PRACTICAL USE OF IT IN TRACEABILITY IN FOOD VALUE CHAINS

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Abstract: Traceability is today considered an essential requirement for the food value chain due to the need to provide consumers with accurate information in the event of food safety recalls, to provide assurance with regard the source and production systems for food products and in certain countries to comply with government legislation. Within an individual business traceability can be quite simple to implement, however, in a global trading market, traceability of the entire supply chain, including logistics is extremely complex. For this reason IT solutions such as TraceTracker have been developed which not only provide electronic solutions for complete traceability but also allow products to be tracked at any point in the supply chain.

Keywords: traceability, global food value chain, tracking, IT solutions, TraceTracker

1. INTRODUCTION

Today's consumers are informed and aware and they demand much more information about the food they buy than their parents did. Beyond simply wanting to know how much it costs, today's shoppers also ask: Is it safe? Is it healthy? Does it contain any allergens? Where was it produced? Was it grown organically? Is the farming and harvesting done in a sustainable manner? Is the packaging recyclable?

As a result, brand and private label owners need to communicate more information about their products than ever before. To respond to the modern

consumer's need for food they can trust, they need to be able to obtain accurate information from within their own business processes, from their supply networks and from their suppliers' suppliers and intermediaries. Even for a simple food chain example, the amount of data required and the time scale for response to provide complete traceability is one reason that IT solutions can be an invaluable tool to provide the information required within the food value chain. For the purpose of this paper I will refer to the TraceTracker software solution package.

2. BUSINESS DRIVERS FOR IMPLEMENTING TRACEABILITY

Food safety is probably the primary basis for the current drive for traceability in the food industry. Food scares are usually based on solid facts of unsafe foods, and it then takes solid facts to keep the public from becoming scared of all products in the same group. Traceability and traceability systems provide such facts. In cases of unsafe foods, it is vital to be able to differentiate the safe from the unsafe. Without traceability, this may be impossible, and scenarios of very costly product recalls may result. Some products and companies may take major blows from recall scenarios, and may never recover their market shares or even go out of business. There are many examples of such incidents, and there will undoubtedly be more to come. Traceability is an important form of insurance from such situations, and traceability systems are the tools for using the traceability information registered. Companies that implement traceability systems may actually get lower insurance premiums, both for their recall insurance and their general liability insurance.

Governments all over the world have recently started to focus more and more on food safety and traceability. Politicians do not want to be held responsible for food incidents, and in this case, they are doing their job right, pushing businesses to implement traceability by defining new laws and directives.

In today's markets, competition is often fierce, and differentiating higher quality products from the general commodities can be a difficult task without hard facts to prove marketing claims. Traceability can supply the needed proofs, facilitating high-end markets for superior products. For example, in many countries, eggs from free range chickens are preferred due to both welfare and quality issues and they are willing to pay a higher price for such eggs. However, consumers do not like to be cheated, and there have been a number of incidents in Europe whereby cage eggs have been sold as free range. It is imperative for the honest farmers to have good traceability practises to be able to restore consumer confidence in their brands.

3. DEFINITIONS OF TRACEABILITY

The most widely used definition of traceability, is probably the ISO9001 definition from 2000. It defines traceability as:

«The ability to trace the history, application or location of an item or activity by means of recorded identification. When considering product (3.4.2.), traceability can relate to the origin of materials and parts, the processing history, and the distribution and location of the product after delivery».

This definition of traceability is considered by a number of experts as being too broad in scope for use in the specific context of the food value chain. The EU Commission[1] (defines traceability within food value chains as:

«the possibility to find and follow the trace, throughout all the stages of production, processing and distribution of a food stuff, feed stuff, an animal destined for food production or a substance destined to be incorporated in food stuff or feed stuff or with a probability of being used as such»

The EU definition is a little bit more specific, but still vague, for instance in what it means by follow the trace.

It is important to stress that traceability really involves more than only the minimum of what is required to provide the one-up, one-down type of information required by different legislations which tend to look at traceability as something internal to each company in the chain. However, it is important not to miss the complete chain view on traceability. As an example, consider the following figure:

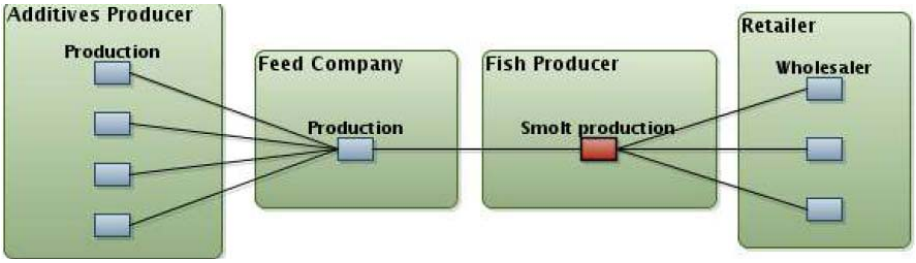


Figure 1 Chain Traceability

In this scenario, all four companies in the chain are able to trace and track their raw materials, their internal production batches and their outgoing trade units, not only one step up and one down, but across the whole chain.

TraceTracker offers the following definition:

«Chain Traceability means the ability to transparently trace and track the production and manufacturing history and content of any food item (including ingredients) exchanged between companies in the chain. This requires each company to

1. register all their incoming raw-materials in a globally unique way at the batch/lot level, and who the supplier is
2. link the raw material lots to the internal production steps they are entering
3. link together all internal production steps up to and including the final step of production where the «trade units» are created
4. for each such traded unit, register who the traded units are being sold to»

Two words which are frequently used, are the words tracing and tracking. Some tend to use these interchangeably, but there are different semantics associated with them, which let us make more precise definitions. Tracing is normally defined as following a path backwards towards its origin, also called upstream, in the meaning towards where the stream starts. In this case, the stream is the food value chain. Tracking is normally defined as following a path forwards towards its end, also called downstream.

4. BUSINESS EXAMPLES

In a small business, such as a single fishing boat, traceability would consist of logging when and where a catch (in traceability terminology called a lot or a batch of fish was caught and when it was sold and delivered to a specific wholesaler or other bulk customer. The log could be electronic or on paper, this does not matter for traceability, except that electronic documentation may make it much simpler and faster to communicate the traceability-information to the customer or other interested parties. When a customer might ask: Where did the fish I bought come from? The fish person would consult their log and have a ready answer. If the government asked who bought fish caught at a specific location within a certain timeframe, the fisherperson could again consult their log and after a little work would come up with a list of customers. This is traceability. Due to smart internal processes, the little fishing business can be said to have full internal traceability.

Out there in the real world, there are businesses of greater complexity than the simple business described above. Some of these may be vertically integrated, meaning that they have subsidiaries that produce the parts or raw materials they use (backward integration) or they may have subsidiaries that use or distribute their products (forward integration), or both. Vertical integration means extending the value chain of the enterprise to a higher number of traceable links. For example, a fish farming company may decide to buy both a feed producer, a fillet plant and a distribution company, thus covering the complete value chain from raw materials to supermarket chain Traceability for such a company would require detailed logs of many

manufacturing steps to determine where the fish products came from, but all the steps could be local to a single enterprise. Such traceability would be hard to handle on paper, but can certainly be well handled electronically, given good traceability routines and reasonably standardized IT systems across the whole enterprise chain.

When different businesses anywhere in the world trade products with each other, global value chains are a fact. For instance, a food additives producer in Germany may sell chemicals to a fish feed producer in Norway, which provide raw materials (feed) to a fish farmer in Chile, while this company may sell slaughtered fish to the big Japanese retail market. This would be a truly global value chain, and traceability in this chain could be hard to imagine. However, with today's telecommunication infrastructures and the Internet in particular, such distances are not a problem. The companies mentioned should, however, have good traceability processes and internal traceability systems implemented, and of course some effective tools for interconnecting their traceability data. Such tools happen to be just what TraceTracker provides.

5. LEVELS OF TRACEABILITY

It is sometimes useful to distinguish between different levels of traceability, as both business use-cases and the required capabilities of the (traceability) software systems involved will differ slightly among these levels. The lowest level of traceability is called internal traceability. This is about traceability inside and internal to one single company. This is sometimes also called one-up-one-down traceability, which means keeping records of the sources of everything received and of the destinations of everything sent out. But note that one should actually differentiate between one-up-one-down and full internal traceability. The latter is more extensive than one-up-one-down. One-up-one-down traceability only require that a business keeps records of who their supplies come from and to whom products are sold. There may not be records inside the company of which supplies are used for which products. Full internal traceability on the other hand, also requires records of which raw materials are used for which products, and this is clearly more extensive than on-up-one-down. Internal traceability can for simple internal chains sometimes be handled by general or special purpose Enterprise Resource Planning (ERP) systems or other types of enterprise software. The reason is that the business scope of such software is per definition a company internal scope, hence the name Enterprise Resource Planning. A reasonably modern ERP system will therefore most often be able to handle one-up, one-down traceability, given that the required data is fed into the system. The same may be true when it

comes to full internal traceability, but unless good traceability practises are implemented in the company, one often see that the required data is not logged, even if the system was capable of modelling full internal traceability. For more complex internal value chains however, ERP systems tend to come short in modelling the required dynamics, and special purpose traceability software should be installed on top of the ERP systems.

Enterprise traceability is just full internal traceability extended across two or more locations or companies within a larger enterprise, for instance within a vertically integrated company. Requirements and challenges are therefore the same as for internal traceability, but complicating factors may be that more than one ERP system are involved, and with probably missing links between the different systems.

To accomplish Chain Traceability, it is necessary to be able to trace and track between different companies in a given value chain, as stated in the definition given at the beginning of this document. Clearly, this requires some kind of interconnected value chain, and standardized ways of communicating with each other. In addition, each company needs to have full internal traceability in place, so that it is possible to trace and track through the internal chain of each company. TraceTracker provides a software solution called the Global Traceability Network (TT GTNet) which is able to connect different internal traceability systems from different companies.

6. PREREQUISITES TO TRACEABILITY

Traceability is not only about having good software systems to administer all the needed information, it is also about having internal production processes that support traceability and not break it. In fact, this is the single most important thing to focus on before doing any installation of traceability software.

All internal processes supporting the internal production, from the reception of raw materials to the shipment of finished products, must support traceability, not break it.

Examples of processes which do not support traceability, can be

1. feeding silos which are hardly ever emptied completely or cleaned between each refill
2. water tanks similar to feeding silos
3. recycling ingredients in production processes

1. and 2. are sometimes described as the never-ending-batches problem, both often seen within all kinds of industrial animal production. It is not always obvious whether existing processes need to be re-engineered to

guarantee a satisfactory level of internal traceability, so it is recommend that companies conduct a traceability survey done by traceability professionals.

7. UNIQUE IDENTIFICATION SCHEMES

One of the most important things a traceability survey will address, is whether the traceable entities (batches and trade units in our model) are being identified properly. By properly, we mean in a unique way within the scope of such a traceable entity. The scope of a batch is per definition an internal scope, and internal to a company or probably an enterprise. Supporting software used in the internal production must then be able to generate enterprise wide unique identifications for all batches in the enterprise value chain. If the numbers generated for some reason are recycled at some time in the future, this must not happen until the old batches with the same numbers are completely out of scope. Trade units on the other hand, are exchanged between companies, so the scope of a trade unit is really a global scope. This means that trade units must be identified in a globally unique way. As it happens, there is an organization which has been working with global identification schemes for a long time, namely the GS1 – formerly EAN.UCC organization.

EAN.UCC, recently renamed to GS1, is a globally active industry organization with members in 103 countries. The organization handles standardization of numbering systems for many purposes. The mission statement for GS1 is as follows:

By creating Open, Global, Multisectoral Standards based on Best Business Practices, and by driving their implementation, play a leading role in Supply & Demand Chain Management improvement worldwide.

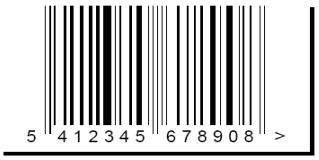
The organization is probably best known for their standardization of bar code systems world wide, but they have recently broadened their business scope, for example by looking also into RFID based technologies. When talking about traceability, it is really the numbering systems GS1 offer which are interesting, not the technology used to carry the numbers, i.e. bar codes, RFID tags, EDI or XML messages and so on. GS1 provides unique numbering systems for a wide range of applications, and also suggests how several such numbers can be concatenated to form globally unique traceability keys.

7.1 The Global Trade Item Number – GTIN

The GTIN is one of the most important of the GS1 numbering systems. GTINs are allocated to GS1 member companies according to criteria decided by GS1. They consist of two main parts:

1. A company prefix
2. A product number

In addition there is an extra GTIN type digit, and a check digit. The GTIN is easily encoded in different bar code schemes or alternatively in an RFID tag following a product. GTINs are used by the companies to identify specific products. GS1 suggests allocating the numbers sequentially, so two consecutive numbers may specify two totally different products, but this is really up to the company. The numbers may be reused after 4 years if a product is discontinued. Each company that has a company prefix can freely allocate their own GTIN product numbers, but quite detailed rules for how to do so are given by GS1 in order to have uniform practises around the world. An example of a GTIN is given below, here encoded as an EAN-13 bar code.



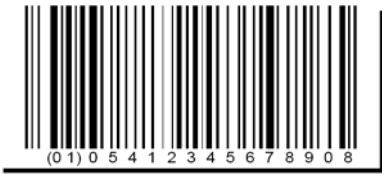
GTINs are perfect for identifying a manufacturer of a product and identifying a product's exact type. However, there may be millions of identical products all carrying the same GTIN number. If there is no way to differentiate these products from each other, tracing the product to the correct production batch on the correct day may be impossible. Therefore, a batch or lot number that is unique to this batch of products is needed. This information must be carried along with the product to its point-of-sale (POS) if traceability from consumer to ingredient production shall be possible. Note that a company that manufactures a specific product is uniquely specified by the company prefix of the GTIN number, so the company only needs to allocate its batch/lot numbers unique internally within the company for the combination of GTIN and batch/lot number to be globally unique.

7.2 Bar Codes

The bar codes you normally find on all supermarket items are normally used to carry GTIN information. They are read electronically with a bar code reader, but the number information is also written at the bottom of the bar code, so it can be read by humans and manually entered into a point-of-sale computer if necessary. There are many types of bar codes, and some can carry only a few digits of information while others can carry more. GS1 has a variety of standardized bar codes, such as EAN-13, UPC-A, ITF-14 and UCC/EAN-128. These can carry different amounts of data, and can be used to carry for example a batch or lot number and more in addition to the GTIN.

We will look at the EAN-128 in some more detail, as this is the most modern and flexible bar code scheme for carrying information between trading partners.

EAN-128 defines a concept called Application Identifiers (AI), which is used to encode different fields in the bar code in a flexible manner. When the scanner equipment reads the bar code, it will identify the AIs. Each AI defines the meaning of the next N (the number N depends on the given AI) digits in the code, and they can occur in any order. Two trading partners can agree on what to encode in the bar code, based on the requirements of the receiver. With many customers, the manufacturer should of course try to standardize what is encoded in the bar code. The screenshot below shows a fictive EAN-128 bar code, where the numbers below the bars represent the encoded information in a human readable way. Application identifiers are often visualized by putting parentheses around them. In this example, we see the AI 01 which represents the GTIN, indicating that the next 13 digits represent the GTIN number.



GS1's globally unique numbering systems are perfect for constructing traceability keys that are globally unique, and that's just what is needed for identifying trade units. So, how can a company, through their ERP or production systems, create a unique traceability key for each trade unit they ship out? GS1 has a suggestion for what the key should look like:

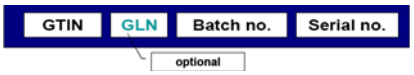


Figure 2 The GSI suggestion for traceability keys on trade units

The suggested fields are shown above. The GLN is optional, but should be used when there is a risk that the same batch numbers may be generated across different production plants of the same company, for the same GTIN. The serial number is a way to serialise the production batch, and this is in fact necessary to be able to end up with a globally unique traceability key, which uniquely distinguishes between two trade units coming from the same production batch, the same GTIN and of course the same company. The serialisation is up to each company to implement, and the number can be anything as long as it gives rise to a unique traceability key. Sometimes companies use a datetimestamp to accomplish this.

7.3 RFIDs

RFID technology has been around for a while, its origins lie in the Identify Friend or Foe (IFF) systems developed for military aircraft in the second World War. The first trials of commercial applications began in the 1970s, but it was only in the late 1990s that RFID started to become viable for widespread business use. The technology has over the years steadily been improved, and today RFID devices are used for many practical purposes within a multitude of functions that include purchasing, production, storage, shipping and sales. It is for this reason that RFID is now common within many retail chains as a means to automate restocking, track products in transit and also track consumer purchase behaviour. The specific characteristics and functionalities of the software components of an RFID system vary greatly depending on the applications and other needed requirements. The components can be categorised as follows:

- **RFID system software:** This is needed for the collection of applicable software functions necessary to effectuate the basic interaction between a tag and reader. The functions are: read/write, Anti-Collision, Error detection/correction, encryption, authorization and authentication (security).
- **RFID middleware:** This consists of software components that acts as a bridge between the RFID system components (tags and readers) and the host application software. It performs two primary functions:
    - Monitors the device (reader) health and status
    - Manages RFID-specific (tag & reader) infrastructure and data flow.
- **Host application:** This receives processed and normalized data sent from the tag, via the reader and the RFID middleware software.

8. TRACETRACKER'S TRACEABILITY MODEL

It is useful to start this description with an illustration which depicts the chain view of the model, i.e. Companies in the chain trade with each other, and one single company is typically both a buyer and a seller. In Figure 3, this is shown.

The dashed rectangle in the figure symbolizes the internal production chain of a company. At the start of this chain, the company receives raw materials which enter the internal production chain. At the end of the production chain, some kind of final product is created and then sold. Both the received raw materials and sold products may be assembled in logistic units such as pallets, but this is a modelling option. The model defines two

types of traceable entities – batches and trade units. They are described in the following:

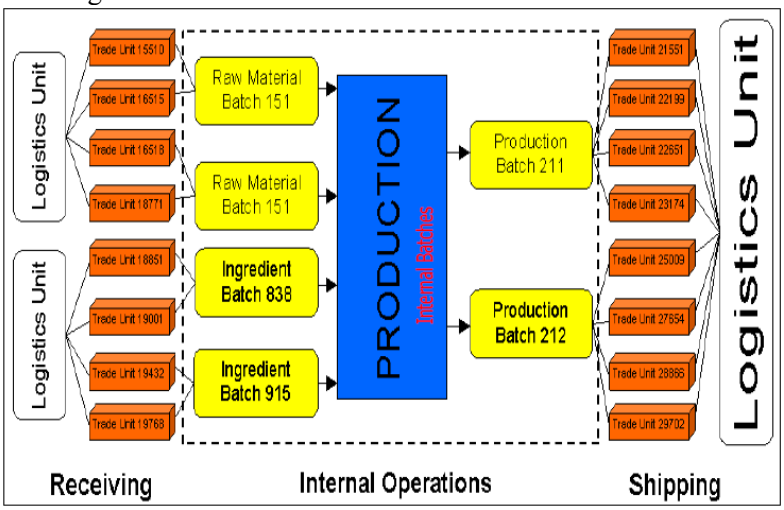


Figure 3 TraceTrackers traceability model

Batches are one of the basic units of TraceTracker's traceability vocabulary and represent an object of production internal to a company. They will seldom need to be exposed to the outside world, and are mainly of interest to quality managers and staff working with the internal production of a company. However, batches carry with them the history a final product has gone through, from the mix of raw materials through intermediate internal batches up to a final product. This history is modelled through two other modelling concepts described below – transformations and batch properties.

A typical batch in for example a bakery would be the last morning's production of a certain type of bread. These loaves of bread may all be expected to share the same characteristics since they are made from the same raw materials. If they were made from two different batches (for example two shipments from different mills) of flour, the baker might have separated them into two batches of bread for traceability reasons, but chances are, if something was wrong, he wouldn't know which loaves of bread came from which flour. (Unless flour is known to vary much in quality, in which case an expert might be able to trace batches based on quality differences). A Production Batch is a normal batch which is marked as being a production batch, which should be taken to mean that it is the last batch of the internal production chain. The reason for giving these batches special attention, is that these batches are the primary targets when doing recalls and withdrawals.

Trade Units are another kind of traceable entities, but they are used to model trade between companies and from retailers to consumers. The distinction between batches and trade units is especially useful when we look at the different levels of traceability described earlier. Internal traceability systems and processes have the **batches** in focus for the tracing and tracking, while the **trade units** are the primary focus in global traceability scenarios. In reality, both batches and trade units need focus when there is a food crisis where some contaminated traded goods have crossed several organizations in the value chain. A typical scenario would be to first locate the production batch of the company which were suspected to be the cause of the contamination, then to track this batch downstream again, as well as to trace it backwards internally to be able to isolate the cause of the contamination. To be able to handle such scenarios transparently and fast, both internal traceability systems and a global traceability solution which can connect all the internal traceability systems are needed.

Both batches and trade units can appear in clusters, and they will then be named as cluster batches or cluster trade units. The most typical use of this modeling concept, is to use it for modeling of logistic units, for instance pallets. Going back to the previous example – in the bread business, one loaf of bread would be a single trade unit at the consumer retail level, but the bakery might not operate with less than a dozen loaves as the smallest quantity of sale. This could be modeled as a trade unit cluster. Any batch or trade unit can have any number of so called properties associated with it, but all batches of the same type have the same set of properties. This must not be confused with the actual values of the properties. As an example, consider a model of a value chain for salmon farming. Let us assume that we had defined a batch type in this chain called Fry, and with two mandatory properties called Genetic strain and Number of fish. Two batches of this type would automatically have the two properties defined, but with possibly different values.

9. STATIONS AND TRANSFORMATIONS

Station is a useful modeling concept used to describe some kind of influence that batches or trade units are exposed to without being physically transformed. That is, they are kept intact throughout the period of influence. The traceable entities are said to enter and leave the station, and these two timestamps should be recorded. The station may be associated with measurable physical environment parameters, such as a log of temperature, humidity, pressure etc. A real life example of a station could be a truck. Modern trucking companies have many sophisticated means of recording

data during a transport, for instance temperature loggers. If such a log was electronically available from the transporter, it could easily be associated with the station (the truck) and the batches or trade units which had been in the truck within a certain time frame.

Transformations model the changes raw material batches or intermediate batches go through as they are mixed and split and handled through a production process. Both batches and incoming trade units may take part in transformations. Transformations can also be thought of as the glue which links one traceable entity in the chain to the next step, which always is another batch or trade unit, or a station.

10. SOFTWARE SOLUTIONS

To be able to deal with traceability issues other than only the most trivial ones, efficient software solutions are needed. As previously mentioned, ERP systems or other types of internal enterprise software may be of some help, but primarily as tools for solving internal traceability issues. Even then, modifications or add-ons are often needed. Such software has not been written with traceabilty in mind from the beginning, and it may turn out to be more costly to build traceability functionality into such software than installing a native traceability application on top of the enterprise software. Some big vendors of ERP software have come up with dedicated modules targeting traceability in food value chains, examples could be SAP and Navision (Microsoft). Industry specific solutions also exist, but they tend to be very narrow and specific to the industries. They are not necessarily well suited for global traceability scenarios, at least not without add-ons on top of the solutions.

10.1 TraceTracker Enterprise Solution TT ES

TraceTracker Enterprise Solution is an Enterprise wide traceability system which can be used as a standalone system for internal and enterprise wide traceability. In addition, it is an enabling platform for being able to handle global traceability challenges, where the company or enterprise needs to be able to exchange traceability information with trading partners. TT ES integrates smoothly with any reasonably modern ERP system or other enterprise software, as long as the underlying systems are capable of modeling internal traceability according to the definitions given earlier in this document.

10.2 The Global Traceability Network – TT GTNet

TT GTNet is short for the TT Global Traceability Network. GTNet is created by TraceTracker and offered as a subscription service (Software as a Service) to members of any supply chain. By subscribing to the network and contributing own data to the network, the subscriber gets basic and transparent access to upstream and downstream trading partners in the same supply chain (not only one step up and one step down) they are members of. However, all access to data is controlled by the company who contributed the data in the first place. A robust web application is offered for easy access to all GTNet services. Public APIs are available for both data capture and data lookup. These APIs can be used to create custom applications. GTNet also provides rich and full blown services for internal traceability, and a subscriber may choose to use only this functionality (not sharing data with trading partners). The Global Traceability Network delivers traceability right across the businesses involved, allowing customers, governments and other interested parties to trace products from company to company. Figure 4 illustrates a real global example where a fillet of smoked salmon found in a supermarket in France may be traced through many links upstream in the value chain, through trucking, transport and fish farming to end up at a manufacturer of chemical additives used in the fish feed. As a result, users of the system always known the answer to such questions as;

Where are my products located?
Where, when, and in what quantities were they produced?
Which ingredients and processes were used to make them?
What quality assurance data is available for each of them?
Where, when, and in what quantities were they shipped to/from?

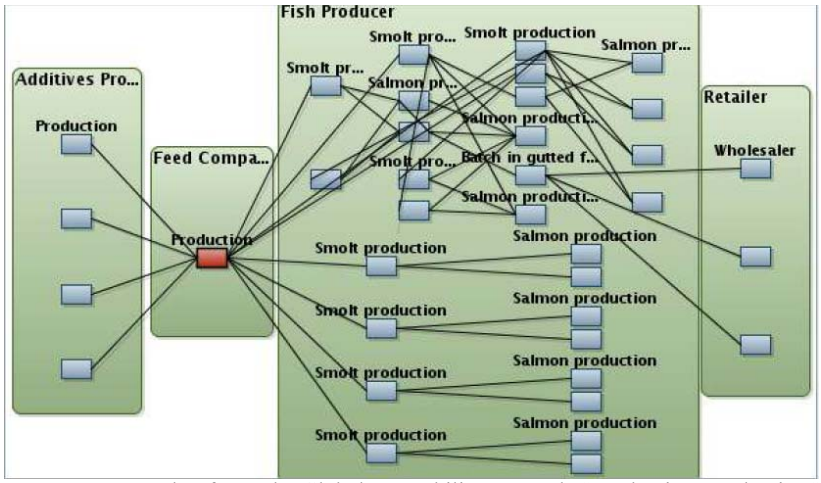


Figure 4 screenshot from The Global Traceability Network, "Production Batch View"

11. CONCLUSION

Traceability has been driven by issues of food safety and product recalls and fraudulent claims for higher value food products such as free range and organic. Traceability is ultimately about trust. Consumer trust for the products and brands that they purchase, and supplier trust within a global food value chain. It is possible to manage a system for a simple internal one step up and one step down traceability, but for more complex supply chain situations and the ability to provide real-time tracking IT software solutions are required. IT solutions are able to utilise internationally recognised identity code schemes to provide web based access for both traceability and tracking and provide real time answers that ultimately can enhance a brand or product or save cost through efficient management of the supply chain.

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