Tracking and tracing bottled water with RFID technology

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Abstract: *The present paper is a case study of how to improve the tracking and tracing system done by Inal.Ltda a Bolivian company using RFID active tags with sensors to comply with the handling practices and assure the softness of the product. The result shows that the company did not only was able to improve the handling practice but gain inventory visibility and is looking to use RFID passive tags to increase its products visibility.*

Since the terrorist attacks of 9/11 and 7/07 the world has changed the perception about security and safety. The change has been so radical that it has impacted everywhere; the food industry is of no exclusion and it has been affected in several ways, one of which is the tracking and tracing of food products which has been supported by law enforcement both in Europe and USA.

The bookkeeping system used for tracking and tracing has its origins on NASA's space missions to control the food digested by its crew members (Mortimore and Wallance, 1994). As a result of this Hazard Critical Control Point (HACCP) was originated and since then adapted for tracking and tracing food products. It assures that products are not contaminated both chemically and physically. In order to keep the recording of processes HACCP asks for the compilation of information inside companies' documents that can take the form of computer systems and/or paper documents. Through out the world this is done on batch level only.

There are several critiques to this practice but the main one is that neither importers nor retailers are able to see the products on batch levels, moreover when they are de-palletized and the batches are mixed customers lose location and item identification. This has created unresolved issues to entire supply chains. Nowadays, one technology has been made commercially available to tackle these issues: Radio Frequency Identification (RFID).

The technology, especially on its passive format, can allow supply chains to collaborate and share the information on the products besides sharing the location and state of the products. Having both the informatics and physical properties of the products shared at all time can help supply chain partners coordinate the actions to be taken when tracking and tracing products, especially when a recall happens.

One company, Inal.ltda., has trialed with the system on its active format and has been able to use the technology to vertically integrate its customers in one of its selling routes to its bottled water production plants. Thanks to RFID informational and physical capability the company has been able to track and trace the products. These has allowed it to reduce the paperwork needed inside its HACCP system at its manufacturing plant and above all the company has been able to increase the route's return on investment (ROI) by better matching inventory control.

The present paper is structured as follows; first the relevant theory for tracking and tracing food products with a critique to the used identification systems is matched in order to

understand the issues they generate, after a description of the technology is done in order to introduce the reader to the topic. Then a case study is performed in order to analyze the problems the company faced and a description of the solution proposed with the technology in a route is explored. After that, the paper discusses the results and concludes.

1. Tracking and tracing systems

Van Vorst (2004) proposes a model to define the data identified by tracking and tracing systems. The author defines tracking as: “the determination of the ongoing location of items during their way through the supply chain”. Tracing refers to “defining the composition and the treatments an item has received during the various stages in the production life cycle” it can be divided in chain-upstream and chain-downstream: “chain-upstream tracing aims at determining the history of items and is used to determine the source of a problem of a defective item. Chain-downstream tracing aims at the determination of the location of items that were produced using, for example, a contaminated batch of raw material”. (Figure 1)

These implies that a huge amount of location data is needed to be used for tracking and tracing activities, all whom need the food information to be imputed in a database. The different data needed for tracking and tracing food have different properties that are currently not recorded on item level (Table 1). The information, therefore, suffers from several limitations as it is mainly done on batch level, thus generating problems with supply chain partners whenever there is a contamination outbreak.

2. Current issues regarding tracking and tracing systems

Tracking and tracing systems have developed a series of issues regarding the information compiled. As seen on Table 1 the information has to reflect location, time, identity, quality and quantity, because current technologies do not solve dynamically these data properties they have generated different issues for supply chain members.

Issues for exporters: exporters need to assure that the products sold assemble the requirements of their clients. Therefore assurance of quality has become of vital importance during recent years. The assurance of food products has developed in such a way that exporters are required to take care of the product trough-out all the stages of the chain.

Because of recent trends of giving third parties more involvement inside the business processes, grey areas -where neither the exporter nor the third party can claim responsibility of the product-have being developed, this goes in determent of the customer interest. A technology where complete visibility is needed as to surpass these grey areas and assure that each product is being take care off as the case study presented above states.

Issues for importers: Continuing with the issues of exporter, importers face the need to assure inside their market that the quality of the products meet the standards the countries customers demands. There have been cases of counterfeited food products that were not up-to the standards of each country, passing all control points and being sold using a counterfeit food brand in determent of the bran owner. Technologies that can fight food counterfeit and

assure intellectual property are needed to assure customers that the products they buy in the market have the quality they demand.

Issues for producers: Along the same lines, producers have been urged to comply with all type of standard with technologies that are neither beneficial for them nor the community they represent. This has created a huge resistance to new technologies that are used to identify products. Producers on each country need a technology that can be ubiquitously found assuring that the price is low enough as not to take away their benefits and allow them to really reap the benefits of a constant communication with exporters and importers so they can be advised on the situation of their products.

Issues for transporters: Food products are temperature sensible and inside a container different temperatures can be found. Therefore, if a batch of food products were submitted to high temperature on the front of the container it does not mean that the products in the back are damaged. Technologies that can sense and identify the level of temperature food products have been submitted are needed as to assure supply chain members that the products have been kept inside the desired temperature levels.

Current technologies such as the barcode or the traditional written paper have not been able to address these problems. Moreover, when products have an outbreak, retailers and importers tend to destroy entire batches and sometime all the cargo, making exporters and producers pay the price without allowing them to investigate the cause of the contamination.

3. RFID technology

Radio Frequency IDentification (RFID) tags within the Electronic Product Code Global (EPCglobal^{TM}) framework can help customer, retailers, importers, exporters, transporters and producers solve these issues as item level can be tracked and traced. Therefore contamination points can be easily identified allowing differentiating from product, batch, cargo and complete production contamination when recalling and allowing complete product information to the customer when selling.

RFID is a technology among a wide range of Auto identification technologies such as barcode or biometrics identification technologies. One of the benefits of RFID is that the data does not need to be in-put or carried by a person rather it is done automatically. The basics are simple it uses radio waves to receive and transmit data found on chips (tags). There are a lot of business applications it can be used for: Asset tracking, Manufacturing, Supply chain management, Retailing, Payment systems, Security and Access control. The most important application is information sharing as stated by Brofman and Aguiar (2006).

The information is allocated into a tag, once the tag is charged or triggered by radio waves emitted by an antenna subject to a reader, the information is sent back to the reader's antenna only to be codified and transmitted to a database. A tag is a silicon chip with an antenna. Inside the chip the information is stored which usually is a unique serial number and some other information, depending on the silicon chip properties. The desired application will

dictate the tags to be selected, for tracking and tracing bottled water the tags that are most commonly used are passive tags for item tracking -shield by two plastics layers to isolate the effect of water over the tag- and active tags with temperature sensors for cases level.

RFID tags can store information both on the tag and inside databases. For tracking and tracing systems the passive tags should store only the Electronic Product Code (EPC^{TM}) assigned to the company and any other information shared through databases or wireless identification technologies, restricting information being read by third parties Brofman (2007).

4. Inal use of active RFID to Track and trace bottled water with RFID

Since 2006 “Industria Nacional de Alimentos limitada” (INAL) has been using active RFID transponders to track packages of bottled water to their destination in doing so it has improved the inventory accuracy and the lead time on the distribution process has been reduced, moreover it has assured customer the softness of the water it sells. INAL is a company founded in 1986 its core activity is the Ice Cream production and distribution throughout Bolivia. It has presence in 7 of the 9 Bolivian departments. It also has presence on the yogurt, water and jelly industries. “El Alto” water is demanded all over the country because of its soft properties and the company assures that its softness is achieved.

Even though Bolivian law offers the possibility for bottled water to be sold on the streets just as any products, the number of recalls the company was facing was enormous because of the exposure to the sun. The product comes in polyethylene terephthalate (PET) bottles that are used as a plastic packaging for the bottles. They come in two forms 500 cc and 2 liter forms. The 500cc was the format the company was experiencing most of the recalls where 12 bottles come in the pack. PET bottles have the disadvantage that when exposed to sun its components start getting mixed with the water creating two types of contamination: chemical and Bacterial. Even though, when the bottles where sold to the small retailers the level of contamination was according to Bolivian standards, when it reached the consumer the softness was decreased, the HACCP system did not allowed the required visibility to forward trace this problem.

Since PET bottles is the package product desired by Bolivian customers who buy bottled water, and is the cheapest bottle currently on the market, the solution had to come from another source. The water had to be delivered with the less exposure to sun as possible in order to assure lower levels of contamination. The way water was bottled and sold in INAL is depicted on figure 2. Three main contamination points were identified the first one was in final product warehouses were the water was waiting to be picked up. The second point, were most of the contamination used to occur was inside transportation cars, because of handling activities the bottles of water were exposed to the sun for long time inside the car. The third point can be found on point of sale where the customer is in charge of selling to the product to the people on the street. Most of the contamination occurred on this point were there are no rules for storing the product. As a result the product that used to reach the “street customer”

was damaged and not proper for consumption. In some cases, the bottle was damaged and in others water contamination was discovered.

In 2006 the company decided to start a trial with active RFID tags inside packs of bottles in one of its routes. It chose the one that goes inside “El Alto” a poor zone were storing conditions were not accurate and was the source for more than 45% of the damaged product. It decided to bring the customer closer to the production by eliminating the inventory point. The company shifted bottled water production to night staffs were it is produced on demand. To keep track of the products that were being sold, the company established readers on key ice cream freezers along the routes. The freezer were chosen according to the customers buying history and the ownership of it, that in most cases was own by the company.

Although, active tags with sensor do not require passing the information to readers since they have enough space to keep track of the cases’ temperature, this was needed to indicate the seller which product were exposed to high temperatures that cannot be sold on point of sale. This also has the advantage of being able to track inventory remotely for planning the purchasing order of raw materials during the day, since the company dos not own a PET blower. A picking order is generated that is passed to the companies’ database for next day production, when the location of the tag is not found. The seller at the end of the day has the responsibility of adjusting the order. After a new production process begins. Products that were exposed to high temperatures during the day are discarded and eliminated. The tags are charged for next day and the production starts all over. Figure 3 shows the new process for INAL’s bottled water.

The company has been able to reduce damaged product in 99% and moreover the ROI has come from the increased inventory visibility. Supply chain coordination is now a reality for the Bolivian bottled water company than now knows when and where to replenish bottles if the active transponder disappears from the freezer range, moreover when a case is observed to being submitted to high temperature it can be almost immediately replaced by the seller with another package. The company has increased its sales, and moreover customers’ well-being has being assured as they purchase real Bolivian “soft” water.

5. Discussion

Even though, Inal is not currently affiliated to EPCglobal^{TM}, nor is sharing information with supply chain partners, the company has used the standards the system proposes to track and trace the identity and the information needed to complete the route redesign, this was done using a vertical industry approach. Therefore contamination points were easily identified allowing the company to understand the information required in the database to follow the products contamination points.

Table 2 shows the information required by the company and how it was used to redesign the routes supply chain. As it can be seen the archaic method of writing the reports in a piece of paper are long gone for “El Alto’s” route, moreover the information of each individual packet of

bottled water has been able to generate satisfaction to all its stores. As it can be observed databases are used to allocate the information freeing the tag to record temperature all the time.

As table 2 shows, major emphasis was done on the chemical and physical properties of the product; this has enabled the company a registry of contaminated products and points that led to better manufacturing practices. Moreover the accuracy on its inventory control allows the company to respond to its customer (small poor shops) in a secure manner not engaging the brand in problems and assuring the products softness.

The customers, that are capital limited, have agreed to allow the company visibility of the products inside their stores, receiving in exchange not only better service but better price. The company form the customers assures better handling practices on their products and obviously the brand has not been counterfeit as the sensors tell the company about the state of the bottled water. This has creates a major competitive advantage for the company.

For future practice the company is currently looking for passive tags that will be embedded inside each bottle, increasing item level specific information and linking the other routes and 7 departments information to the companies central. Inside other rotes temperature will not be traced as the technology will be used for inventory control. Other department will use both technologies to increase “softness” temperature accuracy and inventory control.

The satisfaction the company expresses has only been limited by the price of tags, the company is willing to continue trials within the technology and moreover the company is looking at EPCIS™ standards to be used as the coordinating tool for departmental and external operations, especially to export the water to the neighbor country of Chile. The company already possesses a system that addresses supply chain members tracking and tracing issues stated above and is willing to deploy it on other settings.

6. Conclusions and recommendations

RFID is the technology of the future, it will revolutionize businesses and the way industry processes are done. The tracking and tracing capabilities of the technology can redefine the data to be captured for assuring food products, making them safer and more secure for the final customers.

When combined with sensors the food industry can redefine their supply chain and quality assurance processes in a more profitable manner as the technology has demonstrated at a Bolivian company. The company has increased inventory control in 99% and has assures that customers in one of its routes, that are low capital companies, comply with better handling practices the company needed as not to damage the product and keep the softness of the water provided. Moreover, the company future plans is to go into Item level on the technology been used on RFID passive format. The company is considering using EPC™ to links its departmental applications and is also considering exporting the bottled water to neighbor countries such as Chile because of the water “soft” properties cannot be founded in the region

and the company possesses already a system to assure that the properties are protected, thus creating a comparative and competitive advantage.

There is a need to explore in more depth the benefits the technology can bring when deployed with sensors. Currently companies, government's agencies and universities are starting to study passive tags with sensors; the benefits this could bring to the food industry have to be studied. The benefits of being able to capture remote data on each product can significantly improve tracking and tracing systems. Inal's case is only one undergone in the world.

8. References

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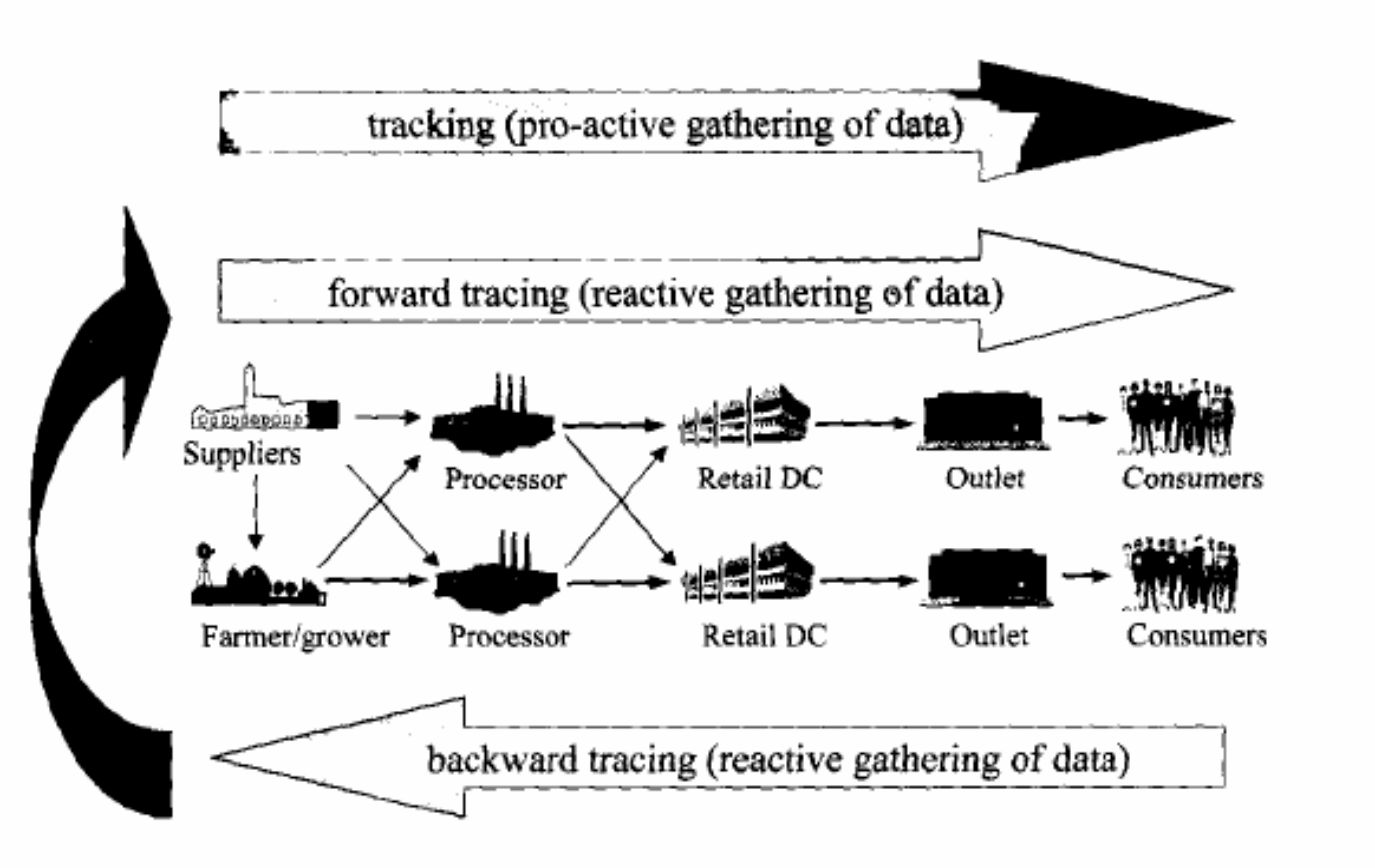
Figure 1
Tracking and tracing



Source: Van Vorst (2004)

Figure 2

INAL previous bottled water processing

Raw materials Purchase 7

Inventory control 5

Process order 3

Generate order 2

Plan production 6

Plan order picking 4

Product devolution 1

Record Sale 14

8 Receive, Store,

9 Produce Bottled water

Pick order 10

11 Load Truck

Transport 12

Sell products 13

Contamination point

Contamination point

Main Contamination point

Planning Process

Costumer driven process

Figure 3

INAL current bottled water processing

Raw materials Purchase 5

Plan production 4

Process order 3

Generate order 2

Plan order picking 8

Record Sale and temperature chart 1

Receive 6

Produce Bottled water 7

Pick order 9

Load Truck 10

Transport 11

Sell products 12

Main Contamination point

Costumer driven process

Table 1 **Data inside tracking and tracing systems and its redesign within RFID**			
Data on batch level required	**Data on item level required**	**Current problem**	**RFID within EPC™ system improvement**
a. The inherent properties of the product. Divided in:		Done mainly on batch level losing all information of individual items.	Individual properties of the batch can be recorded.
	1. The properties that a group of products has in common.	Done on group formulas, losing individual visibility.	Individual properties of the group of products can be recorded
	2. The properties that products have uniquely.	Hard to capture as each individual product belongs to a group of products and almost all the time they are done on industrialized levels.	Individual observation about the product can be recorded
	3. The type of attributes (e.g., chemical, biological).	Done on group formulas, losing individual visibility.	Individual observation about the product, the group of products and the batch of products **must** be stored.
b. The properties assigned by the processes in which they were made.		Done mainly on batch level loosing all information of individual items.	Specific process properties could be recorded to share with specific trading partners
c. The properties of production means that were used during the processes.		Done mainly on batch level losing all information of individual items.	Specific production means information properties could be recorded to share with specific trading partners
d. The provenance properties and origin properties.		Done on batch levels of procured items, losing visibility of items that are effectively contaminated and items that are not.	Specific properties about the procured items could be stores to share with trading partners
e. The relation between them.		Done mainly on batch level losing all information of individual items.	The network relationship will determine the information to be shared
Source: proposed by the author based on Van Dorp (2004)			

Table 2 Inal's data allocation inside the RFID active tag		
Data on batch level required	**Data on pack level required**	**Inal approach**
a. The inherent properties of the product. Divided in:		Allocate numbers according to each package of bottled water.
	1. The properties that a group of products has in common.	Write in the database the number of the package tag.
	2. The properties that products have uniquely.	Write in the database if any of the bottles of the pack was affected during the fill-up.
	3. The type of attributes (e.g., chemical, biological).	Write in the database the temperature the pack left manufacturing plant. Update the system once it arrives to deposits. Update the system once the product leaves the company. Update the system once the product is nearby a freezer. Update the system once the tag disappears from the read range of the freezer, update temperature and trigger a replenishment process.
b. The properties assigned by the processes in which they were made.		Update database information relevant to the HACCP system and the number of the tag.
c. The properties of production means that were used during the processes.		Update database information relevant to the HACCP system and the number of the tag.
d. The provenance properties and origin properties.		Update database information relevant to the HACCP system and the number of the tag.
e. The relation between them.		Update database information relevant to the HACCP system and the number of the tag.
Source: proposed by the author		