this would be information collected as animals move from farm to feedlot, to abattoir and beyond. A Stockyard Blockchain would be geographically and organisationally distributed to match the structure of the current supply chain in the following way:

The entities identified to be node participants in the Blockchain are:

- The Kerwee feedlot
- The NLIS database
- Processing plant
- Freight forwarder
- Australian Department of Agriculture
- Changi International Airport
- Singapore Immigration
- Customer

Each of the entities listed above would be members of a "permissioned" or "private" blockchain and hold a copy of the distributed ledger. Each participant would add to the blockchain as an item is moved through the supply chain.

As an example, when an animal is inducted into the Kerwee feedlot the RFID tag would be scanned. This scanning action would then record the NLIS number associated to the RFID tag and record the breed, date and time of entry into the feedlot (plus any other relevant information). At present this is what the current system records, however, the deviation is that in a Blockchain enabled system the NLIS tag would be verified against the NLIS database using an API or some similar technology. The Blockchain would then send a request to all the participating nodes in the Blockchain for a "consensus" vote. If all the nodes agree that the NLIS tag and RFID plus any associated data, is indeed the correct combination, then the movement of the animal would be recorded into the Blockchain. It is important to only record the relevant/required data into the Blockchain. Due to potential speed implications, it is best to record only the relevant data into the Blockchain, as an example; only recording data identified to be of relevance to provenance.

As each participant is an independent entity, some information is no doubt commercially sensitive, this is another reason to only add that data that is relevant to the proving of provenance.

When supply chain information is available on a blockchain, there are many potential derived benefits. Visibility and data integrity for logistics and commercial documentation in the supply chain can provide evidence to manage risk and enable customs authorities to clear shipments expeditiously.

4.2 Case study B: Teys

The PoC undertaken for Teys identified that a "permissioned" blockchain should also be utilised to provide provenance for a meat product produced and distributed by Teys to overseas markets.

Distributed trust is critical in supporting the wide variety of participants in a supply chain, therefore a Blockchain must act as a trusted centralised database of supply chain information. In the case of Teys, this would be information collected as animals move to the abattoir, are processed and then shipped to the end destination.

A Teys Blockchain would be geographically and organisationally distributed to match the structure of the current supply chain in the following way:

The entities identified to be node participants are:

- Teys processing centre (abattoir)
- The NLIS database
- Shipment company (From abattoir to port of departure)
- Australian Department of Agriculture and Water Resources
- Destination Port
- International Distributors

The entities listed above would be members of a "permissioned" or "private" blockchain and hold a copy of the distributed ledger. As each of the participants perform their defined functions in the supply chain, relevant data is stored into the Blockchain. By way of illustration, when the Shipment company collects from the abattoir, the shipment details are recorded into the Blockchain against the record already in existence for the processed animals, thereby adding to the trackability of provenance for the processed lot and ultimately the single meat product produced.

Each participant would add relevant data to the blockchain as a product is moved through the supply chain.

As an example, when the shipment of product is to leave Australia, the Department of Agriculture and Water Resources could scan the Container barcode and be able to identify the NLIS tags that make up the export shipment being processed. This check, via an API or similar technology could by way of example; confirm that all the NLIS tags have life time traceability and are valid NLIS tags belonging to cattle and not another animal species.

Once that test is passed then the status of "exported" could be assigned to the shipment and loaded to the Blockchain, provided that a "consensus" vote is passed with all the other participating nodes in the blockchain. It is important to only record the relevant/required data into the Blockchain as its best use is not to replace an entire database, but rather to be an alternative to logging changes to a dataset that would have relevance when analysing the data being recorded.

As each participant is an independent entity, some information is no doubt commercially sensitive, this is another reason to only add that data that is relevant to the proving of provenance.

When supply chain information is available on a blockchain, there are many potential derived benefits. Visibility and data integrity for logistics and commercial documentation in the supply chain can provide evidence to manage risk and enable customs authorities to clear shipments expeditiously.

5 Opportunities

Blockchain has the potential to contribute to the following outcomes which are relevant to the Australian Beef Industry.

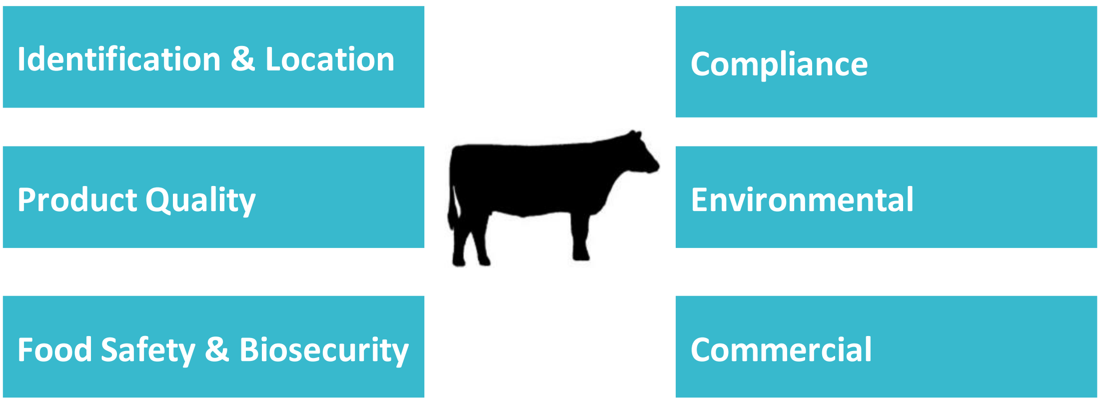

Figure 3: Potential opportunities for Blockchain

1. **Identification & Location**
   - **Product Identification**. Providing confidence that the product that is being processed or consumed is what it is meant to be. For example, is this Grain-fed Australian Angus?
   - **Track and Trace**. The ability to find out where and when animals or products have been across the Supply Chain.
2. **Product Quality**
   - **Grading & Taste**. Provide information, and linking information, on the quality of the product along the Supply Chain. For example, how does the MSA grading align with a consumer's assessment of quality?
   - **Breeding & Genetics**. Providing feedback to breeders on quality or yield outcomes to improve breeding programs.
3. **Compliance**
   - **Religious**. Evidence that the religious processes have been followed, such as Halal
   - **Market Access**. Confirmation that import conditions can be demonstrated as satisfied.
4. **Food Safety & Biosecurity**
   - **Disease**. Providing information on the status of animal health, disease etc.

- **Product Handling**. Information on the handling, preparing, shipping and storing of food

5. <u>**Environment**</u>
   - **Animal Welfare.** Information supporting humane treatment, animal care, animal husbandry etc.
   - **Green Credentials.** Evidence that methods that comply organic or natural standards have been employed.
   - **Environmental Integrity**. Information showing that integrity has been maintained, such as Cold Chain in shipping.
6. <u>**Commercial**</u>
   - Facilitating trade and improving commercial processes. For example, the introduction of Smart Contracts to address issues with Letters of Credit etc.

6 Constraints

In the Supply Chains investigated, several constraints which may prohibit the demonstration of Provenance were identified.

Processing	Complexity	Commercial Resistance
• Disassembly as product moves down the Supply Chain • Loss attribution with previous stages	• Many active participants and industry bodies. • Wide range of products and legislative compliance requirements.	• Clarity and insight might highlight sensitive information and issues.
Labelling & Packaging	**Islands of Information**	**Consumer Engagement**
• Exports not in consumer-ready packaging. • Loss of attribution in downstream packaging & labelling.	• Information needed to support Provenance claims exist in a range of disparate systems.	• Consumers will need to be interested and motivated to Opt-In.
Technology & Paperwork	**Information Completeness & Accuracy**	**Part of a Broader System**
• Remote locations without technology. • Heavy reliance on paper-based information and email.	• Given reliance on paper and disparate systems, information that may be required is imperfect.	• Blockchain is an enabler and cannot alone deliver Provenance outcomes.

Figure 4: Identified constraints in a supply chain

1. <u>**Processing**</u>.
   Moving down the supply chain, a process of disassembly takes place from whole animal to consumer ready cuts of meat. At certain points of this process, the direct association to attributes are lost. For example:
   - **Chiller to Boning Room.** Where single-body boning techniques are not deployed, the direct link between carton contents and specific animals or carcass numbers is lost. The best granularity of association for carton contents is down to 10 carcasses. This means that Provenance claims that require attribution to a batch / run (e.g. Halal + Angus + Kerwee Feedlot) can be proven, but those that require attribution to an individual animal (e.g. NLIS Tag 3RDEW231XBD011243) cannot. With products where more intermingling takes place such as offal, the granularity is even further reduced
   - **Carton to Consumer.** When product is provided to a distributor, wholesaler or retailer, identification is available for the carton, but not for the contents. When the product is further distributed, processed and/or prepared for the consumer, the link between individual cuts of meat and the carton are lost if labelling that makes the connection is not available

2. **Labelling & Packaging**.
   As identified above, labelling and packaging of exported beef is most commonly not consumer-ready. As part of a complete Provenance system, the product, information and packaging need to be aligned. Tamper-proof packaging will also reduce the ability to substitute product.
3. **Access to Technology & Paperwork**.
   Many Australian beef-related activities occur in remote locations that do not have access to technology and the industry is still heavily reliant on paper-based information and email. This limitation needs to be taken into consideration in the design of any industry-wide solution.
4. **Complexity**.
   Starting with breeders and ending in the end-consumer, the beef supply chain involves many disparate active participants and industry bodies, a wide range of products, and variations in legislative compliance requirements.
5. **Islands of Information**.
   Given the complexity of the industry, information exists in islands within a variety of industry and private systems and is not integrated. Although linking disparate information sources is one of the Blockchain value proposition, this information needs to be accessed in a Blockchain-enabled system to satisfy Provenance.
6. **Completeness and Accuracy of Information.**
   Points 3, 4 and 5 above do not lend themselves to situations where information is complete and accurate. A Blockchain-enabled system will need to be able to take this into consideration and work in an environment where data is imperfect.
7. **Commercial Resistance**.
   In linking information, Blockchain has the potential to provide improved clarity and insight across the supply chain. This additional information might not be welcomed if it highlights sensitive information or issues.
8. **Consumer Engagement**.
   A major potential value proposition for Provenance is with respect to consumer. This entails providing with the consumer with information about, and confidence in, the product. It can also provide industry with information on consumer location, demographic and sentiment. Both aspects will require the consumer to have sufficient interest or incentive to “Opt-In”.
9. **Part of a Broader System**.
   Blockchain is a single enabler that alone will not deliver “Provenance”. Broader changes to processes and systems, and a reliance on trust of partnerships will be critical success factors in achieving the required outcomes.

7 Proof-of-Concept Overview

7.1 Proof-of-Concept Objectives

- Demonstrate Blockchain to record live cattle movements through interface to the NLIS database.
- Demonstrate Blockchain to record lineage of Beef product from processor to consumer (With simulated transactions were gaps exists).
- Use Blockchain to demonstrate how potential fraudulent product received by the consumer can be detected.
- Demonstrate transparency of Blockchain through a user interface that can inform all members of the supply chain.

7.2 Proof-of-Concept Assumptions

As an objective of this project was to create a PoC, some assumptions and concessions were made to distinguish between the scope of a prototype solution.

1. Access to the NLIS database API was to be provided and any fees associated with access to this database waived for the PoC.
2. If integration to the NLIS databases was not practical, then a manual process would be utilised to prove the technology.
3. Where transactions in the supply chain were not practical to capture, they were simulated.

7.3 Candidate A: Stockyard Beef

7.3.1 Proof-of-Concept Scope

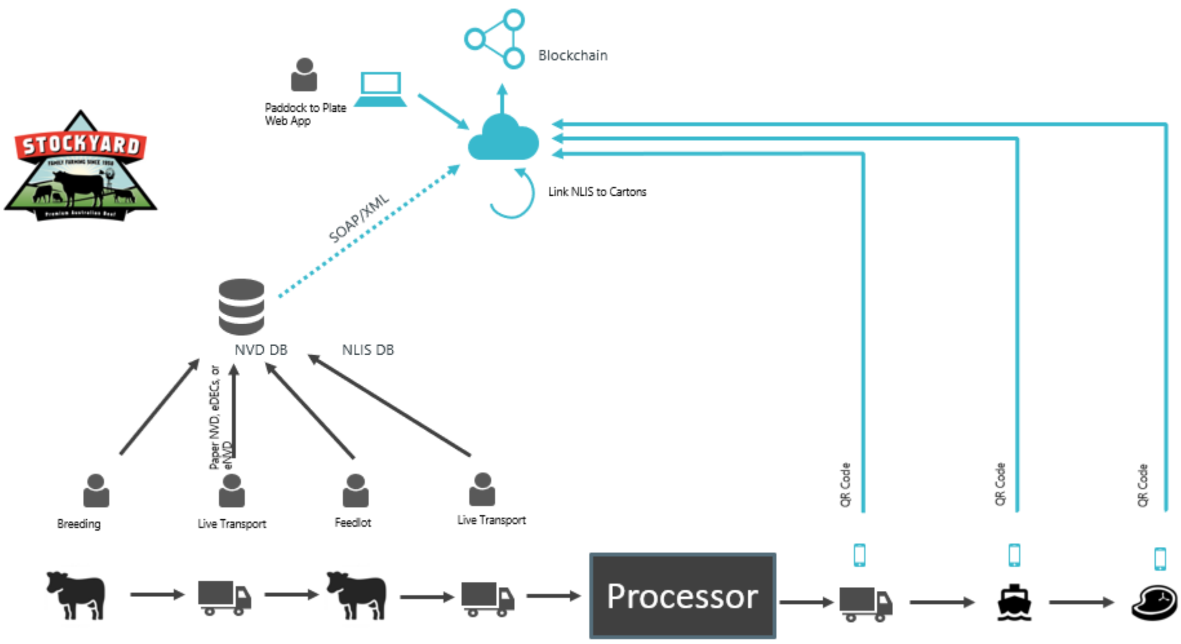

Figure 5 – Proposed PoC diagram – Stockyard Beef

The PoC used Blockchain to trace the provenance of a premium product of Stockyard on both upstream and downstream of the processor. As Stockyard use a third-party processor this was worked into the PoC.

The Long Fed Angus Gold product from Stockyard was selected for this PoC.

Stockyard's long fed beef is derived from Angus cattle fed on a specially formulated high energy grain ration for a minimum of 200 days at Kerwee Feedlot. Where possible only locally grown wholesome wheat, barley and sorghum.

The product contains absolutely no growth promotants, animal by-products and is not fed with genetically modified (GMO) feed.

The above formed part the "brand promise" that the Stockyard provenance Blockchain PoC would present on the scanning of a QR Code.

To gain a better understanding of the complete supply chain for the Stockyard example, the creation of the PoC scope necessarily included the following activities and/or steps:

- A site visit to the Stockyard owned feedlot and the processing plant in Queensland, this was complemented with a trip to an importer of the Angus Long Fed Gold product in Singapore.
- A permissioned Blockchain environment needed to be created in the cloud. The ability for a mobile device to scan QR codes to record transactions into the Blockchain was identified as the interface between the supply chain steps and the Blockchain solution.
- A Web interface for different users including consumers to login and view the lineage of a portion or carton of beef.

7.4 Candidate B: Teys Australia

7.4.1 Proof-of-Concept Scope

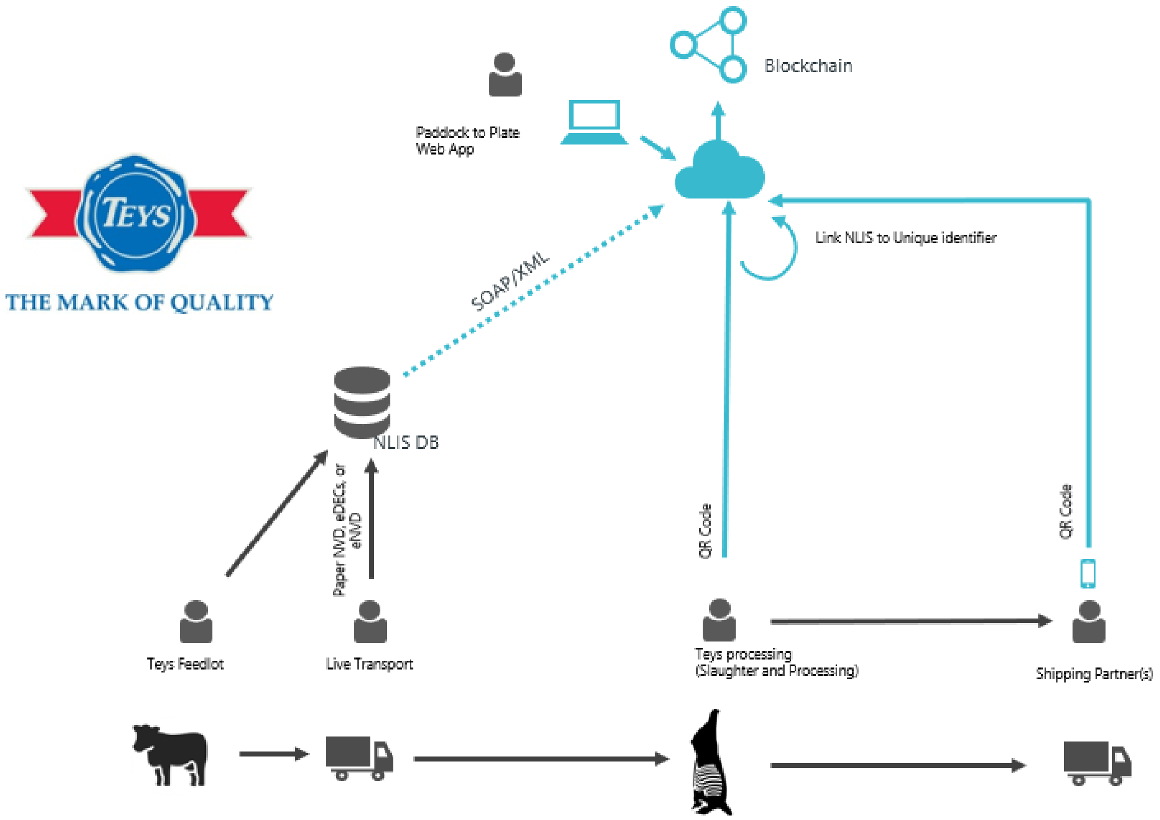

Figure 6 – Proposed PoC Diagram – Teys Australia

The PoC used Blockchain to focus on the distribution steps in their supply chain and tracked the provenance of Teys prime cut products from processor to distributor.

The creation of a second permissioned Blockchain environment needed to be created in the cloud for the Teys PoC. The ability for a mobile device to scan QR codes to record transactions into the Blockchain was identified as the interface between the supply chain steps and the Blockchain solution

As no integration to the production and packaging machines was in scope for this PoC, it was necessary to create an interface that enabled a user to upload a starting set of data to the Blockchain.

7.5 Proof-of-Concept QR Coding

An aim of the PoC was to enable an end consumer of a beef product to have a scannable label on the product that would when scanned resolved to a Proof of Provenance. To do this Quick Response Code [QR codes] were chosen.

QR codes are widely supported on modern phone operation systems IOS and Android in particular. The standard behaviour of phones when a QR code is scanned is to look for a URL in the scanned data and offer to take the user to that URL in the phones browser.

The PoC used this behaviour to provide scanning of artefacts in the system.

When a product is scanned the URL in the QR code is resolved. This URL then forms the boundary of the system.

The QR Code chosen is described in ISO/IEC 18004:2015

Figure 7: an example of a QR code that redirects a user to a website – this redirects to the MLA website.

It is recognised that in a real system, integration with industry standard scanners and barcoding systems would be required.

For the PoC, iPhones were used as both the scanning and data entry systems. Obviously, a real implementation would as indicated interact with the real production line, industry barcodes etc, however for the end consumer provenance would most likely be resolved via a QR code as this is widely accepted and readily available through consumer phones.

7.5.1 QR Codes for Stockyard Proof-of-Concept

Three very specific QR Code URL's were chosen

1. Placement on a carton:
   When the QR code is scanned, the URL associated to the QR code will present information relating to the carton. The design of the PoC presented an authorised user with a list of the contents of the carton. This information was read from the Blockchain.

Figure 8: QR code placed on the carton – Stockyard Gold

2. Placement on the wholesale cube rolls:
   When the QR code is scanned, the URL associated to the QR code will present information relating to the wholesale cut of meat. The design of the PoC presented an authorised user with a wholesale brand promise screen. All information presented on the screen was read from the Blockchain.

Figure 9: QR code placed on the wholesale Cube roll – Stockyard Gold

3. Placement on retail cuts that originate from the wholesale cube roll:
   When the QR code is scanned, the URL associated to the QR code will present with retail specific brand promise and provenance information.

Figure 10: QR code placed on retail cuts from the wholesale Cube roll – Stockyard Gold

7.5.2 QR Codes for Teys Proof-of-Concept

As the two PoC's differed, each required its own set of QR codes. For Teys the PoC was a conducted on 5 cartons which contained 9 portions of meat in each. The concept was to activate the selected product QR codes when a specific QR Code was scanned. As a result, 3 distinct categories of QR Codes where created;

1. Placement on Container:

The QR code placed on the container when scanned activated the QR codes placed on the products contained in the cartons. Prior to this step the Product QR codes would not display any provenance information if scanned. The reason this step was introduced was to show that a Blockchain system has the potential to ensure that any fake QR codes are unable to show provenance information.

Figure 11: QR code placed on container – Teys

2. Placement on Carton:

Unlike the PoC for Candidate A, the Teys PoC had 5 cartons loaded into the system. An authorised user had to log into the system when scanning a carton QR code, a list of products contained in the carton could then be seen. Further it was possible to identify if these product QR codes had been activated or not.

Figure 12: QR code placed on cartons – Teys

3. Placement on Product:

When the Product QR codes were scanned and the QR code was activated then a provenance screen would be presented.

Figure 13: QR code placed all products in carton – Teys

The next section discusses how the simulations were arrived at, it also discusses how the simulations vary from a putative real-world solution and where they do vary why this choice was made.

The methodology employed was different for Stockyard and Teys, consequently they are discussed separately below.

7.6 Candidate A: Stockyard

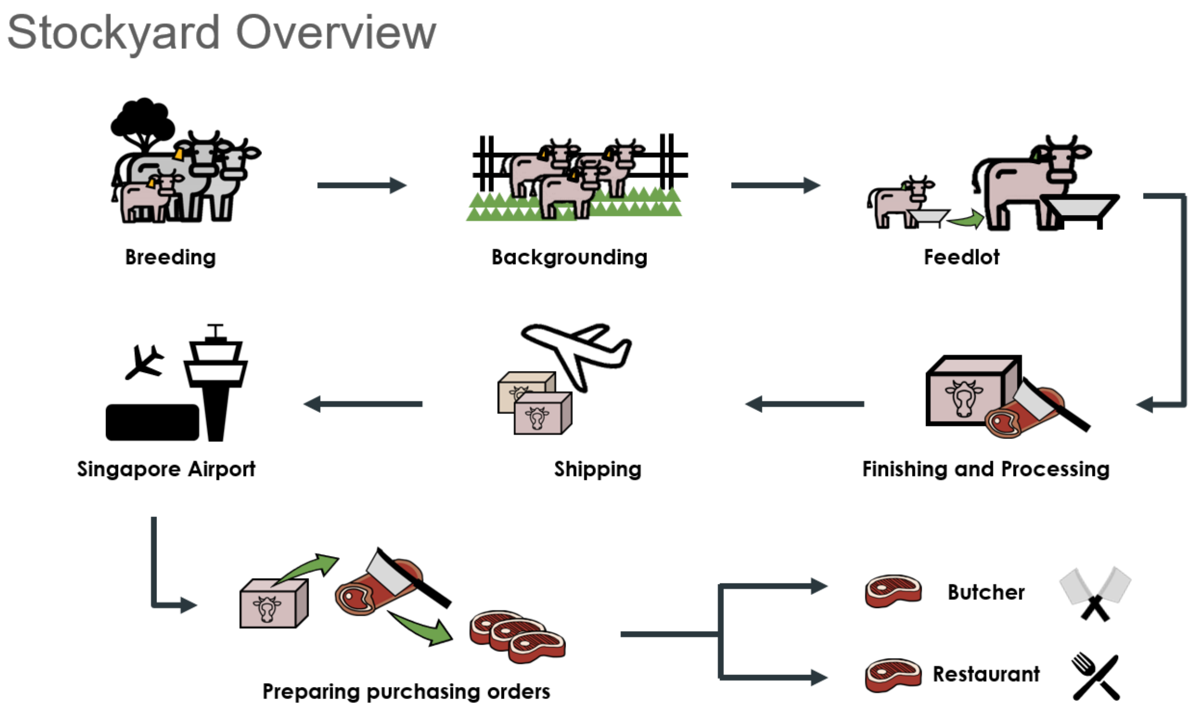

Figure 14 – Current process diagram – Stockyard Beef

7.6.1 Lot creation

For Stockyard an important aspect of their brand promise is that animals have been grain feed on a feedlot for a minimum of 200 days. Ideally the PoC would have run for this period so that transactions could be created when the animals are inducted to the feedlot and other transactions would track the animal whilst on the feedlot. Such a data set would create powerful provenance information when a Blockchain was reviewed by any participant or viewing authority.

A lot in the context of animal processing is a group of cattle that are slaughtered and processed together to produce products.

Due to time constraints, the required data was collected from an exisitng form that contained the required information and uploaded to the blockchain to simulate an integration point to the NLIS database. This dataset contained all the NLIS tag numbers for all animals that made up the lot being processed on the day.

This dataset allows for the identification of all carcases that made up a particular production run (lot). In the case that any further information regarding the feed, origin or genetics of an animal for any relevant purpose is required, it would be possible to identify, because of the NLIS tag or RFID number associated to the production run.

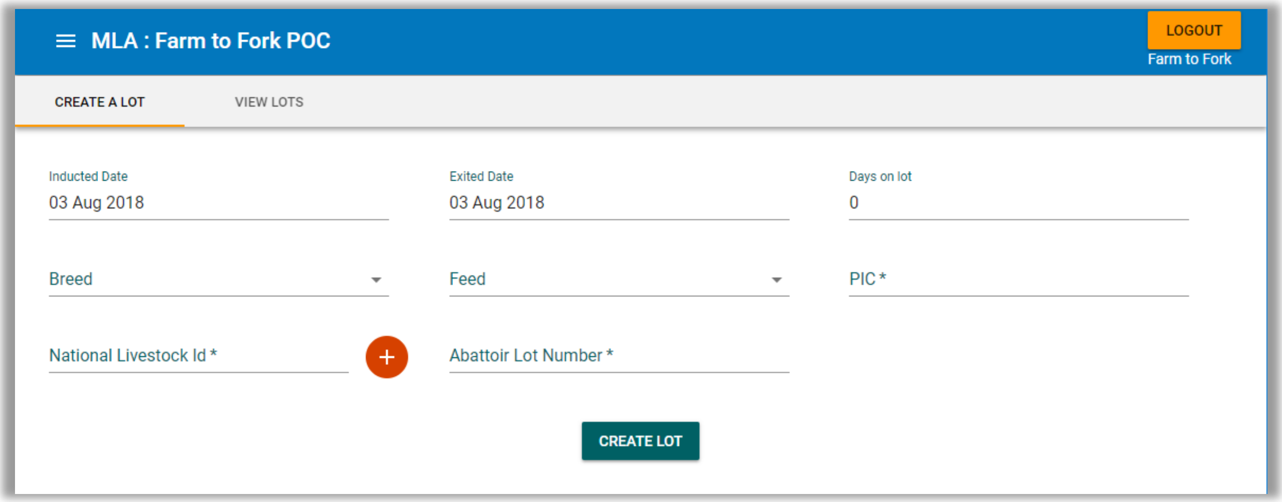

Figure 15: Lot creation form – Blockchain web interface for candidate A – Stockyard Beef

The lot record was saved into the blockchain.

7.6.2 Product creation

The Product in the PoC is a simulation of the type of data that would be included from a production line at the processor into the Block Chain to support provenance.

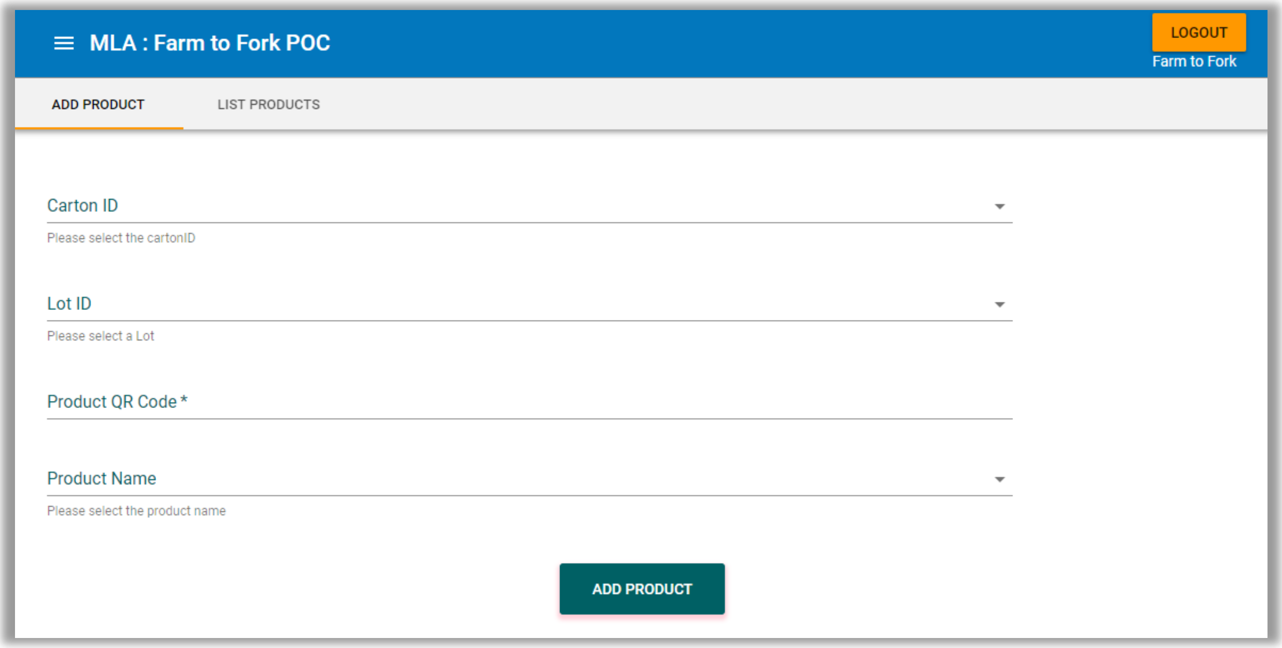

Figure 16: Product creation screen – Blockchain web interface for candidate A – Stockyard Beef

In the PoC data entry is via a screen. This screen captures a minimal set of data about the product, sufficient to demonstrate provenance. In a real-world solution this data would be added to the Blockchain via integration with a package line and the systems therein.

7.6.3 Carton creation

The packaging of products assumes that products are packed into cartons, cartons are then packed into a shipping container. In the PoC the shipping container is represented by the Waybill.

It should be noted that in addition to the industry standard barcoding on a carton the PoC has added a food safe QR Code label which can be scanned via a mobile phone. This QR code is an artefact of the PoC.

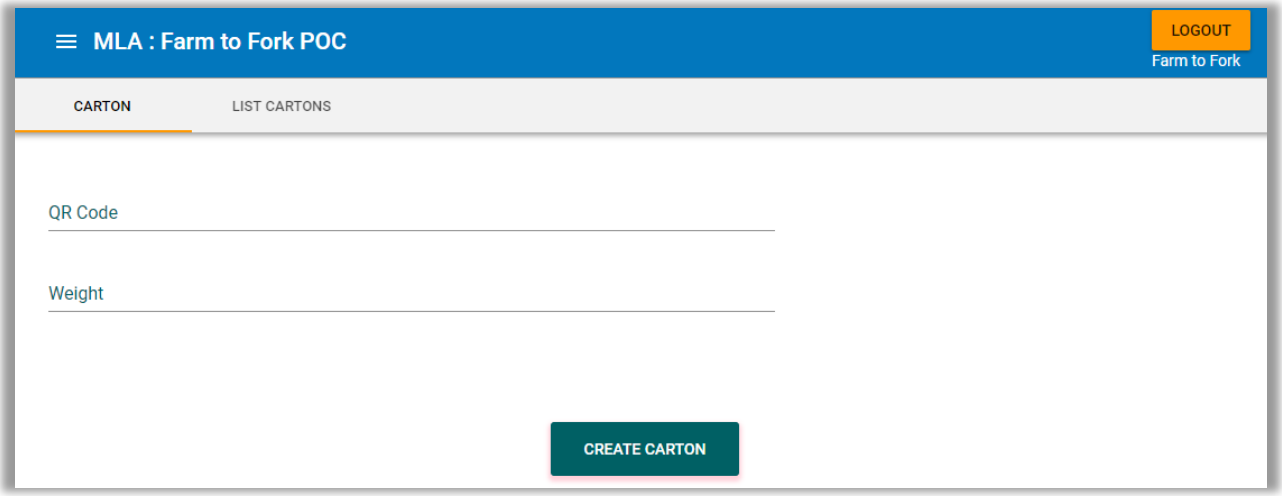

Figure 17: Carton creation – Blockchain web interface for candidate A – Stockyard Beef

7.6.4 Waybill

In the PoC the waybill represents three different interactions. Firstly, it collects together a set of cartons for shipment to a customer. As the industry commonly refers to such a collection by the document that accompanies it, the PoC has used the term Waybill.

Secondly, the waybill captures shipping information. In a real-world system such information would either be obtained via integration with a logistics system's Blockchain or by integration with a logistics system and a direct writing from the logistics system to the provenance Blockchain.

Shipping systems contain a wealth of information. For the PoC the dates of shipment from Australia and arrival at destination were used as the data-points to represent integration with a logistics system. A real-world system would have richer data, but the essential point is derived. That the product has originated from Australia and travelled to the destination port.

Thirdly a shipment has with it a set of accompanying documents. Typically, these documents are exchanged via electronic mechanisms for example email. The Waybill in the PoC allows for the attachment of a single document, an AQIS Certificate. Clearly this is not the set of documents that would accompany a shipment. One document demonstrates how a document can interact with the blockchain in a verifiable way.

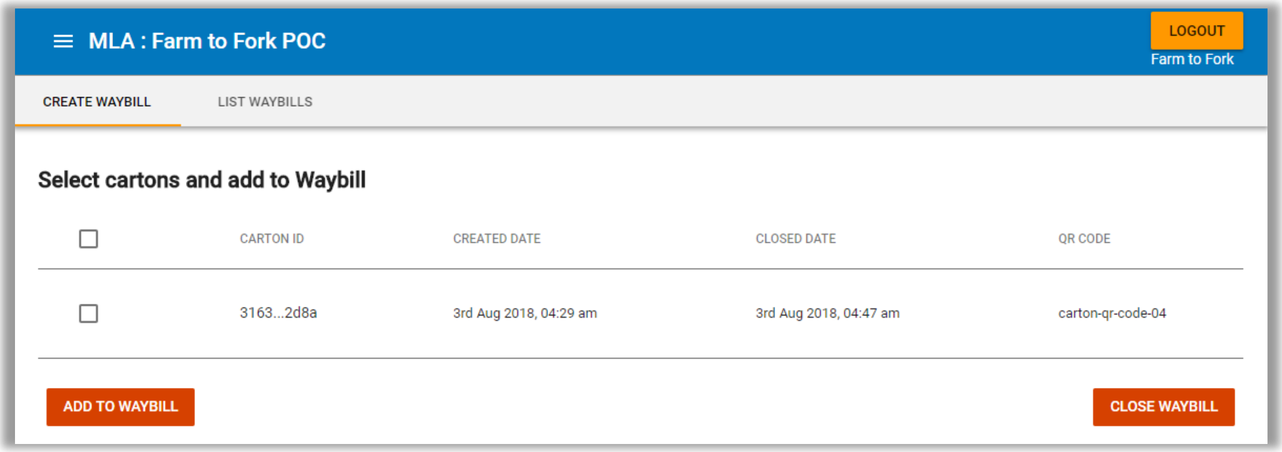

Figure 18: Waybill creation – Blockchain web interface for candidate A – Stockyard Beef

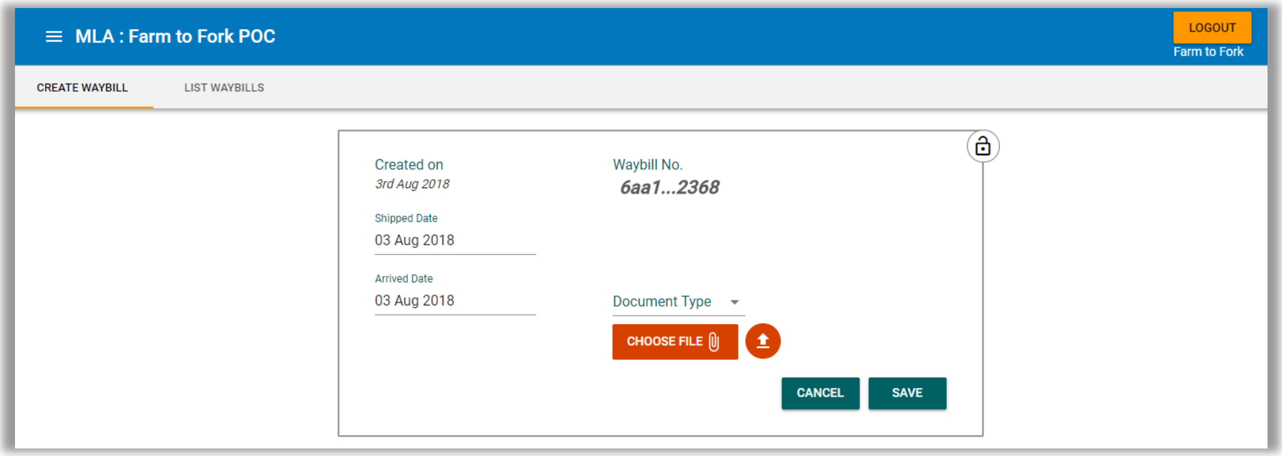

Figure 19: Saving documentation to the waybill (AQIS certification) – Blockchain web interface for candidate A – Stockyard Beef

7.6.5 Stockyard Provenance Screen

Figure 20: Wholesale provenance screen. – Blockchain web interface for candidate A – Stockyard Beef

7.6.6 Document Management in the Proof-of-Concept

There are several ways that documents can be stored in a Blockchain system that provide both the document and provide proof of the documents authenticity and irrevocability.

A document can be written directly to the Blockchain as a transaction. This mechanism is sometimes used in private Blockchains but can impose a burden in both speed and store size in a Blockchain solution. This is particularly true when there are many nodes as each node will end up storing a copy of a document.

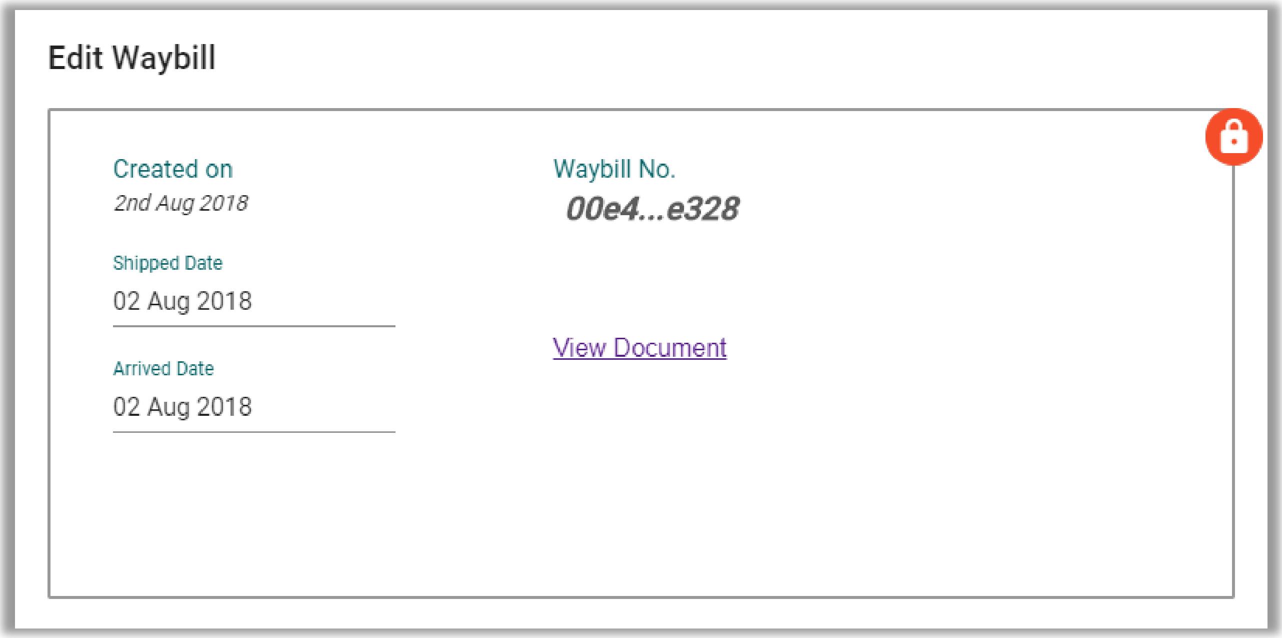

Figure 21: View document stored in Blockchain – Blockchain web interface for candidate A – Stockyard Beef

Alternately a document can be stored in a file system and document metadata written to the Blockchain. This creates an opportunity to reduce the paperwork that would traditionally accompany an international shipment by allowing the key information to be stored in an immutable way.

What is required for a document is that it is storable, viewable and that the system allows for proof that a document has not been altered after its storage.

The mechanism that the PoC used was to store a reference to the document in the Blockchain, this reference creates a unique name for the document derived from the Blockchain transaction id. The named document is then stored in a file store. The unique name makes it hard to tamper with a document but not impossible. To ensure that the document is not tampered with and to make any tampering evident, a hash of the documents contents is created and is recorded in the Blockchain when the documents meta data is recorded in the Blockchain. This would be the proposed approach for a production system.

When a document is viewed it's, hash is compared to the stored value and the viewable document is presented if these hashes agree.

7.7 Candidate B: Teys

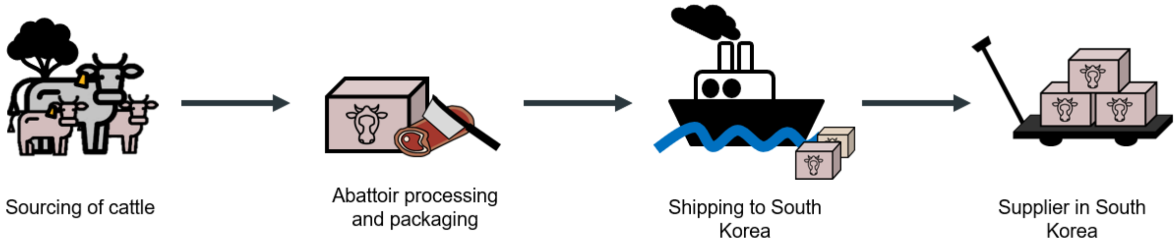

Figure 22: – High level overview of Teys POC

7.7.1 Lot creation

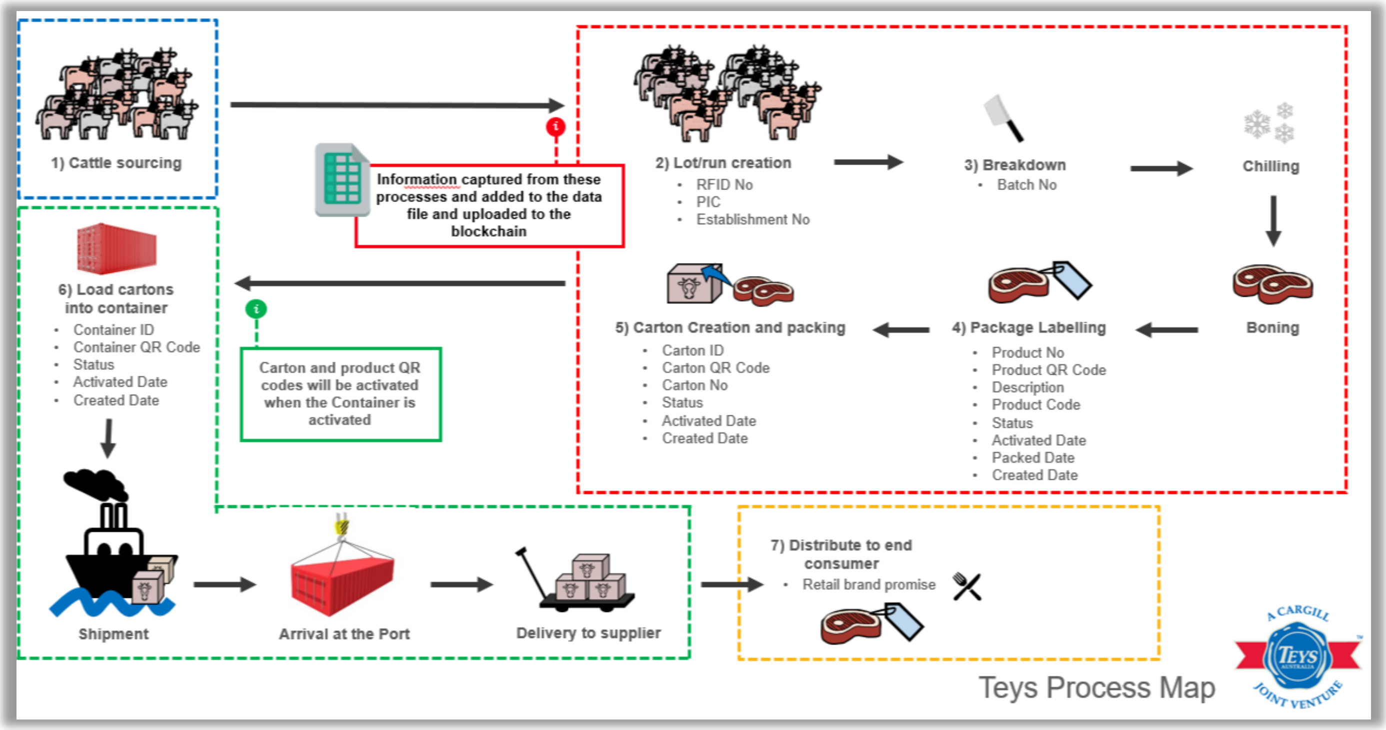

Figure 23: – Detailed overview of PoC process - Teys

The process in inside the blue dotted rectangle in *Figure 21* above, was simulated with data being uploaded into the blockchain via a web interface.

The information contained in the upload file was:

1. Container QR Code – A Unique Code Identifier (UUID) used to link all the products earmarked in the PoC.
2. Carton QR Code – A UUID, unique to each carton part of the PoC.
3. Product QR Code - A UUID that is unique for each product.
4. Active Flag (Y/N) – Set to "N" as a default, until the shipment is activated.
5. Description –Product (*TEYS CLASSIC GRAINFED *EQG* CUBE ROLL PIECES MSA IW/VAC GF*)
6. Establishment Number – The number assigned to the animal processing plant.
7. Pack Date – The date the product was packed.
8. Product Code – Internal Teys product code for the product.
9. RFID – RFIDs associated to the product, to identify which carcases the meat originated from.

10. PIC – PIC ID's associated to the product, to identify where the carcases originated from.
11. Batch Number – Internal Teys batch number
12. Carton number – Internal Teys Carton number

ContainerQR	CartonQR	ProductQR	Active	Description	Est No	Pack Date	Product Code	RFID	PIC	Batch No	Carton Number
b623b99c-7037-11e8-adc0-fa7ae01bbebc	170afd28-6f90-11e8-adc0-fa7ae01bbebc	f66d4c06-7a7b-11e8-adc0-fa7ae01bbebc	N	BEEF CHUCK TAIL FLAP PORTION	294	05/08/2018	13333	982 12351	QALI0510,	30082018	66
b623b99c-7037-11e8-adc0-fa7ae01bbebc	170afd28-6f90-11e8-adc0-fa7ae01bbebc	f66d4f94-7a7b-11e8-adc0-fa7ae01bbebc	N	BEEF CHUCK TAIL FLAP PORTION	294	05/08/2018	13333	982 12351	QALI0510,	30082018	66
b623b99c-7037-11e8-adc0-fa7ae01bbebc	170afd28-6f90-11e8-adc0-fa7ae01bbebc	f66d50f2-7a7b-11e8-adc0-fa7ae01bbebc	N	BEEF CHUCK TAIL FLAP PORTION	294	05/08/2018	13333	982 12351	QALI0510,	30082018	66
b623b99c-7037-11e8-adc0-fa7ae01bbebc	170afd28-6f90-11e8-adc0-fa7ae01bbebc	f66d534a-7a7b-11e8-adc0-fa7ae01bbebc	N	BEEF CHUCK TAIL FLAP PORTION	294	05/08/2018	13333	982 12351	QALI0510,	30082018	66
b623b99c-7037-11e8-adc0-fa7ae01bbebc	170afd28-6f90-11e8-adc0-fa7ae01bbebc	f66d548a-7a7b-11e8-adc0-fa7ae01bbebc	N	BEEF CHUCK TAIL FLAP PORTION	294	05/08/2018	13333	982 12351	QALI0510,	30082018	66
b623b99c-7037-11e8-adc0-fa7ae01bbebc	170b0066-6f90-11e8-adc0-fa7ae01bbebc	f66d55ac-7a7b-11e8-adc0-fa7ae01bbebc	N	BEEF CHUCK TAIL FLAP PORTION	294	05/08/2018	13333	982 12351	QALI0510,	30082018	66
b623b99c-7037-11e8-adc0-fa7ae01bbebc	170b0066-6f90-11e8-adc0-fa7ae01bbebc	f66d5a5c-7a7b-11e8-adc0-fa7ae01bbebc	N	BEEF CHUCK TAIL FLAP PORTION	294	05/08/2018	13333	982 12351	QALI0510,	30082018	66
b623b99c-7037-11e8-adc0-fa7ae01bbebc	170b0066-6f90-11e8-adc0-fa7ae01bbebc	f66d5ba6-7a7b-11e8-adc0-fa7ae01bbebc	N	BEEF CHUCK TAIL FLAP PORTION	294	05/08/2018	13333	982 12351	QALI0510,	30082018	66
b623b99c-7037-11e8-adc0-fa7ae01bbebc	170b0066-6f90-11e8-adc0-fa7ae01bbebc	f66d5d40-7a7b-11e8-adc0-fa7ae01bbebc	N	BEEF CHUCK TAIL FLAP PORTION	294	05/08/2018	13333	982 12351	QALI0510,	30082018	66
b623b99c-7037-11e8-adc0-fa7ae01bbebc	170b0066-6f90-11e8-adc0-fa7ae01bbebc	f66d5e6c-7a7b-11e8-adc0-fa7ae01bbebc	N	BEEF CHUCK TAIL FLAP PORTION	294	05/08/2018	13333	982 12351	QALI0510,	30082018	66
b623b99c-7037-11e8-adc0-fa7ae01bbebc	170b012e-6f90-11e8-adc0-fa7ae01bbebc	f66d6222-7a7b-11e8-adc0-fa7ae01bbebc	N	BEEF CHUCK TAIL FLAP PORTION	294	05/08/2018	13333	982 12351	QALI0510,	30082018	66
b623b99c-7037-11e8-adc0-fa7ae01bbebc	170b012e-6f90-11e8-adc0-fa7ae01bbebc	f66d63b2-7a7b-11e8-adc0-fa7ae01bbebc	N	BEEF CHUCK TAIL FLAP PORTION	294	05/08/2018	13333	982 12351	QALI0510,	30082018	66
b623b99c-7037-11e8-adc0-fa7ae01bbebc	170b012e-6f90-11e8-adc0-fa7ae01bbebc	f66d6556-7a7b-11e8-adc0-fa7ae01bbebc	N	BEEF CHUCK TAIL FLAP PORTION	294	05/08/2018	13333	982 12351	QALI0510,	30082018	66
b623b99c-7037-11e8-adc0-fa7ae01bbebc	170b012e-6f90-11e8-adc0-fa7ae01bbebc	f66d6786-7a7b-11e8-adc0-fa7ae01bbebc	N	BEEF CHUCK TAIL FLAP PORTION	294	05/08/2018	13333	982 12351	QALI0510,	30082018	66
b623b99c-7037-11e8-adc0-fa7ae01bbebc	170b012e-6f90-11e8-adc0-fa7ae01bbebc	f66d68b2-7a7b-11e8-adc0-fa7ae01bbebc	N	BEEF CHUCK TAIL FLAP PORTION	294	05/08/2018	13333	982 12351	QALI0510,	30082018	66
b623b99c-7037-11e8-adc0-fa7ae01bbebc	170b046e-6f90-11e8-adc0-fa7ae01bbebc	f66d6c9a-7a7b-11e8-adc0-fa7ae01bbebc	N	BEEF CHUCK TAIL FLAP PORTION	294	05/08/2018	13333	982 12351	QALI0510,	30082018	66
b623b99c-7037-11e8-adc0-fa7ae01bbebc	170b046e-6f90-11e8-adc0-fa7ae01bbebc	f66d6dbc-7a7b-11e8-adc0-fa7ae01bbebc	N	BEEF CHUCK TAIL FLAP PORTION	294	05/08/2018	13333	982 12351	QALI0510,	30082018	66
b623b99c-7037-11e8-adc0-fa7ae01bbebc	170b046e-6f90-11e8-adc0-fa7ae01bbebc	f66d6f92-7a7b-11e8-adc0-fa7ae01bbebc	N	BEEF CHUCK TAIL FLAP PORTION	294	05/08/2018	13333	951 00030	QDBY0223	30082018	66
b623b99c-7037-11e8-adc0-fa7ae01bbebc	170b046e-6f90-11e8-adc0-fa7ae01bbebc	f66d7190-7a7b-11e8-adc0-fa7ae01bbebc	N	BEEF CHUCK TAIL FLAP PORTION	294	05/08/2018	13333	951 00030	QDBY0223	30082018	66
b623b99c-7037-11e8-adc0-fa7ae01bbebc	170b046e-6f90-11e8-adc0-fa7ae01bbebc	f66d72c6-7a7b-11e8-adc0-fa7ae01bbebc	N	BEEF CHUCK TAIL FLAP PORTION	294	05/08/2018	13333	951 00030	QDBY0223	30082018	66
b623b99c-7037-11e8-adc0-fa7ae01bbebc	170b0662-6f90-11e8-adc0-fa7ae01bbebc	f66d74e2-7a7b-11e8-adc0-fa7ae01bbebc	N	BEEF CHUCK TAIL FLAP PORTION	294	05/08/2018	13333	951 00030	QDBY0223	30082018	66
b623b99c-7037-11e8-adc0-fa7ae01bbebc	170b0662-6f90-11e8-adc0-fa7ae01bbebc	f66d7618-7a7b-11e8-adc0-fa7ae01bbebc	N	BEEF CHUCK TAIL FLAP PORTION	294	05/08/2018	13333	951 00030	QDBY0223	30082018	66
b623b99c-7037-11e8-adc0-fa7ae01bbebc	170b0662-6f90-11e8-adc0-fa7ae01bbebc	f66d77e4-7a7b-11e8-adc0-fa7ae01bbebc	N	BEEF CHUCK TAIL FLAP PORTION	294	05/08/2018	13333	951 00030	QDBY0223	30082018	66
b623b99c-7037-11e8-adc0-fa7ae01bbebc	170b0662-6f90-11e8-adc0-fa7ae01bbebc	f66d7910-7a7b-11e8-adc0-fa7ae01bbebc	N	BEEF CHUCK TAIL FLAP PORTION	294	05/08/2018	13333	951 00030	QDBY0223	30082018	66
b623b99c-7037-11e8-adc0-fa7ae01bbebc	170b0662-6f90-11e8-adc0-fa7ae01bbebc	f66d7b72-7a7b-11e8-adc0-fa7ae01bbebc	N	BEEF CHUCK TAIL FLAP PORTION	294	05/08/2018	13333	951 00030	QDBY0223	30082018	66

Figure 24: – Example of data uploaded into the Blockchain - Teys

7.7.2 Inactive QR codes

The shipment was sent to South Korea. On its arrival the container QR code was scanned by the distributor partner of Teys. The scanning of the QR code provided the ability to activate the Product QR codes. Prior to the activation event, if a product QR code was scanned the user will be presented with a screen informing the user that the QR code is not valid.

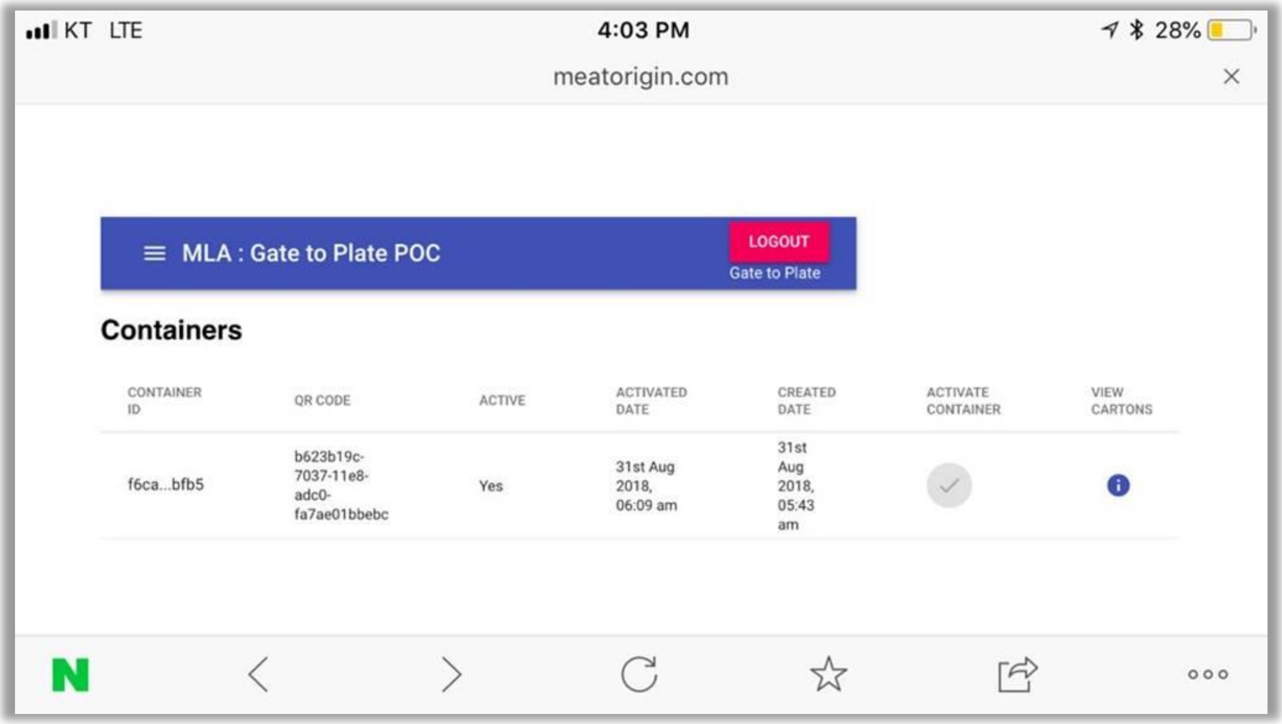

Figure 25: – Example of carton activation screen – Blockchain web interface for candidate B – Teys

7.7.3 Activated Carton

When an activated carton QR Code was scanned, a screen confirming the activation of the carton and the contents thereof.

Figure 26: – Example of activated carton screen – Blockchain web interface for candidate B – Teys

7.7.4 Teys Provenance Screen

When scanning a QR codes attached to the meat product in the container, after it has been activated.

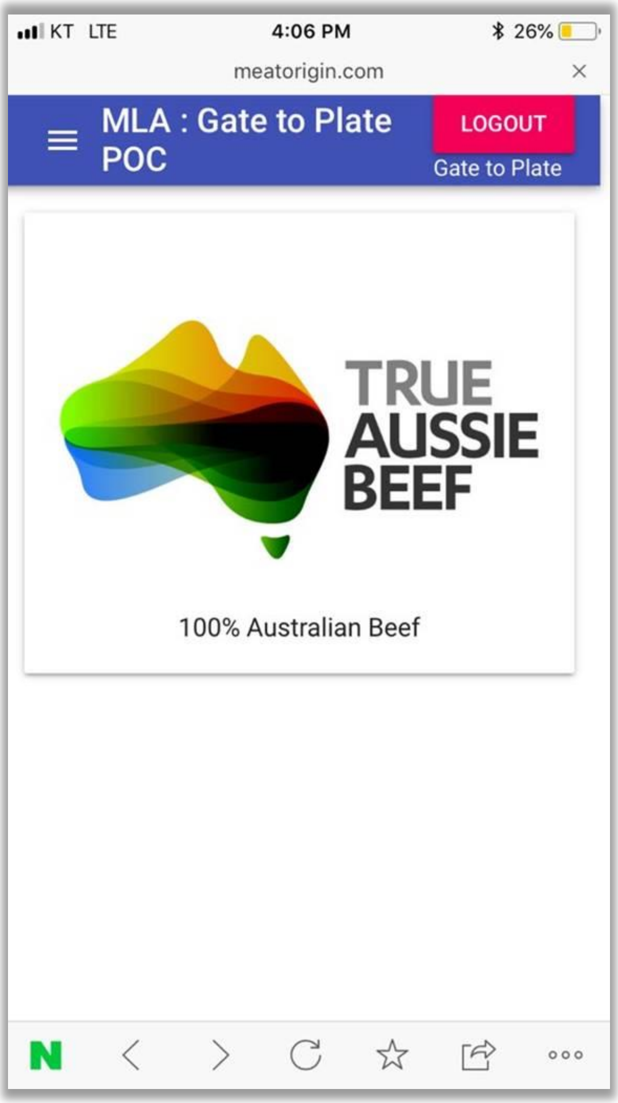

Figure 27: – Example of provenance screen – Blockchain web interface for candidate B – Teys

8 Recommendations

8.1 Industry Recommendations and benefits

In the Australian red-meat industry, an efficient supply chain is vital to the successful movement of goods. Contracts within a supply chain are complex, dynamic, multi-party arrangements, which are constrained by regulatory and logistical influences. The products often cross jurisdictional boundaries. Information exchange in a supply chain is as important as the physical exchange of goods. For example, customs inspections are not able to begin until both the physical goods and the relevant documentation are available. If custom officials had confidence in the documentation it could expedite customs and biosecurity processes, even reduce risk and potentially reduce insurance costs.

Supply chains are a highly promising area for the application of blockchain technologies. The neutral ground provided by a Blockchain can help integrate the disparate participants in a supply chain, and the integrity and audit trail in a blockchain ledger will improve transparency and confidence across the entire supply chain.

Being able to identify how products were processed and distributed is important to establish greater confidence in food safety, creating and building high-quality brands, assisting in the prevention of fraud, and improving supply chain efficiency.

Although producers and logistics agents are likely to bear most of the total costs of deploying and operating a blockchain, these benefits may be felt by consumers globally and by producers domestically.

Although not explored in detail as an illustrative example in this PoC, the combination of distributed integrity, digital currency, and smart contracts in a blockchain may enable new kinds of “contracts” between different roles.

In a red-meat supply chain there are many stakeholders, these range from producers, to transport providers, sorting/processing facilities, wholesalers, distributors, retailers, and consumers. In an international supply chain there are additional stakeholders being customs and biosecurity regulation.

Consumers will benefit from the transparency and immutable nature of a Blockchain, allowing them to purchase with confidence in respect to the origin of the product. To achieve this, the developed system will have to make scanning of a label a once only event, and/or link the scanned code to a profile.

There is an added benefit of the potential profiling of an end customer examples are recording of product type, frequency of purchase and location of purchase.

An inevitable consequence of recording person data are privacy concerns, and these are made more complex when different countries and laws are to be considered. Legal advice and counsel will be critical to the success of any such initiative.
Privacy concerns may also be a barrier to end consumers making use of a scanning solution, this can potentially be overcome by offering incentives, e.g. Competitions, recipes or cooking instructions etc.

Acquiring of additional skills and expertise to succeed with blockchain is a further consideration to the successful adoption. Blockchain is a relatively new technology so underestimating the talent challenge would be ill-informed. We would recommend additional blockchain skills in areas such as

Public Key Infrastructure (PKI), cryptography, information architecture, software engineering, network infrastructure and integration, and user interface/user experience.

It is possible to create a hybrid Blockchain, one part that would store all the “brand promise” information in a publicly accessible Blockchain and the second would store commercially sensitive information.

9 Key Messages

A Blockchain solution won't solve traceability alone, however, it does provide an ideal base layer upon which architectures for robust traceability systems can be built and participated in without ownership by the biggest or richest actors in the supply chain.

Blockchain is still being explored around the globe by private enterprise and governments, due to this it is not possible to predict all the distinctive opportunities and advantages that a Blockchain can offer. As this PoC was specifically developed with the red-meat industry in mind we will only discuss the potential application of this technology within this constraint.

Organisations and government bodies that do nothing about blockchain run the risk of being left behind, but there are also risks in undertaking a blockchain project. Attention should be paid to these areas of risk:

1. The specifics of the business context (such as customer adoption paradigms),
2. Risk management and legal restrictions (e.g., smart contracts and data privacy).

Industry boundaries will continue to become less defined as business ecosystems develop and artificial intelligence increasingly influences decision making. It is impossible to predict precisely what business enterprises will look like in five years, but for now Blockchain is something worth exploring, certainly for businesses that are built on proving the integrity of their products.

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