Final Report

AMPC
AUSTRALIAN MEAT PROCESSOR CORPORATION

Unova Blockchain Anti-Counterfeit Solution

Traceability Solution – Primal to Steak / Steak to Primal (stage 2)

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1.0 Executive Summary

AMPC (and the industry) have an innovative vision, and support R&D program, to continue to advance different approaches and offerings to increasing traceability throughout the supply chain. This project is focused specifically on developing and demonstrating technologies to enable the cost-effective and reliable tracking of a primal as it is divided into steaks, and in turn to ascertain which primal a steak came from once in a retail pack. The focus here is to think about product substitution as well as the supply chain obtaining information about the 'last mile' of the product. In what follows, a short overview is given of the project objectives, approach, project outcomes, conclusions and recommendations for further research/actions.

1.1 Project objectives

The Project objectives are first to develop and demonstrate to AMPC staff UNOVA's approach to offering a cost-effective and robust primal to steak, and steak to primal, traceability system, within a demonstration facility (i. e. not yet within an active supply chain). Secondly, it also needs to be shown how the system will spot and flag fraudulent counterfeit activity.

1.2 Approach

In accomplishing above, UNOVA's blockchain infrastructure and software platforms entailed a very strong basis to build on. Therefore, the main R&D needed was to first find the necessary devices to be able to create the closed system (blockchain infrastructure combined with required hardware devices). Next, development was needed for the hardware setup (including scanner, screen, scale, and label printer) to work in a real-life setting. Finally, multiple functionalities needed to be added to UNOVA's current platforms to flag counterfeiting activity for both the companies and the end consumers.

1.3 Project outcomes

Together with AMPC it was concluded that implementing the complete solution in a real-world supply chain, with all anti-counterfeiting measures in place as demonstrated by UNOVA, would not only benefit the industry with respect to their traceability objectives as also set out by AMPC (see 2.0 Introduction) but would also result in less anti-counterfeiting activities because of the difficulty of attempting in combination with the high risk of getting caught by both the supplier and the end consumer.

1.4 Conclusions and recommendations

During the stage 2 – technology validation, a cost-effective primal to steak and steak to primal traceability system with anti-counterfeiting capabilities, leveraging UNOVA's blockchain infrastructure, has been developed and demonstrated. To be able to satisfy all process objectives, all necessary development activities for the hardware setup to work in a real-life setting have been performed with respect to the devices bought (scanner, scale, screen, printer, and server). Next, the traceability objectives were satisfied with the UNOVA trace module. Finally, the combination of the development of the anti-counterfeiting module, together with the anti-counterfeit notifications on the consumer trace dashboard, allowed for meeting the expectations with respect to the flagging of counterfeiting activity for both the companies and the end consumers.

Going forward with the next stage it would be recommended to both validate and implement the proposed solution in a real-life industry setting and fully leverage UNOVA's blockchain infrastructure by covering all possibilities complementary with AMPC's strategic objectives.

2.0 Introduction

AMPC's 2020-2025 Strategic Plan (AMPC Strategic Plan 2020-2025, n.d.) identifies within the Advance Manufacturing (pages 5-6), Sustainability (pages 7-9), Technical Market Access & Markets (pages 12-13), and Product and Process Integrity (pages 14-15) programs, specifically enabling:

1. Digitisation, via acquiring product, supply chain and consumer information and leveraging data for insights (Adv. Mft.)
2. Sustainability, via underpinning Communities, Energy, Water, Waste and Packaging claims
3. Marketing & Promotion, via offering a new premium value add to premium markets
4. Products, via understanding additional purchasing behavior (and enabling direct connection with consumers). New direct connection with domestic and global consumers could lead to leveraging new product ideas (e. g. Dairy Industry Oak direct consumer engagement - https:/108kflavourgenerator. comau/)
5. Market access, via increased granular traceability systems
6. International Competitiveness, via ideally reducing manual compliance regulations
7. Traceability and integrity Systems
8. Animal Welfare, via communicating animal welfare practices to consumers that the relevant supply chain adheres to
9. Food Safety, via demonstration that forward and backward recalls are now possible to steak level.

As such although the primary goal for the innovation theme is a successful development(s) to enable operational primal to steak, and steak to primal traceability (hence a focus on Strategic Fit 7 above), it is expected that all stages and successful development companies will keep in mind both the primary and secondary goals in the context of the above nine(9) strategic plan touch points.

Therefor, AMPC operated an innovation competition with this (and other) innovation themes. Following a widely practiced approach of other innovation investors (such as DARPA), AMPC where possible supported a number of providers with unique approaches during Stage 1 (and 2). As the stages progress the number of providers supported to the subsequent stages will be reduced.

In doing so, UNOVA was chosen to develop and demonstrate a cost-effective and robust primal to steak, and steak to primal, traceability and anti-counterfeit system as it was quickly realized that UNOVA’s blockchain infrastructure and software platforms already entailed a very robust basis to build on when it comes to (among other things) traceability and anti-counterfeiting.

3.0 Project Objectives

The project objectives are first to develop and demonstrate to AMPC staff, UNOVA’s approach to offering a cost-effective and robust primal to steak, and steak to primal, traceability system, within a demonstration facility (i. e. not yet within an active supply chain). Secondly, it will also be shown how the system will spot and flag fraudulent counterfeit activity.

3.1 Stage 2 – Technology pilot validation

Stage 2 will support development to further develop and demonstrate existing and evolving/new ideas to trace primals to steaks and steaks to primals. The demonstration will occur in private with AMPC and possibly one Australian processing client. In what follows, the minimum expected to be demonstrated is explained.

3.1.1 The process

During this process demonstration, the provider is to articulate and demonstrate how the third-party cutting room will register the inbound of a primal or when the cutting of a particular primal starts using the scanner. Next, it needs to be shown how once a piece is cut and weighed, the appropriate label is printed. Thirdly, the digital asset/event creations through the application on the screen needs to be demonstrated. Finally, it needs to be shown how after creating the data on the local node it gets bundled and distributed through the blockchain to the other relevant company nodes.

3.1.2 Trace forward and trace back

Demonstration of a simple interface that shows which steak each primal has been sourced from.

3.1.3 'Alert' of the non-traced product (primal and steaks)

A demonstration of what is expected to occur in Stage 3 if a 3rd party tries to cut a primal into more steaks that is possible for that primal. An example of how someone in the supply chain knows if a primal and or steak has been scanned. The focus here is to think about product substitution as well as the supply chain obtaining information about the 'last mile' of the product.

3.1.4 Stage 3 design

On the assumption that AMPC (and an Australian processor, if applicable) validate the offering to progress to Stage 3, a Stage 3 R&D submission will be expected after the Stage 2 final reporting process. The provider will also need to secure a host Australian supply chain as part of their Stage 3 submission, which AMPC can assist with, but is not accountable/responsible for obtaining.

4.0 Methodology

As already mentioned, UNOVA's blockchain infrastructure and software platforms already entailed a very robust basis to build on when it comes to (among other things) traceability and anti-counterfeiting. Therefore, to understand the complete picture, first a system overview is given where the foolproof closed system (i.e., blockchain and software infrastructure combined with the necessary hardware to create the unique digital identities of items that are tracked and analyzed) is explained. Next, the parts where the main R&D activities were needed are highlighted, and the corresponding R&D is described.

4.1 System overview

A complete system overview can be seen in Figure 1. In what follows, all segments constituting the system are individually discussed. In doing so, the contribution and importance of each part will be clarified.

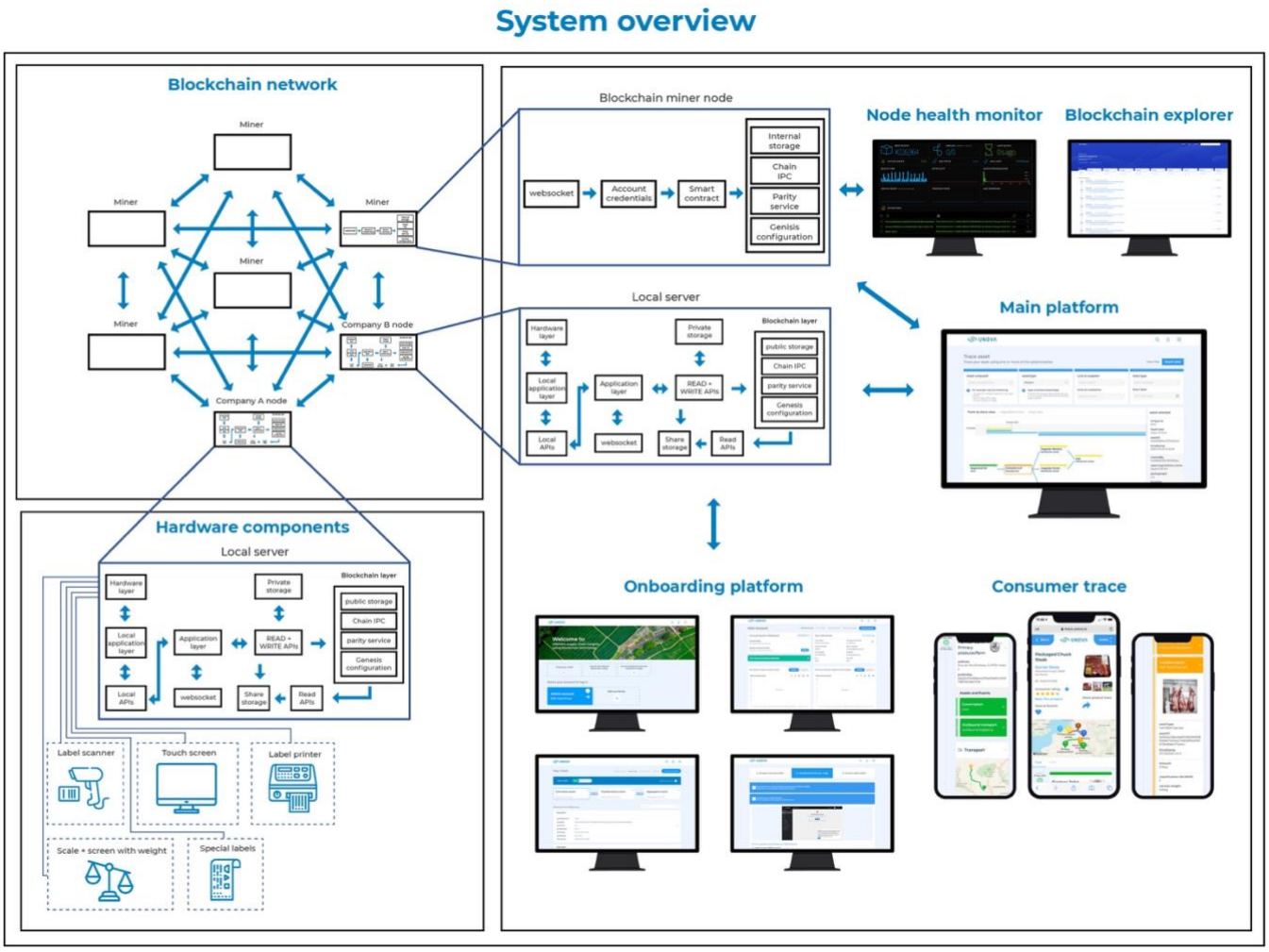


Figure 1: System overview

4.1.1 Onboarding platform

The onboarding platform is created to allow any company to implement the technology with only limited blockchain knowledge. After signing up, each company can log in to their company profile where they can (among other things) create their wallet, install the NOP, invite facilities, invite users, use the chain builder tool to build their internal chain, decide settings and define who will get access to the digitalized assets registered on the network. Many different smart contracts are used in the background to make the whole system run.

4.1.2 Local server

The company node can be installed on the local server using the Node Onboarding Package (NOP). The NOP has a configurable UI which initiates services that allows deploying and setting up the node to a cloud or on-premises server with the necessary configuration that establishes a connection to the blockchain network and is also responsible in managing data processing. Instead of making the company go through a long process to install all the different applications the NOP is designed to install 10 applications in 1 command line. This is important because the

web3 principles need to be followed in which no central authority should control anything thus each member of the network is also hosting its own applications, so it is a fully trustless and decentralized infrastructure.

Once the data is created on the company node, it will be bundled and distributed through a blockchain transaction to the other relevant company nodes after certain conditions are satisfied. These conditions include (but are not limited to) the data being unchanged. The R&D done concerning the needed capabilities of this server is discussed in the R&D section below.

4.1.3 Other hardware

For the system to work in a real-life setting, several devices are needed for various purposes. In what follows, the table below gives an overview of all necessary devices together with the purpose of each device for this project.

Device	Purpose
1. Scanner	Registering the inbound transport or the start of the cutting of a primal, the output of which will be displayed in the user interface of the application running on the screen.
2. Scale	Once a steak is cut, it is put on a scale that is linked to the screen where the weight will be displayed.
3. Screen	Creation of the inbound transport event of a primal on the system. Creation of the unique digital identities of the steaks originating from the scanned primal on the system. Data layer and application layer of the peripherals – which is responsible for communication with the different devices, and reading the relevant data.
4. Printer	Printing corresponding labels for the real steaks.
5. Server	Host the company node - which is responsible for creating data on the blockchain and reading data from the blockchain network.

The R&D activities done for the scanners, screen, scale, printer, and the application running on the screen are described in the R&D section below.

4.1.4 Transactions

To fully understand how the transactions are built up, some terminology explanation first could be helpful.

Firstly, an asset is a digital entity for any physical conceptual element in the supply chain. Depending on the industry, it can be a cow, a box of apples, an apple, a piece of meat, a lasagna, a lot, a batch or box, etc..

Secondly, events record any relevant and time-stamped information that has happened to one or multiple assets. Examples are transports, observations, quality controls medicines administered, etc.

Any additional data can be added to an asset or an event such as weight, time of arrival, sex, …

Thirdly, a bundle is made by grouping assets & events and accompanying data. Bundles have a unique ID that is crypto secured, which is called the bundle ID, created by hashing all bundle data which makes that a change in any data point will result in a different bundle ID.

Finally, Bundle IDs are a part of the transaction getting validated on the blockchain network

4.1.5 Blockchain nodes

Nodes are an essential component of the blockchain infrastructure. Without nodes, a blockchain's data would not be accessible nor distributed. One could say nodes are the Blockchain or store the Blockchain.

A node is the most basic type of computing device that supports a blockchain network. In a general sense, a decentralized blockchain network is simply composed of all the nodes that support it. In Proof-of-Work (PoW) systems, miners are the nodes; in Proof-of-Stake (PoS) systems, staking wallets are the nodes. PoW and PoS are consensus mechanisms that allow nodes to come to an agreement on the validity of transactions and, in turn, the state of the entire Blockchain. UNOVA uses Proof-of-Stake (PoS) as a consensus mechanism as it is more energy efficient and environmentally friendly as opposed to Proof-of-work (PoW).

Generally, there are three distinct types of nodes – miner nodes, full nodes, and light nodes. Miner nodes can propose blocks containing several new transactions and have the complete history of the Blockchain. Full nodes save the entire Blockchain meaning the latest blocks but also the historical data or transactions. However, usually, a full node cannot propose new blocks to the Blockchain. A full node is a program that fully validates transactions and blocks and then relays them to further full nodes. By storing the whole Blockchain, full nodes also ensure that there is complete decentralization. Light nodes rely on full nodes for Blockchain's history but do store the latest block.

4.1.6 Company node

The company nodes are responsible for creating, distributing, and sheltering the actual supply chain data. After the miner node has put the transactions inside a block on the Blockchain, the bundle IDs are distributed to the appropriate company nodes. These nodes will then ask all data of each particular bundle from the company node which created this data and verify whether the bundle ID (hash) formed still matches the original data inside the bundle. If this is the case, the company node will accept all data. If not, then it would mean that somewhere tampering has happened with the data, and hence the company node won't accept this data. This setup makes that although companies could potentially tamper the data inside their own local server, they won't be able to put this data inside the Blockchain nor distribute it to the other company nodes. Therefore, it will not be available on the network. As all applications for the companies are reading from the company node, the companies can be sure that no tampered data is being displayed in the applications because as already mentioned tampered data will never be distributed and will always be rejected.

4.1.7 Main platform

The main platform consists of various modules that help the companies within the supply chain to trace assets, spot possible counterfeiting activity, have real-time demand forecasts, have ways to register documents, and many more. As the platform gets the data from the company node, which in turn only accepts immutable data, the blockchain system already entails the first protection against counterfeiting. Companies won't be able to, after all, alter the data in an attempt to counterfeit. In what follows the most important modules of the platform with regards to the project are discussed.

The **Unova Trace module** allows companies to search for any asset that passed through their supply chain while at the same time not allowing competitors to get access to this data. This helps them to manage their supply chain, create reports, export to excel, or simply display in the "farm to store view", "Ingredient view" or "map view" (see Figure 2).

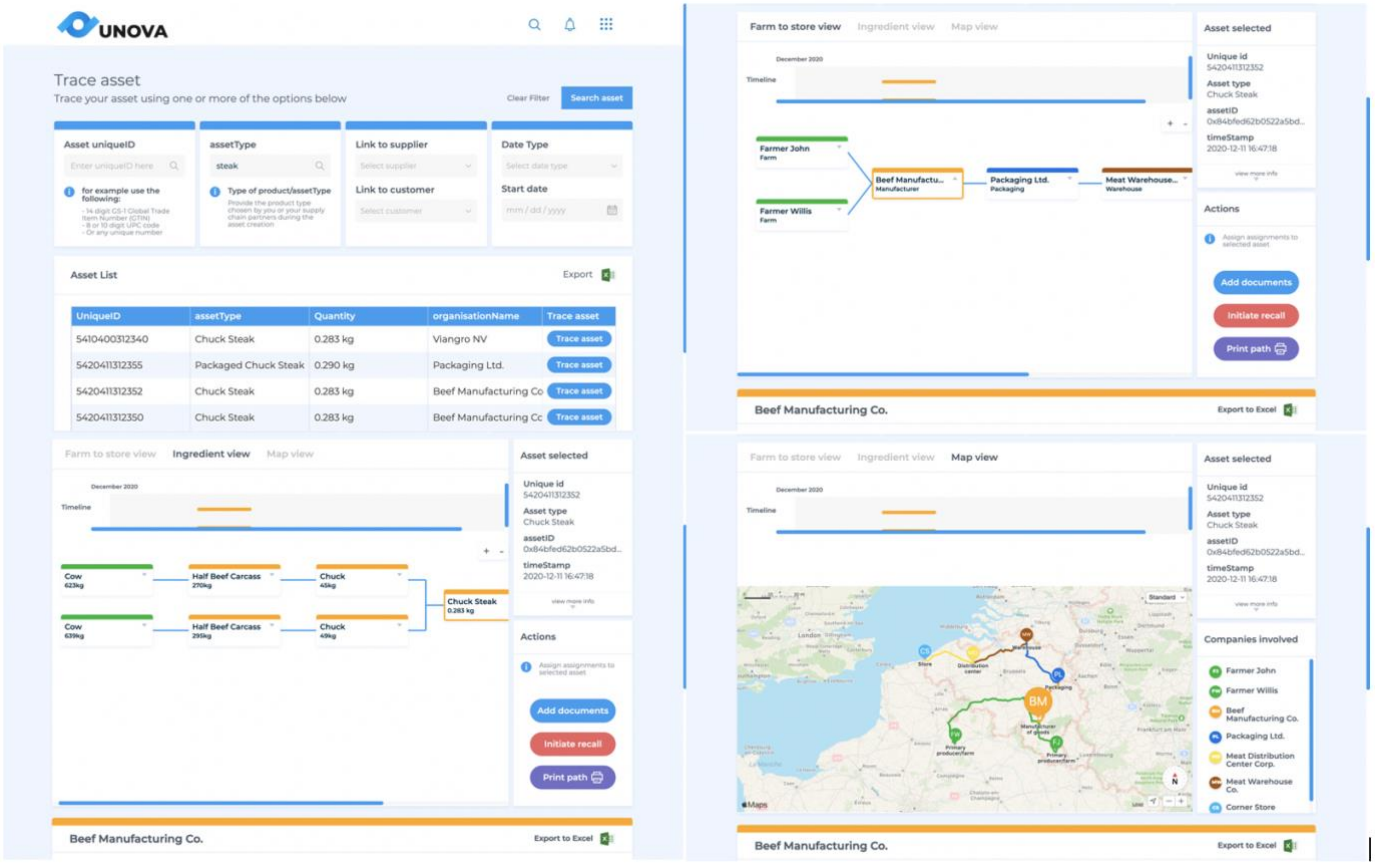


Figure 2: Unova trace module

The Counterfeit flagging module for companies will notify the companies for each primal which corresponding steaks have a high probability of being counterfeit. The companies will also be able to export the list to excel in order to create reports and do further investigations if necessary. As this module is developed for the purpose of this project, the R&D done is explained in the R&D section below.

4.1.8 Consumer trace dashboard

UNOVA's consumer trace dashboard allows the consumer to scan a QR-code/barcode on a physical product and get access to full traceability and transparency data (see Figure 3). This will enable consumers to view, rate, comment, share or store products and view all members in the ecosystem. An additional capability that is needed for this project is that the probability of a particular steak being counterfeit needs to be communicated to the end consumer. The R&D done on this part is explained in the R&D section below.

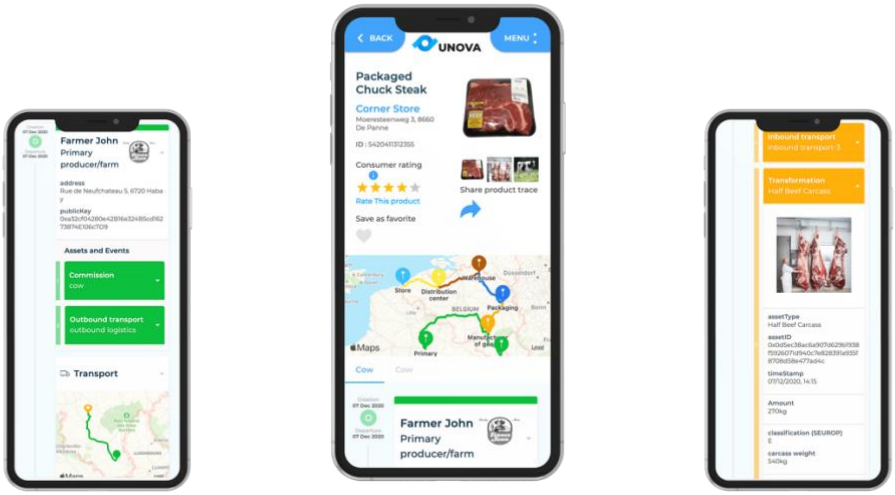


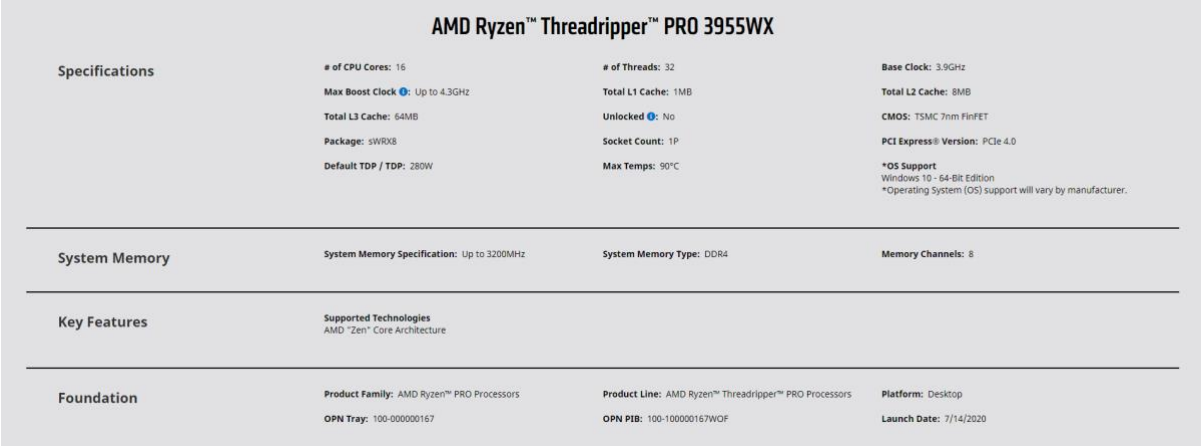
Figure 3: Consumer Trace

4.2 Research & Development

As already explained, UNOVA's blockchain system gives a very robust basis to build up on. However, to come to a closed system and ensure anti-counterfeiting capabilities some extra R&D was necessary. In what follows, both hardware and software R&D done is explained. Concerning the hardware, the devices eventually bought are also stated.

4.2.1 Hardware research & devices bought

For the **server** to have the right capabilities, several choices needed to be made for the different components. First of all, a suitable processor needed to be selected. Based on the number of cores required (16), the Intel Xeon series, AMD EPYC series, and AMD Ryzen Threadripper PRO series were compared based on performance, cost-effectiveness, and availability. According to the research, the AMD Ryzen Threadripper PRO provides the most optimum performance to cost ratio. The processor being released in July 2020, ensures a good performance over the next 5 years, with latest features for enhanced performance. In comparison, Intel's latest processors are highly priced for the same performance. Between AMD EPYC and AMD Ryzen Threadripper PRO, the availability factor played a major role due to the global chip shortage caused by corona. Hence, the AMD Ryzen Threadripper PRO was chosen. The specifications are summarized in Figure 4.



AMD Ryzen™ Threadripper™ PRO 3955WX

Specifications	**# of CPU Cores:** 16	**# of Threads:** 32	**Base Clock:** 3.9GHz
	Max Boost Clock: Up to 4.3GHz	**Total L1 Cache:** 1MB	**Total L2 Cache:** 8MB
	Total L3 Cache: 64MB	**Unlocked:** No	**CMOS:** TSMC 7nm FinFET
	Package: sWRX8	**Socket Count:** 1P	**PCI Express® Version:** PCIe 4.0
	Default TDP / TDP: 280W	**Max Temps:** 90°C	***OS Support** Windows 10 - 64-Bit Edition *Operating System (OS) support will vary by manufacturer.
System Memory	**System Memory Specification:** Up to 3200MHz	**System Memory Type:** DDR4	**Memory Channels:** 8
Key Features	**Supported Technologies** AMD "Zen" Core Architecture		
Foundation	**Product Family:** AMD Ryzen™ PRO Processors	**Product Line:** AMD Ryzen™ Threadripper™ PRO Processors	**Platform:** Desktop
	OPN Tray: 100-000000167	**OPN PIB:** 100-100000167WOF	**Launch Date:** 7/14/2020

Figure 4: AMD Ryzen Threadripper PRO specifications

In deciding the number of cores needed for the processor, two main points were considered:

1. Current deployment of the company node - which is responsible for creating data on the Blockchain and reading data from the blockchain network.
2. Scalability management - for future expansion in the blockchain node and applications.

Keeping in mind the processing power required for the above, and to achieve the desired performance from the server, it was decided that 16 cores were needed.

Next, for the hard drive, 1 TB SSD was chosen, which will be used for the following purposes:

1. Company node (120-150 GB)
2. Database and clustering
3. Operating system
4. Application dependencies (dockers,npm packages,libraries,node js,nvm,nginx server)
5. Redis caching
6. Backup and retention (Backups of databases will be scheduled and stored for disaster management)

Using SSD as compared to HDD ensures shorter wait time, higher performance, and faster data access.

Lastly, the housing and cooling aspects were considered. Assuming there is no existing server rack and taking into consideration the placement of the server, tower housing was selected. The processor cooling fan was chosen, keeping in mind the possible humidity factor and ambient temperatures. It will work well in the temperature range of 5-35 degrees and humidity range of 20-90% (without condensation).

Next, the **scanner** needed to be chosen that would serve the purposes of this project. Based on various key performance indicators such as cost, charge time, sealing, drop tolerance, code capability, and scanning technology, eventually it was decided to opt for the DS36 Zebra series because they present to be the most robust scanners currently on the market that can handle a bump, are easily cleaned, and overall have a good cost to benefit ratio. A list of the devices mainly considered can be found in Appendix 1. Concerning the DS36 Zebra series, the choice needed to be made between the DS3678 ER and the DS3608 SR high performance. The first one is the wireless variant which, because of the ER scan engine, can read bigger bar codes and from a longer distance. Although the

ER scan engine might seem like overkill at first, testing with both made it clear that the far distances from which it can still read bar/QR-codes could potentially save a lot of overhead caused by necessary displacements/movements when using the standard range (SR) scan engine. Next, as the inbound transport registration might happen anywhere on the floor, it wouldn't be advisable to use wired scanners. The trade-off that is being made by using wireless scanners is that this could result in production loss in case the battery of the scanner dies.

For this reason, a station is added where the scanners can be put to charge the batteries. In future stages, a spare charger could be added for the batteries but as the lifetime of the batteries is initially more than 24 hours, this was not added in the current setup. To sum up, the scanner that was bought was the (wireless) DS3678 ER together with a station where it can be put to charge the batteries (see Figure 5).

Figure 5:DS3678 ER scanner with charging station

Thirdly, for selecting the right **scale**, five main criteria were considered:

1. The accuracy
2. The maximum weight amounts
3. Durability and water resistance
4. The size of the scale for ease of use
5. The price of the devices

Generally, there is a trade-off between the maximum weight that can be measured and the accuracy of measuring. However, there is a tool that allows for dynamically scaling the accuracy. This means that the lower the weight of the product you put on the scale, the more accurate it will be. After careful consideration and speaking to multiple providers, the list of options was narrowed down to 3 types of scales (see Figure 6).

Available versions

Code	l x w x h (mm)	Max (kg)	d (g)	M (g)*	M 2R (g)*	d HR (g)*
TSE3-FOOD316	230x330x90	3	0,5	1	--	0,2
TSE6-FOOD316	230x330x90	6	1	2	1-2	0,5
TSE15-FOOD316	230x330x90	15	2	5	2-5	1
TTE6-FOOD316	330x330x90	6	1	2	1-2	0,5
TTE15-FOOD316	330x330x90	15	2	5	2-5	1
TTE30-FOOD316	330x330x90	30	5	10	5-10	2
TQE15-FOOD316	400x400x115	15	2	5	--	1
TQE30-FOOD316	400x400x115	30	5	10	5-10	2
TQE60-FOOD316	400x400x115	60	10	20	10-20	5
TME30-FOOD316	400x500x115	30	5	10	5-10	2
TME60-FOOD316	400x500x115	60	10	20	10-20	5

(*) Divisions obtainable only with the relative options, in combination with Dini Argeo weight indicator.

Figure 6: Scales shortlisted

The size of the three options were narrowed down to ranges from 330x330x90 to 400x500x115. After discussing together with AMPC the accuracy and maximum weighing capability of the scale which should be aimed for at the current stage, it was decided to opt for the TTE15-FOOD316 which is the 15kg maximum weight option with accuracy down to 2 grams already without the additional scaling module. The device comes with a touch screen that holds the computer that is certified for the food industry (see Figure 7). This allows for connecting with the screen or other hardware devices. The scale is made of steel which ensures high durability and is fit for cleaning easily.

Figure 7: Scale setup

Next, multiple options were considered when choosing the **screen** which contains the UI for both registering the inbound transport event and the cutting process to be displayed and steaks created. They can be put into two main categories

1. Android industrial mobile devices
2. Industrial windows touch screen

The android devices are more mobile-focused and show their true benefit in a logistics center where the operator needs to move around to many different locations as they can carry the device. However, the downside is the size of these screens, which make them less user-friendly for someone who needs to stay in one location and do the same process of cutting meat. In addition, linking the other hardware devices to a mobile device would require some more other components making the system less stable.

The industrial windows touchscreens are more robust and fit for placing in one working station. They come with a case and are so strong even sharp knives could do them no damage. These screens are larger, allowing easy access to the information the operator needs, and buttons can be big for easy control. In addition to this, the vast majority of Belgian meat companies use these screens and thus find this the best option.

The option chosen is the 17" Fanless Multi-touch IP65 with Intel Core i5 Processor (see Figure 8) for this demonstration. There is also the IP66 option which is the same in all ways except it is fully waterproof, but this is not needed for the current stage as all other specifications and capabilities are precisely the same, including the way it looks.

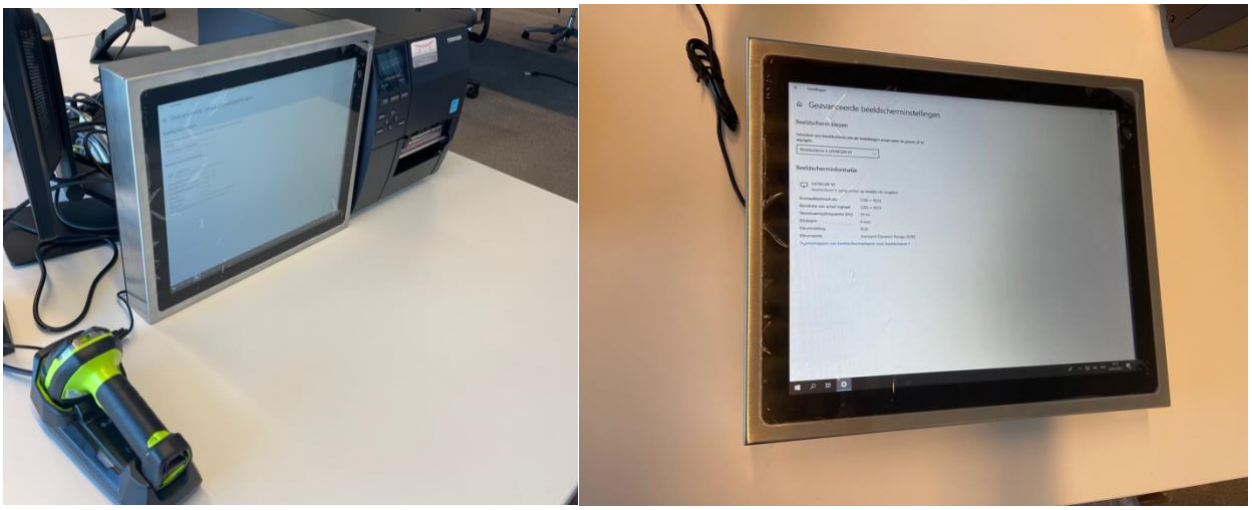


Figure 8: 17" Fanless Multi-touch IP65 with Intel Core i5 Processor

Lastly**,** the main points considered for the printer were print width, print resolution, print speed, and price. The print width and print resolution are two important factors because printing high resolution, big labels with a lot of information/images on forms an extra point of difficulty concerning counterfeiting possibilities as it is harder to copy when compared with small, low-resolution labels. Although the flagging mechanism would flag such copying behavior, making it difficult in the first place already reduces counterfeiting incentives because of the overhead it implicates. Next, the print speed is taken into consideration to avoid that printing the labels would take several seconds and, in doing so, result in significant overhead costs in the long run. Lastly, for obvious reasons, the price to benefits ratio was considered in taking the decision.

Taking all the above into account, the choice was eventually made between an Epson and a Toshiba industrial printer (a complete list of all devices considered can be found in Appendix 2). The main difference between both is that the Epson printer has the capability to print in color. Having labels in color would mean they would be hard to copy, which in his turn would benefit the reduction in counterfeiting incentives, as explained above. However, because the Epson is an inkjet printer, after some time, this would mean that the cartridges will need to be changed, which in the long run will result in a lot of overhead. The possibility exists to print full color, but this would require special media. Taking into account the major overhead the changing of the cartridges would result in and the fact that the labels can be partly preprinted in color so that there is no necessity to use a color printer made the choice go to the Toshiba TEC B-EX4T1 300 dpi NE (see Figure 9). In addition to this, the Toshiba's optional peel off module

was attached, which again lowers the overhead as it literally peels off the labels one by one to make it easier to stick to the package. Although reliability and performance usually translate into a higher price, excellent performance comes as standard with the B-EX series, lowering the initial investment and protecting it for the future.

Figure 9: Toshiba TEC B-EX4T1 300 dpi NE

4.2.2 Development for hardware setup

Before moving to the development part, a quick overview is given of all devices (see Figure 10) after which the purpose of each device in the current setting is repeated.

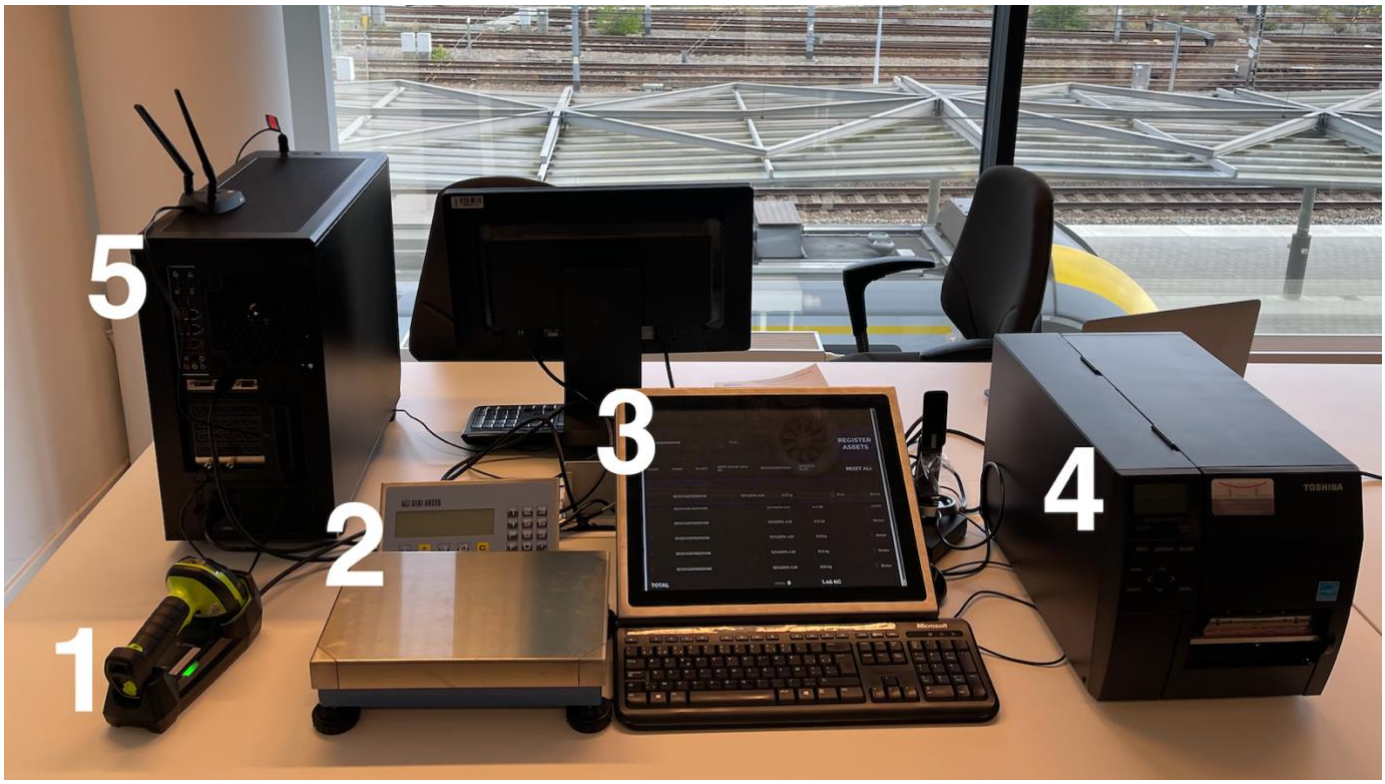


Figure 10: Overview devices

Device	Purpose
1. Scanner	Registering the inbound transport or the start of the cutting of a primal, the output of which will be displayed in the user interface of the application running on the screen.
2. Scale	Once a steak is cut, it is put on a scale that is linked to the screen where the weight will be displayed.
3. Screen	Creation of the inbound transport event of a primal on the system. Creation of the unique digital identities of the steaks originating from the scanned primal on the system. Data layer and application layer of the peripherals – which is responsible for communication with the different devices, and reading the relevant data.
4. Printer	Printing corresponding labels for the real steaks.
5. Server	Host the company node - which is responsible for creating data on the blockchain and reading data from the blockchain network.

In what follows, the necessary development activities performed for the hardware setup are explained for each of the devices.

4.2.2.1 Scanner

Essentially the scanner is a plug and play device, but the existing SDK did not provide the functionality required. Default behavior of the scanner expects an input box in the frontend with focus on that input. When a barcode is scanned, the data is then populated in the field with the focus. There are two issues with this

1. the user must ensure that the focus is always on the intended input field. If not, the user must first click on the field and then scan the barcode which unnecessarily adds to processing time.
2. there is a possibility of the input of the scanner being tampered with because it gets populated in an input box which is editable.

To avoid the above issues, a label (non editable) instead of an input text field was used where the data from the scanner would be populated. As this functionality was not available by default in the scanner SDK, a new code was developed using front end libraries[1] instead of scanner SDK, which populates the data from the scanner in a label field on the screen.

4.2.2.2 Scale

The scale communicates with the port to which it is connected on the panel PC. Before transmitting data to the port, the scale waits for a particular event to be triggered, which in this case is stabilization of weight. This means that the scale will not continuously transmit all the data changes happening on it (weight increasing from 0 to x kg, moving the piece being weighed, manual physical contact/pressure, weight decreasing from x kg to 0). As we are processing only the stable weight of the piece, making this setting saves resources. This data is then read by the backend application and pushed to the JMS queue which is described as below.

To ensure continuous and reliable communication between the weighing scale and the application running on the screen, the concept of JMS (Java Messaging Service) broker is used. The JMS acts as a bridge between two or more applications and facilitates the sending and receiving of messages. Its three main components are producer,

[1] https://www.npmjs.com/package/react-barcode-reader

queue, consumer. JMS also ensures there is no data loss during these communications, as the data is always available in the queue until it is consumed.

The queue works in the FIFO fashion. Each data entry (weights of the pieces being processed) received from the weighing scale will be pushed to the queue in a specific chronological order.

The queue data can be consumed by one or more applications, but each application consumes each data point only once. The consumer part is elaborated on in the screen section below.

4.2.2.3 Screen

The weighing scale is connected to the screen through a serial port. In order to establish the communication between the weighing scale and the screen, three files need to be saved on the screen at specific paths. They are listed as below:

1. Path : C:\Program Files (x86)\Java\jre1.8.0_301\lib\ext
   File Name : comm-2.0.jar
2. Path : C:\Program Files (x86)\Java\jre1.8.0_301\lib
   File Name : javax.comm.properties
3. Path : C:\Program Files (x86)\Java\jre1.8.0_301\bin
   File Name : win32com.dll

A JAVA application[2] has also been developed which then sends the data from the above communication to the JMS to be consumed by the front end.

As mentioned earlier, the consumer/subscriber is the last component in JMS. The consumer can be one or more applications which pull the messages in the queue and consumes them. The messages are pulled one at a time and the application can decide how to process these messages.

The application on the screen works as a consumer. It reads the queue, receives the message, and populates it in the frontend. The benefit of the FIFO mechanism here is that each piece will be associated with a unique ID after weighing. Hence it is important for the queue to maintain the order to avoid cross assignment of weights. In order to ensure data consistency and reception in the front end, by maintaining one queue and one consumer, a jar file[3] was created. Whenever a page is loaded this jar file is executed and the old queue and consumers are deleted, and a fresh consumer is created along with a new queue. As a result, there is only one consumer per queue so the active page will get all the weighing machine data consistently.

Next, an API is developed to create unique IDs, generate[4] QR codes and send these to the printer to be printed[5]. This API follows the GS1-GTIN13 and creates a unique ID for each new piece which is populated on the screen once the stable weight is received for that piece. The API then calls a function for generating a QR code. This function takes the unique ID as an input, concatenates it with the link of the consumer product and links this with a QR code. Hence when this QR code is scanned, it will open the consumer dashboard of the asset with the relevant information on that particular piece (unique ID). The QR code generated by this function is stored locally until it is

[2] apache-activemq-4.1.1.jar
javax.jms.jar

[3] DeleteQueue.jar

[4] https://www.npmjs.com/package/qrcode (QR generation library used)

[5] https://www.npmjs.com/package/pdf-to-printer (printing library used)

printed, after which it is deleted from the system. Another function which is a part of this API enables the printing of the above mentioned QR code. The function gets the path of the QR code as input and triggers the print command on the generation of the QR code.

4.2.2.4 Printer

The main activities for setting up the printer was to setup the correct printing preferences (see Figure 11) to be able to use the peel-off module (physically) installed in the printer in a correct manner. With these settings, the printer does not print the queue continuously but instead waits to print the next label until the previous one has been peeled off (see Figure 11).

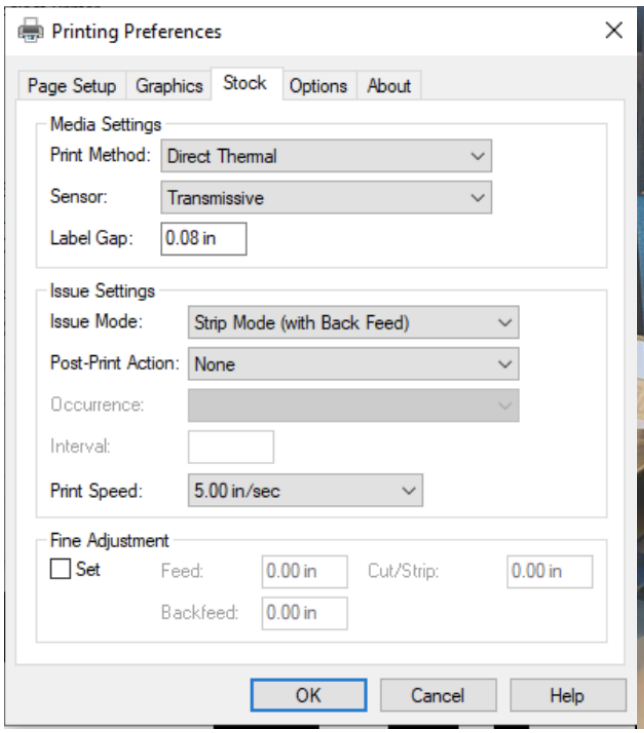


Figure 11: Printing preferences

Figure 12: Peel-off module

It was suggested by AMPC to only print the generated QR codes in the current phase. However, some initial designs of the labels that will be put on the packages in the next phase have already been designed (see Figure 13)

Figure 13: Label designs

As already explained earlier printing high resolution, big labels with a lot of information/images on forms an extra point of difficulty concerning counterfeiting possibilities as it is harder to copy when compared with small, low-resolution labels. Although the flagging mechanism would flag such copying behaviour, making it difficult in the first place already reduces counterfeiting incentives because of the overhead it implicates in combination with the risk of getting caught.

4.2.2.5 Server

First of all, Ubuntu was installed as the operating system for following reasons:

Reason	Explanation
1. Cost	Ubuntu is free and open source which means we do not bear any licencing costs.
2. Customization	It is highly customizable, and many other open-source applications have built in integrations. Programmers can modify Linux servers and software “on the fly” and without rebooting.
3. Security	As compared to windows, Ubuntu is more secure. The simple reason being, Windows has a larger personal user base and hence the chances of people writing malicious software for it is greater. The users also have controlled admin privileges which puts a check on any malicious software being installed.
4. Ease of application deployment & resourcing	Ubuntu is deployment friendly as dockers and applications can run in a secure way. Linux servers and the applications they run generally use fewer computer resources as they are designed to run in a lean fashion. The Linux distros also have different inherent package management tools for example apt for Debian, yum for Red Hat, emerge for gentoo. The biggest difference to Windows deployment lies where the environment and package format are more

	standardised, even if deployment systems vary for example SCCM, Altiris, LANDesk, Citrix, Kubernetes etc. Ubuntu makes it very easy to use them deployment wise.
5. OS and application updates	It is easier to install and manage updates on the Ubuntu server. All the applications can be updated together, along with the OS, as opposed to Windows, where each application needs to be updated individually. There are no forced updates and no automatic reboots after updates in Ubuntu, ensuring high availability of the system.

Next, the company node was installed using the Node Onboarding Package (NOP). In the table below all steps to launch the company node are explained

Step	Explanation
1. Launch a wallet	An important step before the node can be installed is to setup a wallet. This wallet has a pair of public and private keys associated with it, which are necessary while setting up the node.
2. Launch an instance	A cloud or on-premise server is setup which will host the node.
3. Whitelisting of node	The public key of the wallet which will be associated with the wallet as well as the node is shared with UNOVA. UNOVA will then whitelist this node and allow it to join UNOVA's blockchain network
4. Launching the company node	Installation of all the applications necessary to run the node is done in this step through following command line: export WEB3_NODE_PRIVATEKEY=*private key of your wallet* NODE_URL= *IP of your instance* email=*your email address* FIRST_NAME=your first name LAST_NAME=*your last name* NETWORK= *the network you want to onboard the node on (test/main*) && source <(curl -s http://setup.unova.io/nop/auto-launch.sh)

Next, it was checked whether the node was properly installed and running through following commands

Purpose	Command
1. check status of docker	cd /home/$USER/unova-nop ($USER = user that installs the NOP) docker ps
2. check node health	cd /home/$USER/unova-nop ($USER = user that installs the NOP) Sh status-node.sh

4.2.3 Software development

Before moving to the development part, a quick overview is given of the purpose of the various software applications where development was needed.

Application	Purpose
1. Application on the screen	(digital) asset or event creations and the monitoring of the already created (digital) assets or events
2. Settings page	Allow suppliers to set a soft and hard maximum on the number of steaks that can be created out of a specific primal
3. Counterfeit flagging module	Notify the suppliers on counterfeit behavior
4. Consumer trace dashboard	allows the consumer to scan a QR-code/barcode on a physical product and get access to full traceability and transparency data. An additional capability that is needed to be built on top of the existing application is that the probability of a particular steak being counterfeit needs to be communicated to the end consumer.

In what follows, the necessary software development activities performed are explained for the application on the screen, settings page, counterfeit flagging module, and consumer trace dashboard.

4.2.3.1 Application on the screen

After having implemented a first version of the application on the screen, the colors used (see Figure 14: First version of application on the screen Figure 14) could be considered too bright by the operational people working on the floor. As they will eventually be the ones working with the screen, the decision was made to change the design using darker colors so that working with the screen would not be considered tiresome for the eyes (see Figure 14: First version of application on the screen Figure 14).

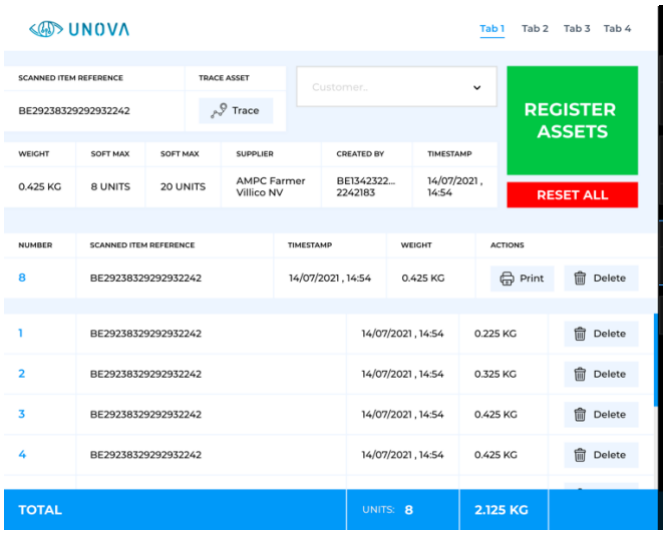


Figure 14: First version of application on the screen

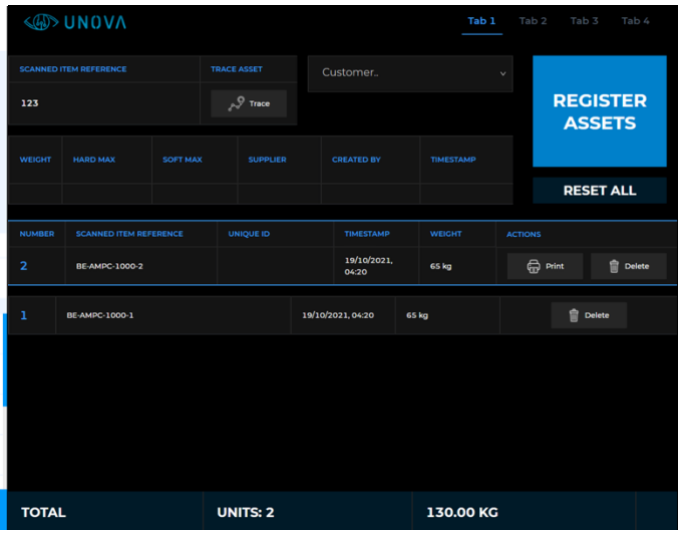


Figure 14: Modified version of application on the screen

Moving on, all development activities performed are explained by going through the complete flow of the application. First, a very simple login screen is developed for the application as can be seen in Figure 15. The people on the floor can then login very easily by scanning a QR-code provided which was created using the production facility private key (each facility will have its own private and public key assigned to it which is in a lower hierarchy and is linked to the node owner's keys). The login screen was created because of several reasons including user management, security authorization, and data creation which requires the facility's private key. By providing the private key when logging in, the data creation can happen smoothly during each session without having to provide it again manually each time data is created.

Figure 15: Login

Next, a simple page is developed for the user to choose whether he wants to register (inbound) transports or Assets (creation) by simple clicking on the corresponding box on the screen.

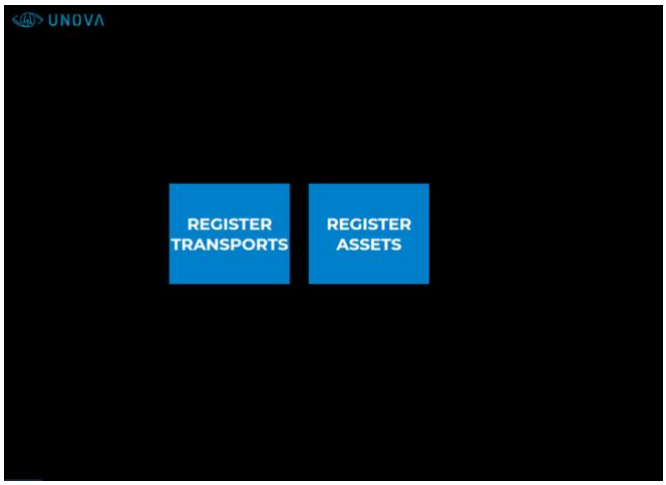


Figure 16: Register transports/assets

The page developed for registering transports can be seen in Figure 17. The development activities will be explained by giving a functionality overview of all components in the table below.

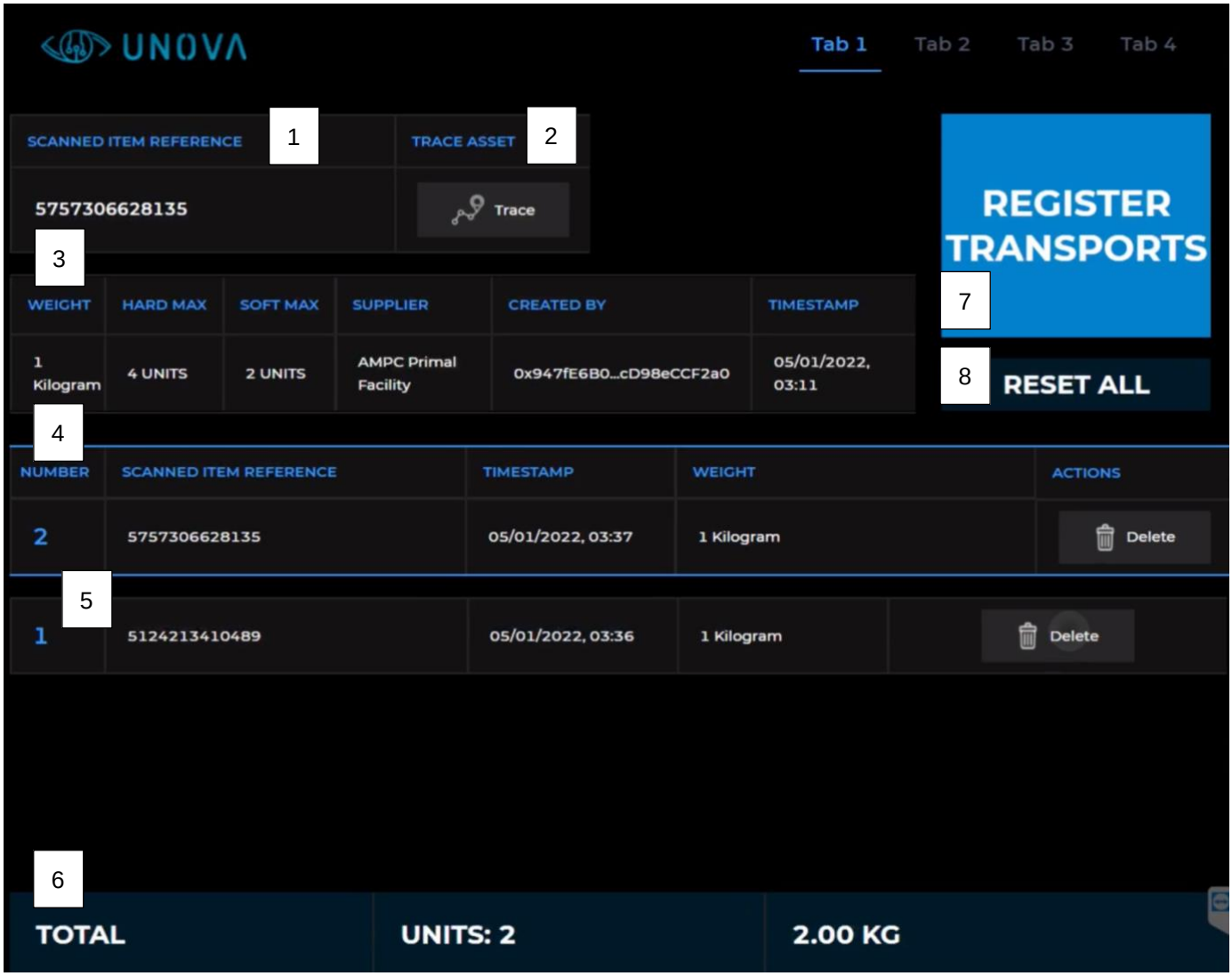


Figure 17: Register transports

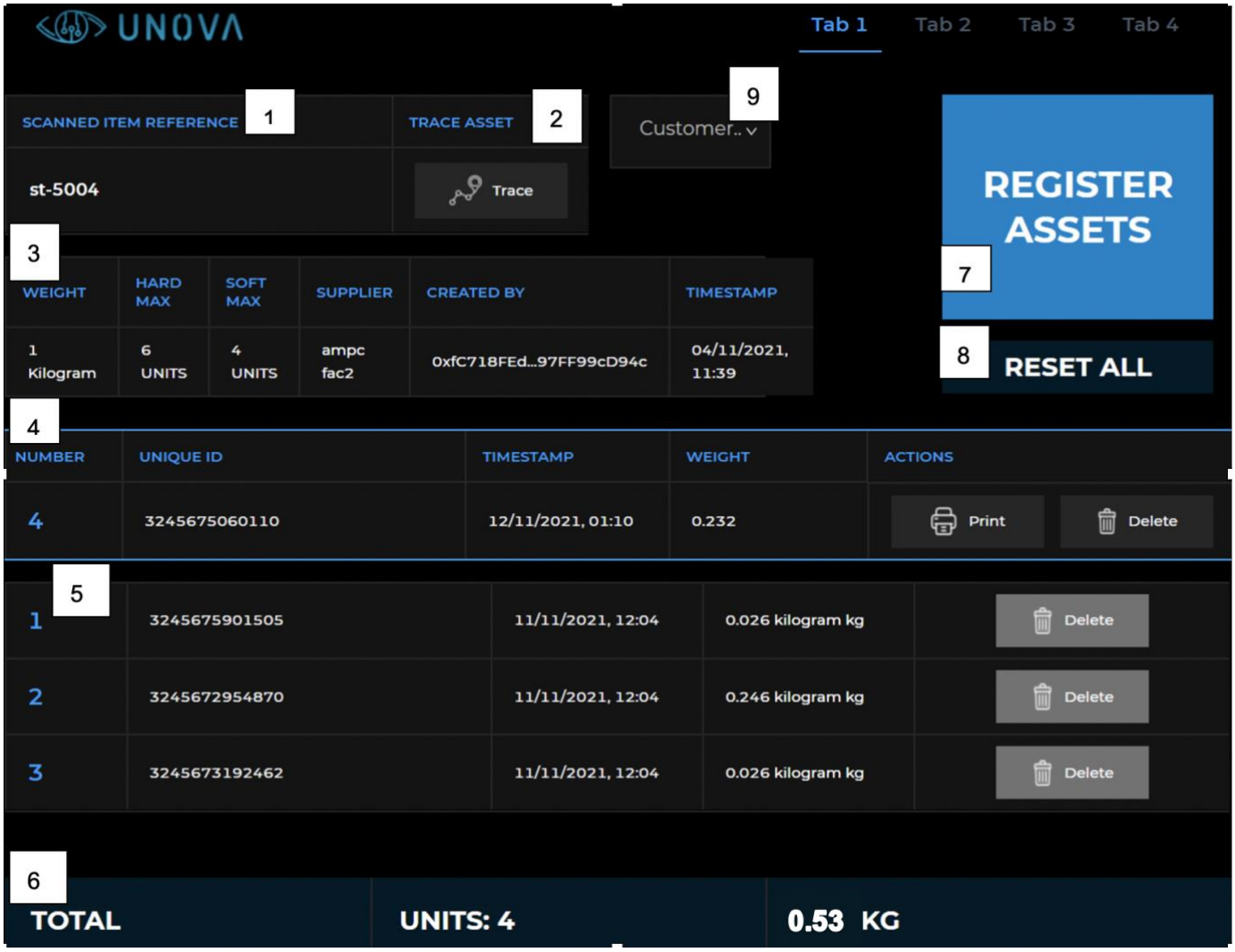
Component	Functionality
1. Scanned item reference	When scanning a barcode/QR-code label attached to the primal piece the user wants to inbound, the unique ID of that piece will appear here.
2. Trace asset	Clicking on “trace asset” will bring the user to the Unova Trace Dashboard where the user can see the complete journey of the scanned item (including the journey of the pieces it originates from, the journey those pieces originate from and so on until the commission piece)
3. Information boxes	6 boxes (from left to right) giving information on the scanned item reference. **Weight** = Weight of the scanned piece. **Soft max** = Soft maximum of the scanned piece. This number is set by the supplier as the number of steaks expected to be created out of the primal. It will be allowed to create more pieces than the soft max. However, this will be

	flagged as a strange situation. The soft maximum provided for a particular primal can be Absolute or Relative. An absolute soft maximum of 5 for example means the supplier expects that 5 pieces will be created out of the primal. A Relative soft max of 5 on the other hand means the supplier expects that per kilogram primal, 5 pieces will be created. Hence, if the primal weighs 15kg, it is expected that a total of 75 (⌈15x5⌉)[6] pieces will be created out of that primal. **Hard max** = Hard maximum of the scanned piece. The hard max set by the supplier as the maximum number of steaks it is allowed to create out of that primal. Also the Hard maximum provided for a particular primal can be Absolute or Relative following the same logic as explained for the soft maximum. **Supplier** = Company name of the supplier of the scanned piece. **Created by** = Public Key of the supplier of the scanned piece. **Timestamp** = Creation timestamp of the scanned piece.
4. Active piece	The active piece is the piece which was lastly scanned. From left to right following information is given **Number** = Indicates which number of piece it is. **Scanned item reference** = Unique ID of the scanned piece. **Timestamp** = Timestamp of scan. **Weight** = Weight of the scanned piece. **Action** = Allows for deleting and redoing the scan for when a mistake has happened. Although a lot of this information is already shown above (as explained under point 3), having the active piece highlighted and in the middle of the page is very useful for the users to allow them to swiftly correct mistakes. For example the user can very easily delete the last scan without having to search for it in the list of processed pieces.
5. Processed pieces	Once there is an active piece and a scan happens, the active piece goes down in the list of processed pieces and the newly scanned piece becomes active.

[6] ⌈x⌉ is a ceiling function which maps x to the least integer greater than or equal to x. The Purpose of the ceiling function can be seen when looking at following example: when a relative hard max of 3 has been set on a certain primal and that primal weighs 10,3 kg, the calculation of the number of steaks allowed to be created (without the ceiling function) results in 30,9 (3x10,3) steaks. Blocking the creation of more than 30 steaks would then result in wastage of meat and hence the ceiling function which allows to create 31 steaks.

	The same information is shown for the processed pieces as explained above for the active piece.
6. Total	Counts total pieces scanned and total weight of scanned pieces.
7. Register	Clicking on the register button creates the inbound event on the scanned pieces on the local node after which the event gets bundled and distributed through the blockchain to the other relevant company nodes.
8. Reset	Clicking on the reset button allows for deleting all scans and redoing everything. Useful for when the user has made a mistake from the start as he does not have to go and delete all scans one by one.

Finally, by clicking on the register assets button (see Figure 16) one will reach the page developed for the creation of the smaller pieces on the system. Although the page looks very similar to the register transport page explained earlier, functionality wise there are some differences. The development activities will be explained by giving a functionality overview of all components in the table below.



Component	Functionality

1.	Scanned item reference	When scanning a barcode/QR-code label attached to the primal, the unique ID of that primal will appear here. Later when creating the smaller pieces, the link (reference) will be made with this unique ID so that the system knows that the smaller pieces originate from this piece.
2.	Trace asset	Clicking on “trace asset” will bring the user to the Unova Trace Dashboard where the user can see the complete journey of the scanned item (including the journey of the pieces it originates from, the journey those pieces originate from and so on until the commission piece)
3.	Information boxes	6 boxes (from left to right) giving information on the scanned item reference. **Weight** = Weight of the scanned piece. **Soft max** = Soft maximum of the scanned piece. As already explained, this number is set by the supplier as the number of steaks expected to be created out of a primal. It will be allowed to create more pieces than the soft max. However, this will be flagged as a strange situation. The soft maximum provided for a particular primal can be Absolute or Relative. An absolute soft maximum of 5 for example means the supplier expects that 5 pieces will be created out of the primal. A Relative soft max of 5 on the other hand means the supplier expects that per kilogram primal, 5 pieces will be created. Hence, if the primal weighs 15kg, it is expected that a total of 75 ($\lceil 15x5 \rceil$)[7] pieces will be created out of that primal. **Hard max** = Hard maximum of the scanned piece. As already explained, the hard max set by the supplier is the maximum number of steaks it is allowed to create out of that primal. The Hard maximum provided for a particular primal can also be Absolute or Relative following the same logic as explained for the soft maximum. **Supplier** = Company name of the supplier of the scanned piece. **Created by** = Public Key of the supplier of the scanned piece. **Timestamp** = Creation timestamp of the scanned piece.
4.	Active piece	The active piece is the piece which was lastly weighed (=physically created). From left to right following information is given on the active piece

[7] $\lceil x \rceil$ is a ceiling function which maps x to the least integer greater than or equal to x. The Purpose of the ceiling function can be seen when looking at following example: when a relative hard max of 3 has been set on a certain primal and that primal weighs 10,3 kg, the calculation of the number of steaks allowed to be created (without the ceiling function) results in 30,9 (3x10,3) steaks. Blocking the creation of more than 30 steaks would then result in wastage of meat and hence the ceiling function which allows to create 31 steaks.

		Number = Indicates which number of piece it is. **Unique ID** = Autogenerated Unique ID following GS1 standard for the smaller pieces. **Timestamp** = Timestamp of weighing (=physical creation). **Weight** = Weight of the smaller piece. **Action** = Allows for deleting and redoing the displayed asset when a mistake has happened. This can only be done before an asset has been bundled and distributed. After that has happened this will no longer be possible.
5.	Processed pieces	Once there is an active piece and a weighing happens, the active piece goes down in the list of processed pieces and the newly weighed piece becomes active. The same information is shown for the processed pieces as explained above for the active piece.
6.	Total	Counts total pieces displayed and total weight of the displayed pieces.
7.	Register	Clicking on the register button creates the (digital) steaks on the local node after which it gets bundled and distributed through the blockchain to the other relevant company nodes.
8.	Reset	Clicking on the reset button allows for deleting all displayed assets and redoing everything. Useful for when the user has made a mistake from the start as he does not have to go and delete all displayed assets one by one.
9.	Customer dropdown	The customer dropdown will in the future display a list of all customers. This will allow for printing custom labels for different customers. For the current phase this will not be used but it is a nice to have as basis for the next phase.

4.2.3.2 Settings page

The anti-counterfeit settings module's design proposal shows how suppliers can set a soft and hard maximum (absolute or relative) on the number of steaks that can be created out of a specific primal (see Figure 18).

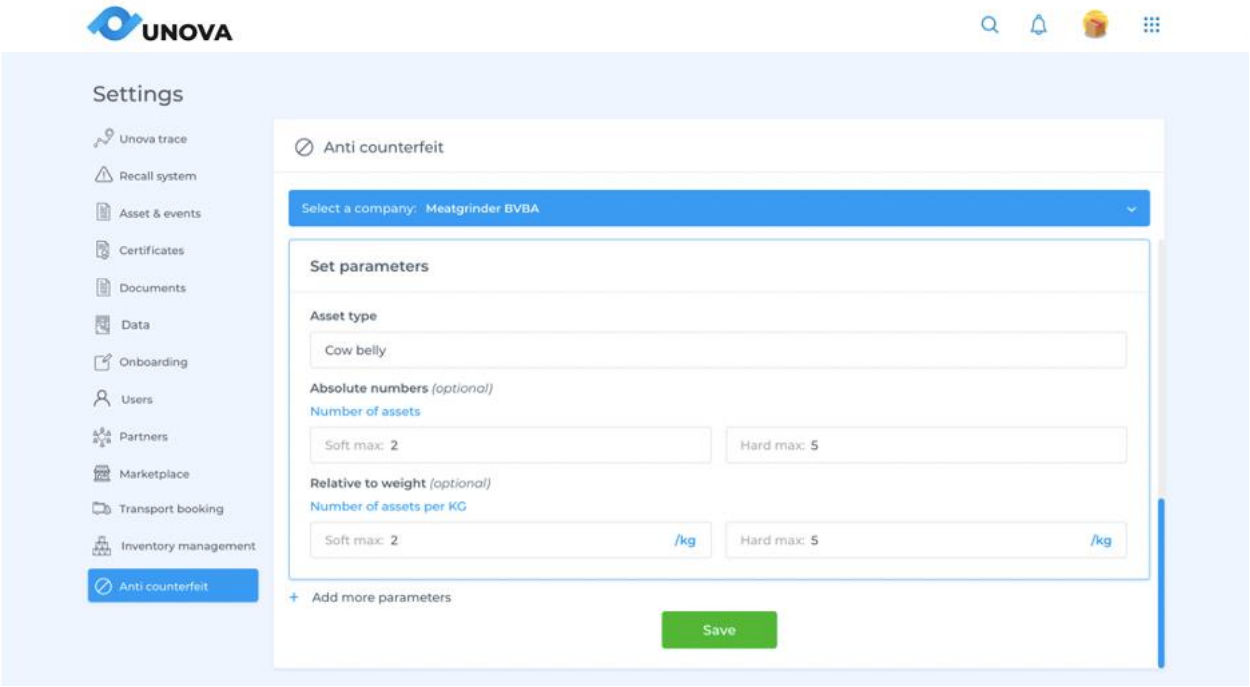


Figure 18: Anti-counterfeit settings module (design proposal)

It was however decided to not yet develop it in the current stage since the added value is low in the current (demo) phase. Instead of setting the parameters through the interface, during this stage a company can directly do it through the request body during the API implementation.

4.2.3.3 Counterfeit flagging module

As already explained, the counterfeit flagging module will notify the suppliers of the meat on possible counterfeit behaviour. For doing this, multiple scripts have been written that run periodically inside the company's own node[8] and monitor the customers validated and distributed data for counterfeiting behaviour based on certain conditions. This policing mechanism first ensures that the monitoring happens on created and validated data and secondly results in better performance of the module speed wise as the calculations don't have to happen on the fly.

The causes for flagging could be multiple and are best explained using the timeline in Figure 19.

[8] This is a trustless infrastructure where you don't need to host a central authority to monitor as each node has the monitoring software built in and it is hosted by each company following web3 principles.

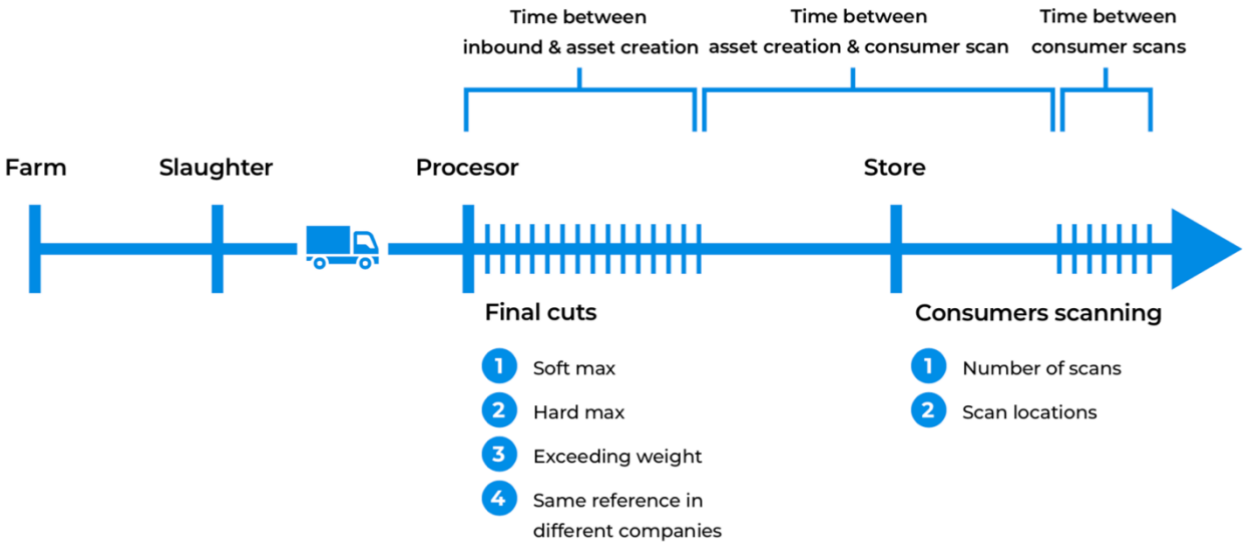


Figure 19: Timeline on when counterfeiting can be spotted

A first point where strange behavior can be spotted is by comparing the moment of arrival of a primal in a cutting facility with the creation time of the final cuts. If the time between the two events is unreasonably long, this will be notified as possible counterfeiting behavior. AMPC communicated that in normal circumstances, this should not take any longer than 14 days.

Next, there are multiple points of monitoring with respect to the creation of the final cuts. Firstly, there is the mechanism of the soft max set by the supplier as the number of steaks expected to be created out of a primal. As already explained, it is allowed to create more steaks than the soft max, but the supplier will be notified in such case. Secondly, there is the hard max as set by the supplier as the maximum number of steaks it is allowed to create out of a primal. As already explained, the system won't allow to create more steaks than the hard max. The same goes for cases where the steaks' weight would exceed the primal's weight, this will be blocked from happening. Lastly, whenever the same reference scan happens for cutting inside different companies, this would mean that the same primal with the same unique ID has arrived in other cutting facilities of different companies. Such case is only possible whenever one of them is a counterfeit primal having a copied label of a real valid asset.

The next point in time on which basis flagging could happen is at the moment of the scan of the steak by the end consumer at the retailer. Considering the relatively low preservability of meat, the time between the creation of the steak and the moment of scanning should not be unreasonably long. If, for example the time considered is several months, a high probability exists that earlier, the label was copied and put on a counterfeit piece. In addition to this, the number of scans of a particular steak also plays a significant role in spotting counterfeit pieces. One can namely consider 4 scans to be reasonable before someone buying the particular piece and hence the piece leaving the shelf at the retailer. However, 100 scans could indicate that a label has been copied and applied to multiple counterfeit pieces, which is the reason for the excessive number of scans. On top of that, if the time between the different consumer scans is unreasonably long, this points towards the possibility that earlier a label has been copied and later applied to a counterfeit piece. Lastly, if scanning a particular steak happens to be in multiple locations at different retailers, this proves that a label has been copied and applied to more than one piece, which in turn shows that multiple counterfeit pieces exist of an authentic, valid steak.

In what follows, all development activities performed in developing the module are explained by going through the complete flow of the application.

The landing page of the module can be seen in Figure 21 and Figure 22 where a list of all customer companies can be seen together with detailed information on counterfeiting behaviour explained in the functionality overview table below.

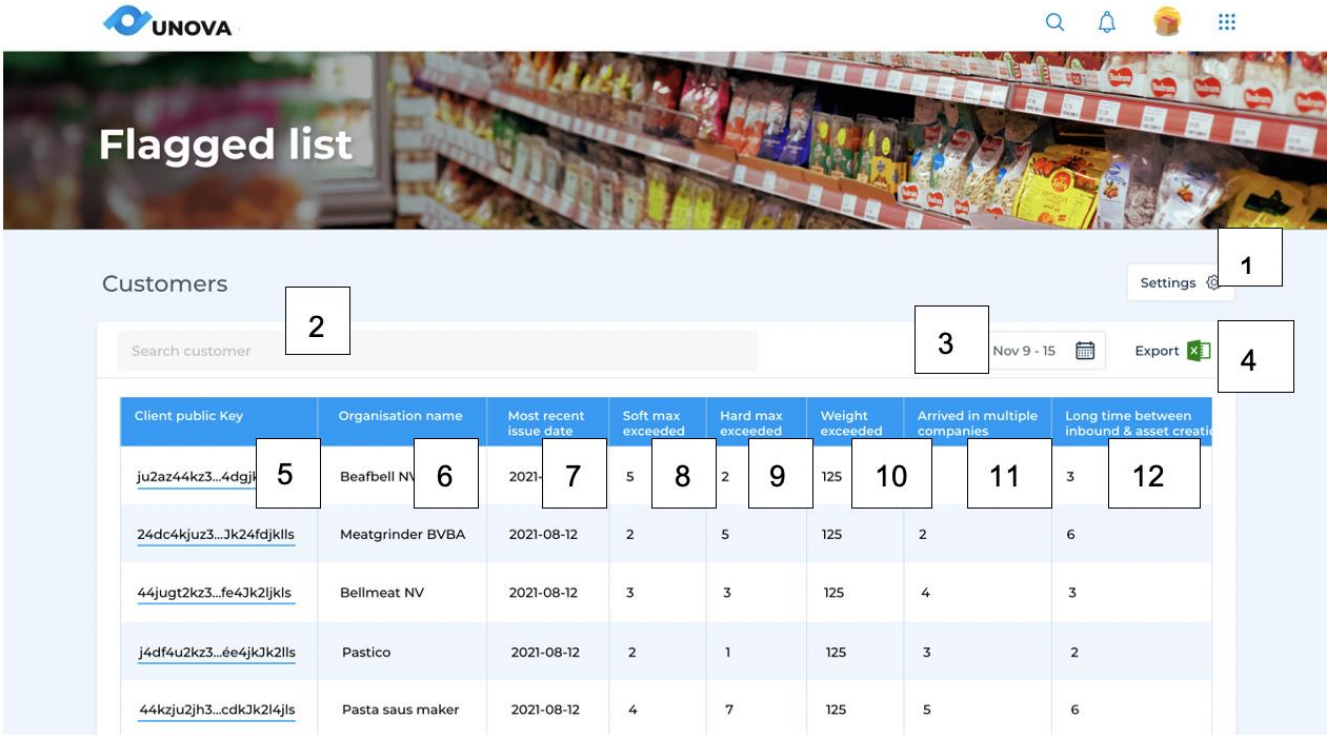


Figure 21: Landing page counterfeit flagging (pt1)

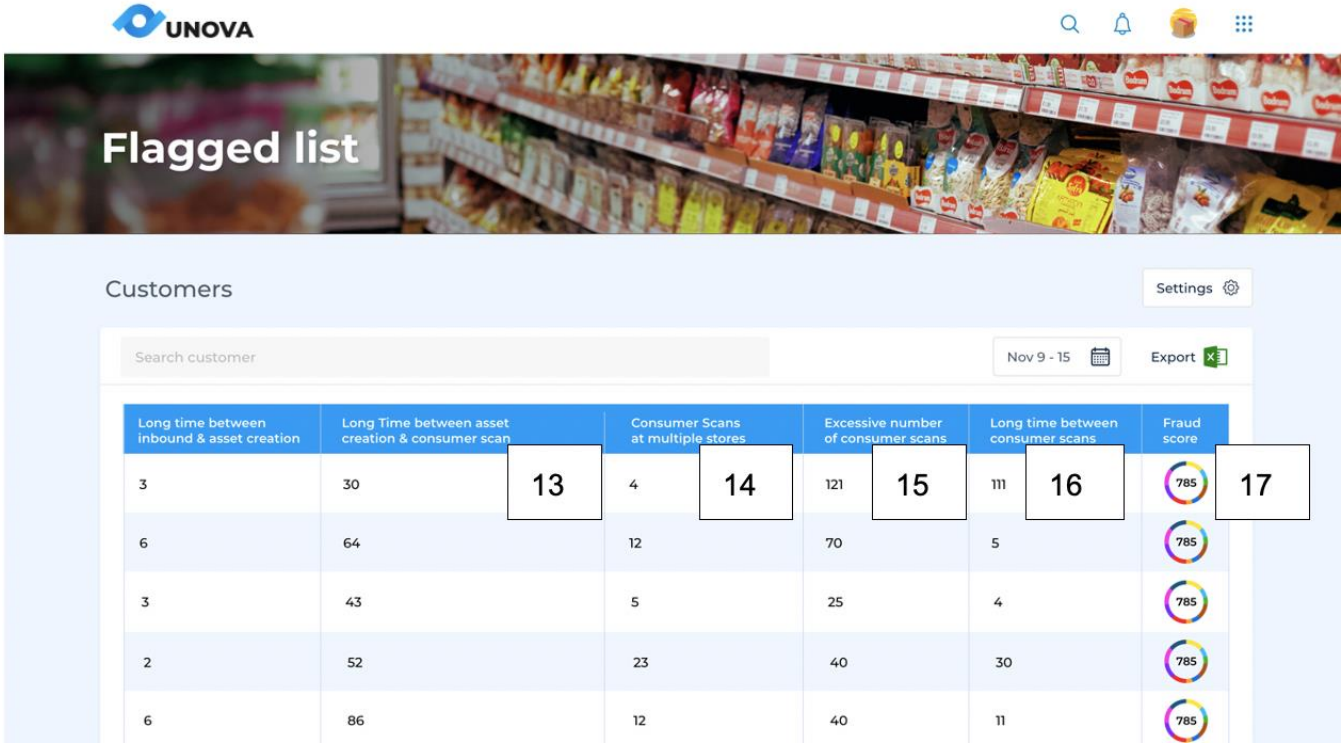


Figure 22: Landing page counterfeit flagging (pt2)

Component	Functionality
1. Settings	Link to the settings page as described above under 4.2.3.2 settings page.
2. Search	Allows for searching a particular customer (on organization name).
3. Date filter	Allows for filtering the list of customers to show only the customers with a most recent issue date within the period chosen.
4. Export to excel	Allows for exporting the list of customers together with all details to excel.
5. Client public Key	Public Key of the customer
6. Organisation name	Organization name of the customer
7. Most recent issue date	Most recent date on which a flagging has happened for a particular customer.
8. Soft max exceeded	Total amount by which this customer has exceeded the soft max considering all primals processed by this customer.
9. Hard max exceeded	Total amount by which this customer has exceeded the hard max considering all primals processed by this customer.
10. Weight exceeded	Total weight (in kg) by which the pieces created by this customer exceed the weight of the primals they originated from, considering all primals processed by this customer.
11. Arrived in multiple companies	Total number of primals processed by this customer that are not only referenced/processed by this customer.
12. Long time between inbound and asset creation	Total amount of time (in hours) that the time between inbound and asset creation has exceeded 15 days, considering all primals processed by this customer.
13. Long time between asset creation and consumer scan	Total amount of time (in hours) that the time between asset creation and consumer scan has exceeded 7 days, considering all steaks created by this customer.
14. Consumer scans at multiple stores	Total number of excess stores (hence more than 1) a steak created by this customer was scanned at, considering all steaks created by this customer.
15. Excessive number of consumer scans	Total number of excessive (more than 4) consumer scans of a steak, considering all steaks created by this customer.

16.	Long time between consumer scans	Total amount of time (in hours) the time between consumer scans has exceeded 5 days, considering all steaks created by this customer.
17.	Company fraud score	Calculated fraud score for the company based on above criteria where different weight is attached to different criteria. The circle diagram reflects which criteria is responsible for which proportion of the total fraud score.

Points 8 - 12 will be monitored by the various scripts that run inside the company's own node and flag off possible counterfeit assets. When the monitoring of these criteria results in flagging, fraud score points will be added to the primal. The reason is that for these criteria it is not possible to pinpoint one particular steak which has a high probability of being counterfeit on the contrary all steaks originating from the primal have an equal contribution to the counterfeiting behaviour. For example, consider a primal with soft maximum equal to ten. If a customer then creates an eleventh steak out of that primal, it wouldn't be fair to allocate fraud score points only to the eleventh piece as all ten pieces created before have an equal contribution in arriving at that eleventh piece. Hence, the fraud score points are added to the primal and in doing so form the base score for all steaks resulting from that primal.

Points 13 - 16 will be monitored by capturing consumer data. When the monitoring of these criteria results in flagging, fraud score points will be added to the steaks. Here, it is possible to pinpoint one particular steak which has a high probability of being counterfeit. For example, when there are excessive number of consumer scans, these scans happen on one particular steak which means the probability of a QR-code being copied of that particular steak and applied to multiple steaks is high. Hence, the fraud score points are added to the steak and in doing so have an individual contribution to the total primal fraud score (= fraud score attached to primal + fraud score attached to all steaks originating from the primal).

A customer company's fraud score is then an aggregate of all total primal fraud scores it has created steaks from (=fraud score attached to all primals the company has created steaks from + fraud score attached to all steaks originating from those primals). A detailed description of the scoring mechanism as such and the weights attached to the various criteria is given further in this section.

Next, by clicking on a company the user can go to the company page (see Figure 20 and Figure 21and) where he can see more detailed risk results of a certain company. An in-depth explanation of all components is given in the functionality overview table below.

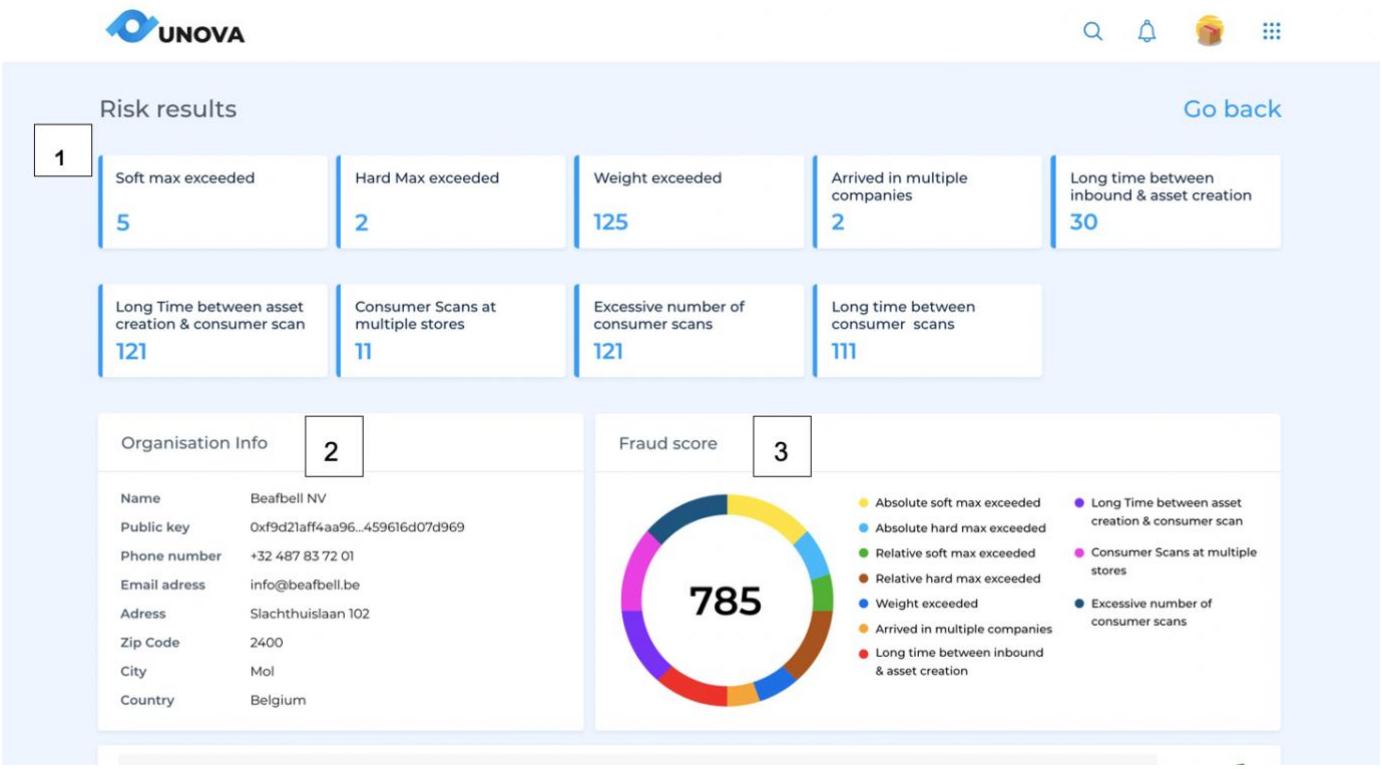


Figure 20: Company page counterfeit flagging (pt1)

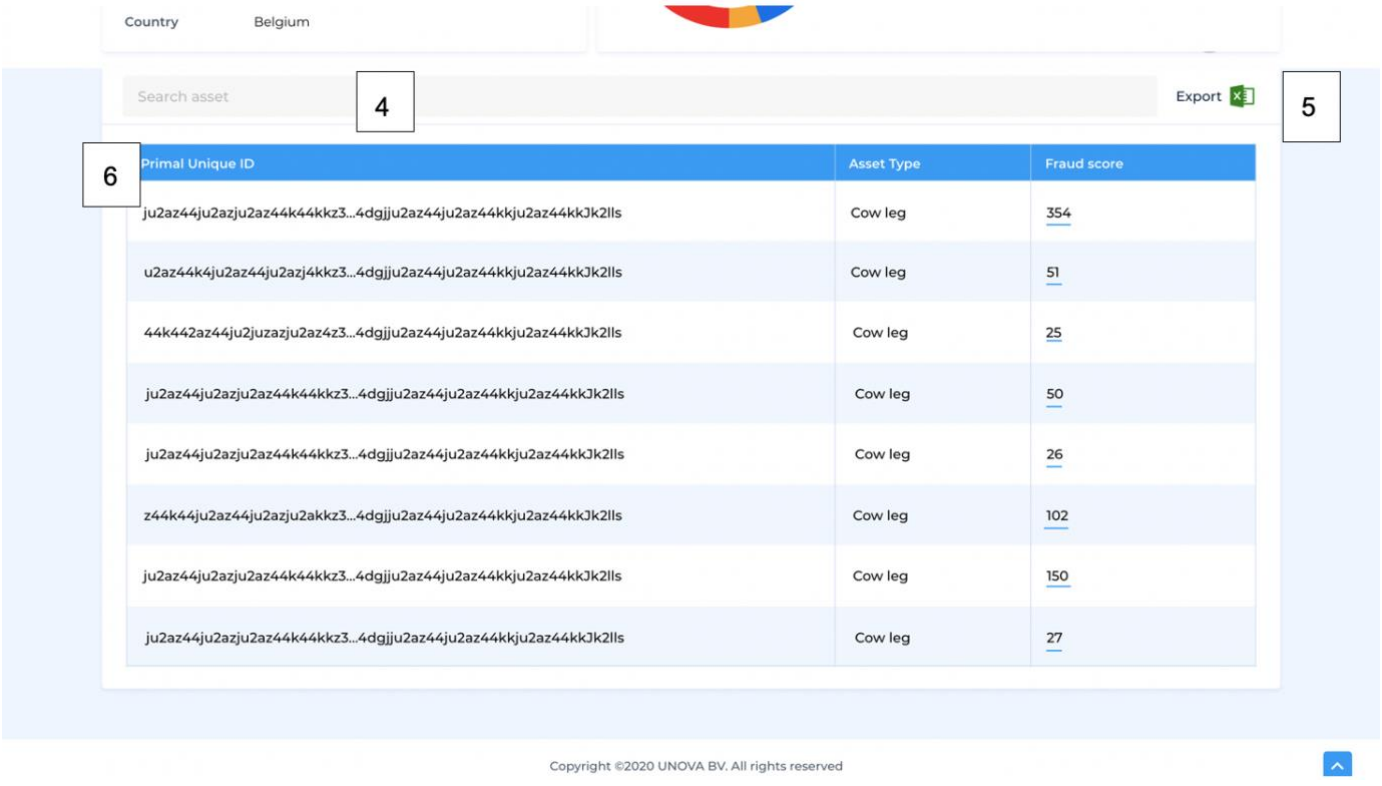


Figure 21: Company page counterfeit flagging (pt2)

Component	Functionality
1. Criteria boxes	Overview of 9 criteria boxes that are being monitored as explained in the former table (points 8 – 16).
2. Organisation info	Displays the customer's company information.
3. Fraud score	Calculated company fraud score based on above criteria where different weight is attached to different criteria. The circle diagram reflects which criteria is responsible for which proportion of the total fraud score.
4. Search	Allows for searching a particular primal (on unique ID).
5. Export to excel	Allows for exporting the list of primals together with all details to excel.
6. Primal table	Gives a list of all primals out of which the selected customer has created steaks together with the asset Type of the primal and the total primal fraud score (= fraud score attached to primal + fraud score attached to all steaks originating from the primal).

Next, by clicking on a primal the user can go to the primal page (see Figure 22, Figure 23 & Figure 24) where more details can be seen on the risk result of a certain primal. An in-depth explanation of all components is given in the functionality overview table below.

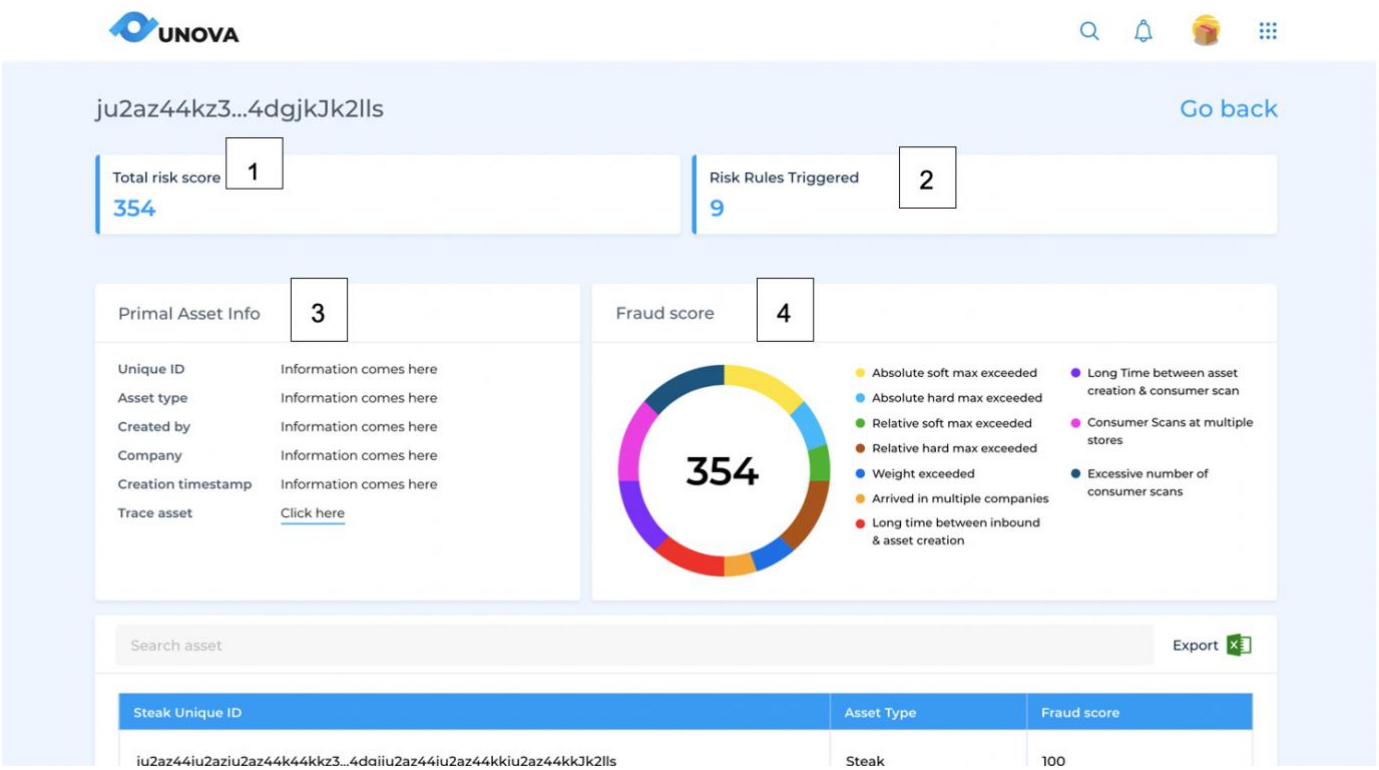


Figure 22: Primal page counterfeit flagging (pt1)

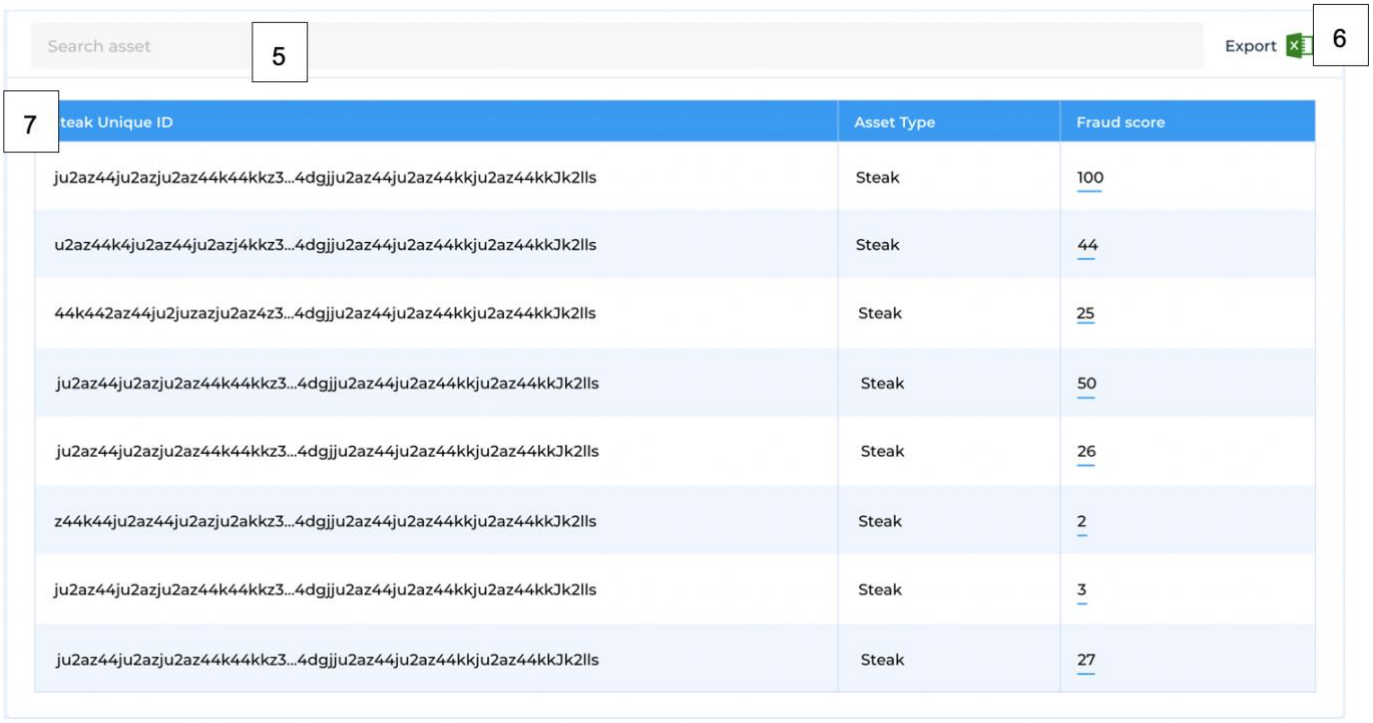


Figure 23: Primal page counterfeit flagging (pt2)

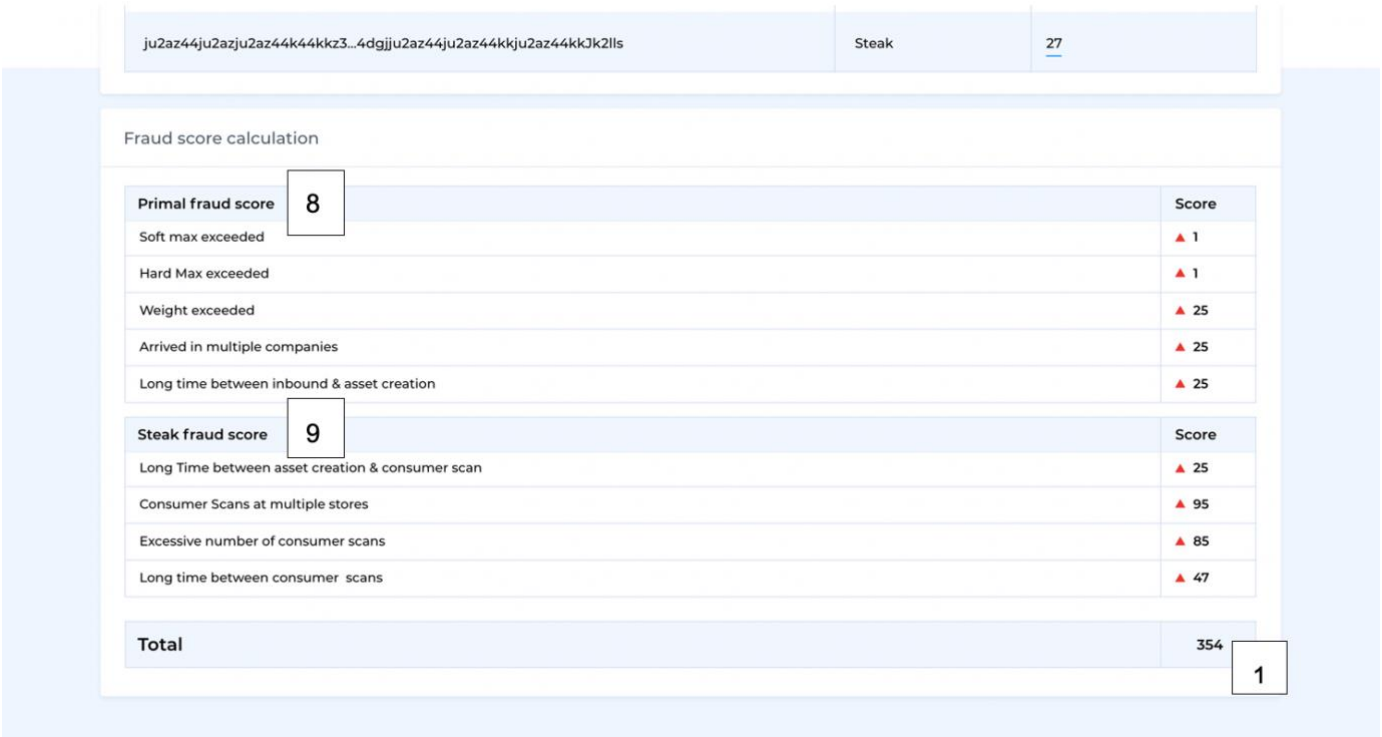


Figure 24: Primal page counterfeit flagging (pt3)

Component	Functionality
1. Total risk score	Calculated total primal fraud score (= fraud score attached to primal + fraud score attached to all steaks originating from that primal).

2.	Risk rules triggered	Displays amount of the monitoring criteria which were triggered.
3.	Primal asset info	Displays the primal asset information.
4.	Fraud score	Calculated total primal fraud score (= fraud score attached to primal + fraud score attached to all steaks originating from that primal) based on the criteria mentioned earlier where different weight is attached to different criteria. The circle diagram reflects which criteria is responsible for which proportion of the total primal fraud score.
5.	Search	Allows for searching a particular steak (on unique ID) originating from the primal chosen.
6.	Export to excel	Allows for exporting the list of steaks together with all details to excel.
7.	Steak table	Gives a list of all steaks originating out of the selected primal together with the asset Type of the steak and the total steak fraud score (= fraud score attached to primal it is originating from + fraud score attached to the steak).
8.	Primal fraud score	Displays scoring details on all criteria of the score attached to the primal chosen.
9.	Steak fraud score	Displays aggregated scoring details on all criteria of all steaks originating from the primal chosen.

Lastly, by clicking on a steak the user can go to the steak page (see Figure 25 & Figure 2) where more details can be seen on the risk result of a certain steak. An in-depth explanation of all components is given in the functionality overview table below.

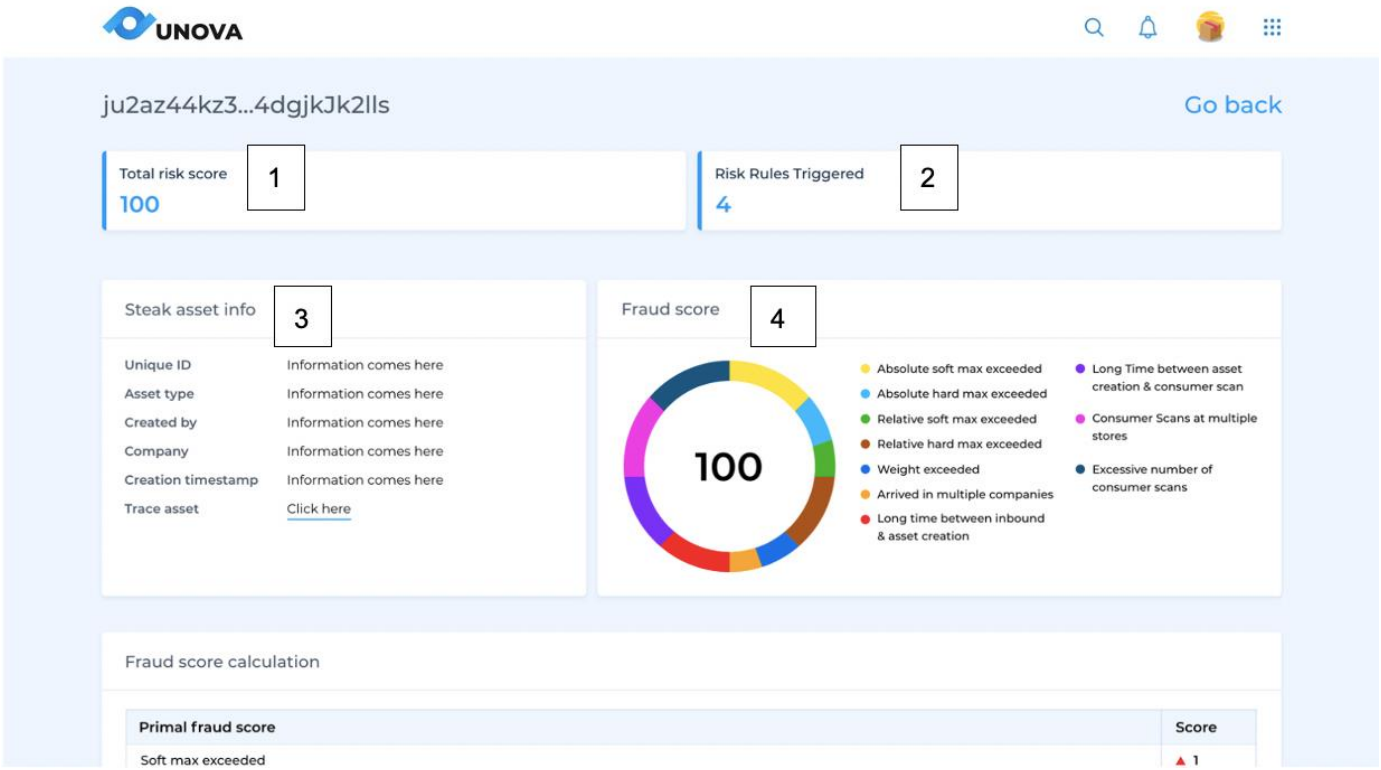


Figure 25: Steak page counterfeit flagging (pt1)

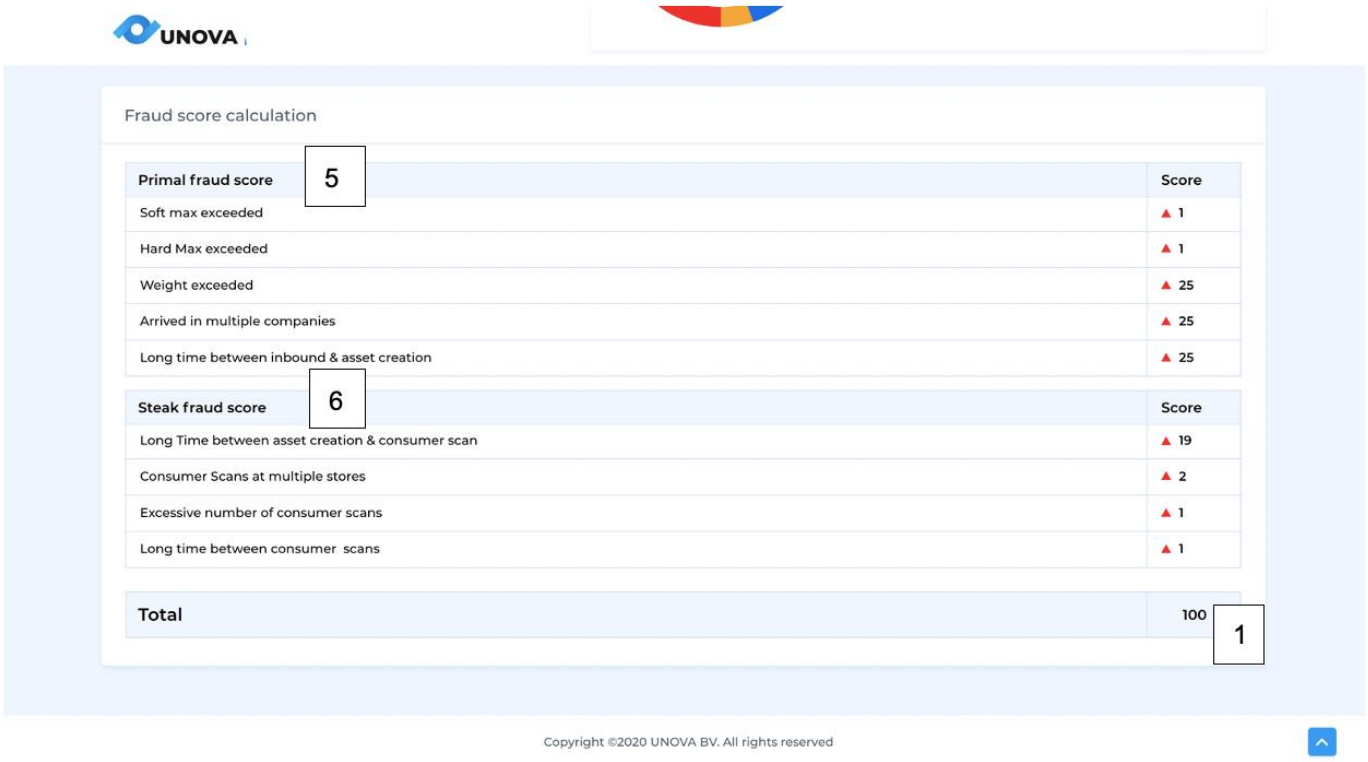


Figure 29: Steak page counterfeit flagging (pt2)

Component	Functionality
1. Total risk score	Calculated total steak fraud score (= fraud score attached to primal the steak chosen is originating from + fraud score attached to the steak chosen).
2. Risk rules triggered	Displays amount of the monitoring criteria which were triggered.
3. Steak asset info	Displays the steak asset information.
4. Fraud score	Calculated total steak fraud score (= fraud score attached to primal the steak chosen is originating from + fraud score attached to the steak chosen) based on the criteria mentioned earlier where different weight is attached to different criteria. The circle diagram reflects which criteria is responsible for which proportion of the total steak fraud score.
5. Primal fraud score	Displays scoring details on all criteria of the score attached to the primal the steak chosen is originating from.
6. Steak fraud score	Displays scoring details on all criteria of the steak chosen.

It was mentioned multiple times before that all scoring criteria have different weights attached to without going into details about the scoring mechanism. In what follows, the scoring mechanism on all criteria is explained in the table below.

Criteria	Scoring
1. Soft max exceeded	+1 per piece exceeded
2. Hard max exceeded	+200 per piece exceeded
3. Weight exceeded	+200 per gram exceeded
4. Arrived in multiple companies	+200 per primal referenced multiple times
5. Long time between inbound and asset creation	+1 per hour from 15th day onwards
6. Long time between asset creation and consumer scan	+1 per hour from 7th day onwards
7. Consumer scans at multiple stores	+100 per store
8. Excessive number of consumer scans	+20 per scan from 4th scan onwards
9. Long time between consumer scans	+1 per hour from 5th day onwards

4.2.3.4 Consumer trace dashboard

The last point where development activities were necessary was in the consumer dashboard to capture relevant consumer data and notify when a possible counterfeit piece is scanned. As already explained, the consumer dashboard already entailed scanning a product and seeing the whole journey from farm to fork and had some data capturing capabilities such as the number of scans of a particular product. However, data capturing capabilities needed to be broadened in order to also record the location the scan happened and the timing of the scan.

In addition to this, counterfeit notifications were added (see Figure 26) that are displayed when scanning a (possible) counterfeit product. In what follows, the development activities will be explained by giving a functionality overview of all components in the table below.

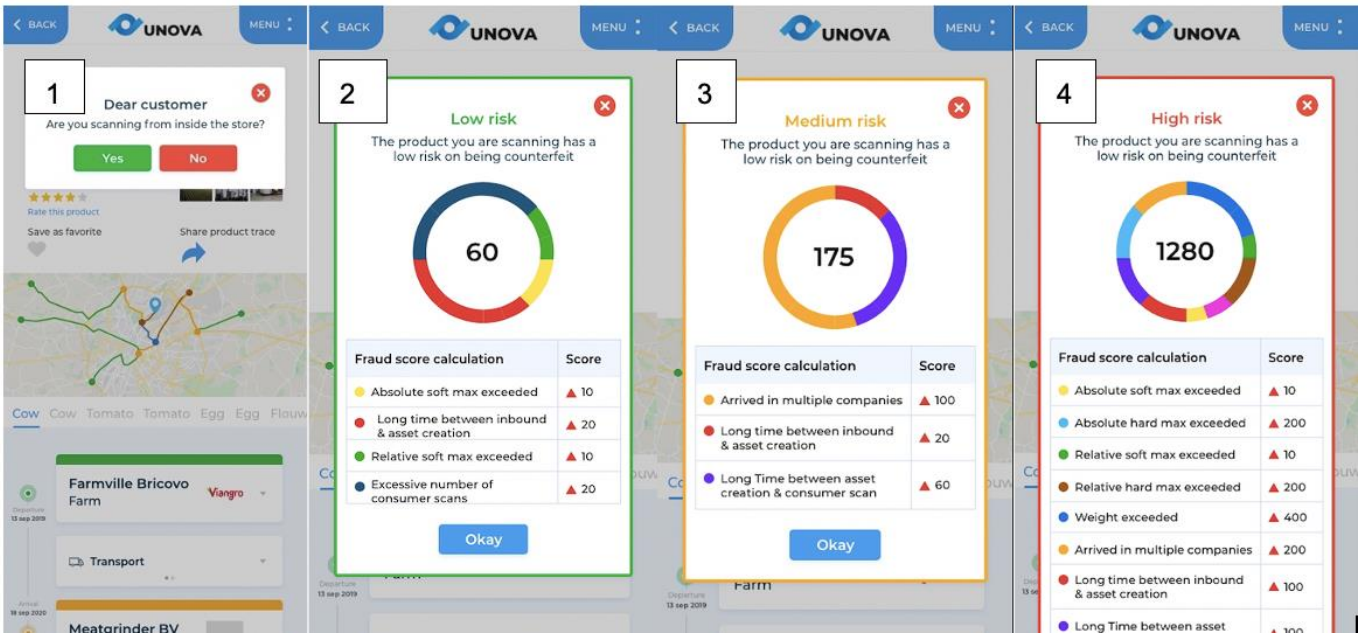


Figure 26: Counterfeit notifications consumer dashboard

Component	Functionality
1. Location pop-up	This pop-up will appear whenever a scan is happening which is not within x km radius of the first scan (currently set to 2 km). One would quickly assume that in case another scan is happening from another location, the QR-code was copied and put on multiple pieces and hence fraudulent activity has taken place. However, it is highly possible that for the later scan, the customer took the packaged steak home where he/she saw the QR-code and only then scanned it. In order to avoid flagging this as counterfeit behavior, the customer scanning from another location is asked whether or not he/she is scanning from inside the store. Only if the answer is yes, the steak will be flagged for the criteria “Consumer scans at multiple stores”.
2. Low-risk pop-up	The low-risk pop-up will appear whenever the total steak fraud score (= fraud score attached to primal + fraud score attached to this steak) is in the range of 21 to 100.
3. Medium-risk pop-up	The medium-risk pop-up will appear whenever the total steak fraud score (= fraud score attached to primal + fraud score attached to this steak) is in the range of 101 to 199.
4. High-risk pop-up	The high-risk pop-up will appear whenever the total steak fraud score (= fraud score attached to primal + fraud score attached to this steak) is equal to or higher than 200.

4.3 Testing

The R&D and development activities performed, as explained above, were tested on several demonstration KPIs as mentioned in the signed agreement with respect to the process, the traceability (both forward and backward), and the counterfeit flagging. In doing so, multiple action learning cycles resulted in an evolved system. In what follows, the test cases are listed which considered the process KPIs being:

1. Check availability of company node on the local server
2. Demonstrate the complete process of registering an inbound transport of a primal
3. Demonstrate the complete process of registering newly created steaks out of a certain primal
4. Demonstrate that the assets/events data created on the local node gets bundled and distributed through the blockchain to the other relevant company nodes.

The traceability KPIs being:

1. Visualize the steps in the supply chain in a user intuitive way available for all parties in the chain to view displaying the traceability
2. Consumer can scan a QR-code and view the full traceability and authenticity of the meat piece

The counterfeit flagging KPIs being:

1. Is it possible to create more assets with a reference to the primal piece than allowed?
2. Can the counterfeit asset be spotted with a high probability?
3. Can the supplier be notified of this potential counterfeit situation happening?
4. Did we display to the consumer in a good way, how likely it is the product is counterfeit?
5. Has it become very difficult and high risk to attempt to counterfeit Australian meat?

N°	Test case description	Outcome
1	Check status of the docker with following command line: cd /home/$USER/unova-nop ($USER = user that installs the NOP) docker ps	✓
2	Check node health with following command line: cd /home/$USER/unova-nop ($USER = user that installs the NOP) Sh status-node.sh	✓
3	Scanning barcodes following GS1-standard gives desired input to the screen	✓
4	Scanning QR-codes generated by the label printer (containing the URL of consumer product) gives desired input to the screen	✓
5	Correct Weight, Soft max, Hard max, supplier, created by, and timestamp data appear based on the scanned unique ID	✓
6	Screen responds correctly to scanning multiple different unique ID’s to be inbounded	✓

7	Screen responds correctly when accidently scanning an already scanned unique ID in the same session (before creation on the local node)	✓
8	Clearing the form through reset button on the screen allows to redo all scans in case a mistake has happened from the beginning	✓
9	Deleting an individual scan (before creating them on the local node) through the delete button on the screen	✓
10	Creating the inbound event on the local node through the register event button on the screen	✓
11	If there are already steaks created out of a certain primal, when scanning that primal the already created steaks are displayed	✓
12	Once weighing a newly created steak, the weight gets displayed on the screen together with the timestamp and a unique ID is created for the steak following the GS1-standard	✓
13	It is not possible to create more pieces than the Hard max	✓
14	The total weight of the pieces created can't exceed the weight of the primal piece	✓
15	When accidentally/purposely scanning a new unique ID in the middle of the process, the screen gives the option to proceed with the current process/redo all temporarily displayed asset creations	✓
16	Deleting an individual steak (before distribution) through the delete button on the screen	✓
17	Creating the steaks with a reference to the scanned primal on the local node by clicking on the register asset button	✓
18	Assets/events get bundled in the local node	✓
19	Once bundled, the bundle ID is put inside a blockchain transaction	✓
20	Once validated, the relevant company nodes shelter the data	✓
21	Unova Trace – Search on unique ID, asset type and Date	✓
22	Unova Trace – Test farm to fork view with a forward trace of complete chain data	✓
23	Unova Trace – Test farm to fork view with a backward trace of complete chain data	✓
24	Unova Trace – Test ingredient view with a forward trace of complete chain data	✓
25	Unova Trace – Test ingredient view with a backward trace of complete chain data	✓
26	Unova Trace – Test map view with a forward trace of complete chain data	✓
27	Unova Trace – Test map view with a backward trace of complete chain data	✓
28	Unova Trace – Test complete event chain data for each company	✓

29	Scanning a created QR-code of a steak through smartphone camera opens consumer trace dashboard and shows full traceability and authenticity of the steak	✓
30	Test the script which checks whether the soft max has been exceeded	✓
31	Comment out the code which blocks creating more steaks out of a primal than the hard max provided and test the script which checks whether the hard max has been exceeded	✓
32	Comment out the code which blocks creating steaks out of a primal of which the weight exceeds the weight of the primal and test the script which checks whether the weight of the primal has been exceeded	✓
33	Test the script which checks whether one primal has arrived in multiple companies	✓
34	Test script which checks whether the time between inbound of a primal and creation of a steak (originating from that primal) surpasses the cut-off point set	✓
35	Test whether consumer product keeps track of the time between the creation of the steak and the latest consumer scan	✓
36	Test whether consumer product (if allowed by user) keeps track of scan location	✓
37	Test whether consumer product keeps track of the number of scans of each steak	✓
38	Test whether consumer product keeps track of duration between first and last scan	✓
39	Test landing (customers list) page of counterfeit flagging module	✓
40	Test (individual) company page of counterfeit flagging module	✓
41	Test primal page of counterfeit flagging module	✓
42	Test steak page of counterfeit flagging module	✓
43	Test location pop-up on consumer trace dashboard	✓
44	Test Low-risk pop-up on consumer trace dashboard	✓
45	Test Medium-risk pop-up on consumer trace dashboard	✓
46	Test High-risk pop-up on consumer trace dashboard	✓
47	Test Fraud score calculation of consumer trace dashboard	✓

5.0 Project Outcomes

UNOVA's approach to offering a cost-effective primal to steak and steak to primal traceability system with anti-counterfeiting capabilities, as described throughout this report, has been developed and successfully demonstrated to AMPC staff. Together with AMPC it was concluded that implementing the complete solution in a real-world supply chain, with all anti-counterfeiting measures in place as briefly shown in 43, would not only benefit the industry with respect to their traceability objectives as also set out by AMPC (see 2.0 Introduction) but would also result in less anti-counterfeiting activities because of the difficulty of attempting in combination with the high risk of getting caught by both the supplier and the end consumer.

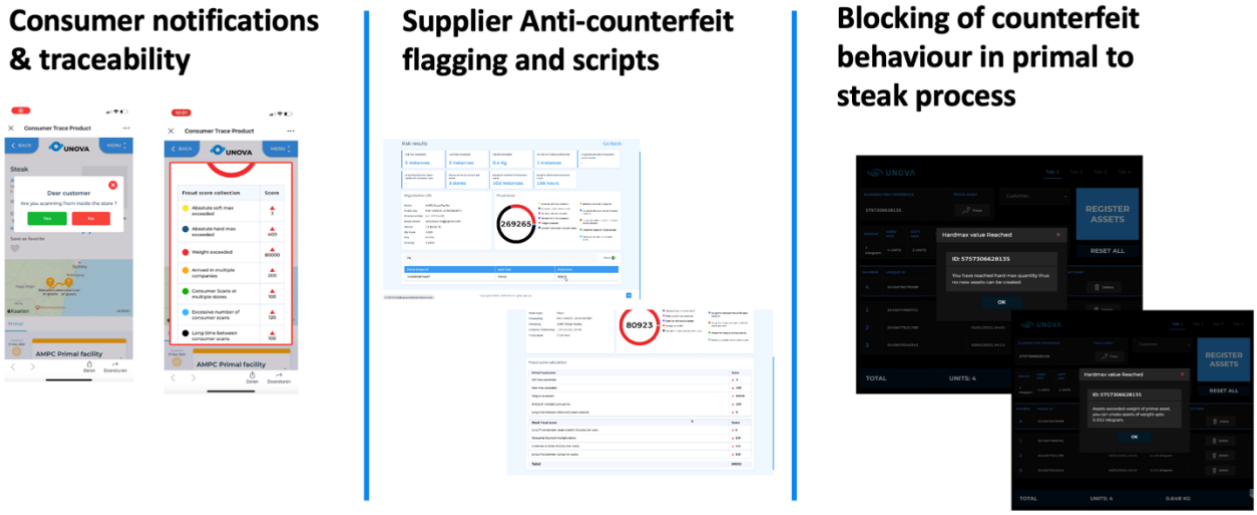


Figure 31: Brief overview of anti-counterfeiting measures

Next, the lessons learned during this phase allowed for a stage 3 submission describing:

1. The development path froward from stage 3 to adoption.
2. Minimum requirement of 3rd parties within a supply chain to comply with to ensure robustness (scope and pricing)
3. Requirements for the Australian source supply chain to enable adoption within their business (scope and pricing)

6.0 Discussion

Together with AMPC it was decided that the solution proposed is ready to be implemented in a real-life setting as part of a phase 3 project. Future learnings during implementation of the promising concept built will be crucial as they will be opening the discussion with respect to:

1. Setting the basis for onboarding the entire supply chains (currently focusing on the primal to steak process)
2. Figuring out what is still missing / to be added
3. Additional R&D requirements needed for specific process/traceability/counterfeiting KPIs.

It is important however not to limit the value of UNOVA's system to solely deal with Primal to Steak traceability and anti-counterfeiting. Especially because the possibilities are complementary to AMPC's additional strategic objectives as described in AMPC's 2020-2025 Strategic Plan. Therefore, the table below gives an overview of topics to be discussed going forward in the next phases:

Topic	Description
1. Increased traceability granularity for market access & food safety	Traceability is always at the core of building a system covering any supply chain. The granularity of this traceability impacts market access and has an impact on food safety. Therefore, most countries have specific requirements. The relevant data that can be captured and become part of the traceability has an increased value add. Hence, researching which data would be relevant to the assets & events that are created and what is operationally feasible to collect would be very interesting.
2. Food Safety & Recalls	As each product goes through supply chains and the process from primal to steak will be covered, a recall system can be developed that allows to recall both backwards and forwards. As UNOVA's company vision is to only develop scalable solutions, it is proposed to create this recall system in a way that it not only allows for recalling for the primal to steak process but essentially allows for recalling any asset, in any step. Thus, it would allow for recalling from animal to steak and from steak to animal. This would be a module as part of the main company platform Important considerations for executing recalls are: 1. Communicating with all relevant companies in the chain 2. Communicating with the end consumer just in case steaks would have arrived in stores and not taken out on time
3. Collect and add sustainability and animal welfare information to the data and communicate it with the end consumer	In modern times consumers care more about sustainability and animal welfare topics. This generally creates a value add for the product and increased marketing opportunities. As the system built essentially allows for communicating any kind of data between stakeholders in a trusted way, it should also be investigated how this sustainability and animal welfare information can be communicated in the best possible way to the end consumer[9]. As part of this effort, two things can be done 1. Figure out which data would be useful 2. Provide a way for companies to add this information to the story that is communicated with the end consumer
4. Other communication	Other communication with the end consumer to both increase the value of the Australian meat and add to existing marketing efforts:

[9] One of the things UNOVA is investigating with a partner company and university is Animal welfare monitoring possibilities via computer vision. If this is possible to achieve going to the future, it may be of large value to communicate this with the end consumer also meaning there should be connection possibilities for sustainability or animal welfare data.

	with end consumer	1. Displaying the traceability data (which is already completed as part of this phase) 2. Showing recipes to allow the user to engage more 3. Collecting relevant data from the consumer 4. Showing analytics of the consumer behavior on the company platform to the companies that are part of the supply chain.
5.	Privacy granularity options with regards to data that is distributed to stakeholders	Since the UNOVA network has two types of nodes (miner nodes, company nodes) where one is responsible for handling transactions (both financial and bundles), and the others are for distributing the general supply chain data, it allows the network to be more scalable for its use case while at the same time maintaining the data immutability and security. Since these company nodes are for creating, distributing, and sheltering the actual supply chain data but are not responsible for creating blocks, it is unnecessary that every node has all the supply chain data, so these nodes don't need to store a complete copy. This, in turn, allows for creating privacy settings where companies can choose where their bundles are sent to. You can see it as multiple private distributed networks being part of the same overall blockchain infrastructure. Therefore, even though every company becomes a network participant in a global infrastructure where the rules (code) is run decentralized and thus all machines know exactly what needs to happen, the data does not get shared with everyone. The basis for the infrastructure has been designed taking this into account by building the multi node type system. However, the granularity and multiple options for deciding who should get access to specifically which data is something that needs additional development as this is a very complex technology.
6.	International Competitiveness, via reducing manual compliance regulations	Automating processes and especially compliance data monitoring will be able to reduce the manual compliance regulation overhead. A starting point could be investigating what specifically could be monitored automatically and what specific scripts could be created to ensure compliance with regulations in an automated way. In addition to this, it can be investigated how pre-shipment clearance technologies can be designed and work in a real setting as a preparation for the next development phase.

7.0 Conclusions / Recommendations

During the stage 2 – technology validation, a cost-effective primal to steak and steak to primal traceability system with anti-counterfeiting capabilities, leveraging UNOVA's blockchain infrastructure, has been developed and demonstrated. To be able to satisfy all process objectives, all necessary development activities for the hardware setup to work in a real-life setting have been performed with respect to the devices bought (scanner, scale, screen, printer, and server).

Next, the traceability objectives were more than satisfied with the UNOVA trace module as the module is not limited to a simple interface showing primal to steak and steak to primal traceability but allows companies to search for any asset that passed through their supply chain and display the complete (both forwards and backwards) traceability in the “Farm to store view”, “Ingredient view” or “Map view”.

Finally, the combination of the development of the anti-counterfeiting module together with the anti-counterfeit notifications on the consumer trace dashboard allowed for meeting the expectations with respect to the 'Alert' of the non-traced product objectives. The combination allows that both the suppliers of the meat and the end consumer will be notified whenever certain parameters are met which flag certain behaviour as counterfeiting activity.

Going forwards with the next stage where the goals would be to validate and implement the proposed solution in a real-life industry setting and fully leverage UNOVA’s blockchain infrastructure by covering the possibilities complementary with AMPC’s strategic objectives as described under 6.0 Discussion, the recommended first steps would be to:

1. UNOVA with the guidance of AMPC secures the companies from within the supply chain wishing to introduce the proposed solution to their production process.

2. Plan site visits to validate some assumptions and see how the practical implementation will/can work. Many things can be done remotely without it being a showstopper (aside from some additional overhead when it comes to imagination required) but if Covid-19 allows, a real site visit would make the process smoother.

3. Plan workshops prepared by UNOVA to make sure everyone is aligned and understands the objectives and the values of the offering. The technology is new and allows for things that were unimaginable 15 years ago. Therefore, organizing some (online or offline) workshops explaining different components of the whole system (from basic to more advanced concepts) will surely be of value for the industry participants.

8.0 Bibliography

Ampc.com.au. n.d. AMPC Strategic Plan 2020-2025. [online] Available at: <https://www.ampc.com.au/getmedia/4832a7b0-def8-4af4-8762-d91bb4cbac42/AMPC_StrategicPlan_2020_2025.pdf>.

9.0 Appendices

9.1 Appendix 1 – Scanners considered

Company	Model
Zebra	DS2200 SERIES
Zebra	DS8100
Zebra	DS36 SERIES
Zebra	DS4608-SR
Honeywell	Xenon 1902 Wireless Area-Imaging Scanner
Honeywell	Xenon XP 1950g General Duty Scanner
Honeywell	Xenon XP 1952g General Duty Scanner
cognex	DATAMAN 8700 SERIES SYMBOLOGIES
cognex	DataMan 8050

9.2 Appendix 2 – Printers considered

Company	Model
Zebra	ZD421
Zebra	ZT610
Zebra	ZT411
Zebra	ZT421
Zebra	ZT220
Zebra	ZD622
Zebra	ZD623
Epson	C7500g
Epson	C6500
Epson	C3500
Toshiba	B-EX4T1
Toshiba	B-EX4T2
Toshiba	B-EX6T3
Toshiba	B-EX4D2