THE INTERNATIONAL JOURNAL OF BUSINESS & MANAGEMENT

The Product-Based Tracking System by Using RFID Technologies in Logistics Applications

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Abstract:
RFID systems supplies benefits like following the process of logistics better, executing inventory managing with less workers, decreasing labor costs and rate of waste, increasing costumer's service quality and following the attitude of costumer. The wrong placement on logistic applications, errors resulting from loading and processing, errors on information are reduces by RFID technology. Despite that, the height of the value of the investment and restructuring process show those RFID investments should be considered a strategic decision for the companies. In order to ensure the success of RFID, a comprehensive analysis of assessment, the acquisitions and the costs that are required by technology investments should be examined. This study aims to develop RFID technology to be used as a 'Product-Based Tracking System'. By using the system on the logistic processes, it will be tried to resolve the problems on the existing processes and to produce added value solutions to the companies.

Keywords: *RFID Systems, Logistics, Product-Based Tracking System*

1. Introduction

In recent years, automatic identification procedures (Auto-ID) have become very popular in service industries, purchasing and distribution logistics, manufacturing companies, and material flow systems. Automatic identification procedures exist to provide information about people, animals, goods, and products in transit. Figure 1 gives a brief overview of the different automatic ID systems.

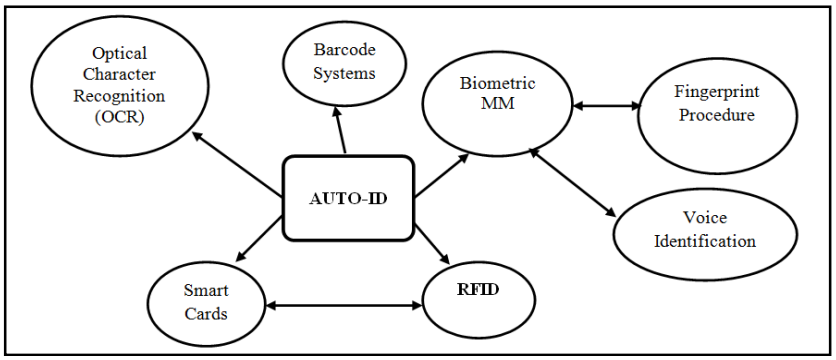

Figure 1: Overview of Auto-ID Systems
Source: (Finkenzeller, 2003:2)

One of the prominent categories of Auto-ID is radio frequency identification (RFID). RFID improves the traceability of products and their visibility throughout the entire supply chain. It makes also operational processes such as tracking, shipping, checkout, and counting processes faster and more reliable, which leads to improved inventory flows and information that is more accurate (Chow et al., 2006; Tajima, 2007). Companies integrate and store the accurate data obtained through RFID technologies in their information technology systems for better logistic systems (Whitaker et al., 2007).

This study aims to develop a product-based tracking system that uses RFID in logistic processes. In accordance with the objectives of the study, a product-based tracking system and related processes were discussed and investigations were carried out in the facilities of the vendor, the company, and the customer. It focused separately on the current processes and on determined the difficulties encountered in these processes to present solutions.

2. RFID Systems

RFID is a system that identifies people or objects using radio frequency technology (Hunt et al., 2007: 5). An RFID system consists of three phases. These are:

- A description of the object, linked to the identification number that has been recorded into the RFID tags attached to an antenna, is transferred to the antenna.
- An antenna reads the information inside the chip, and transmits it to by a radio signal to a reader.
- Transmission of radio waves from the RFID tag reader is converted into digital information into the computer system.

For a smooth and successful system, it is necessary to use the correct tag. Antennas, which are determined based on the application, must comply with the tags, and must coordinate with the readers and software that will make the information available. RFID systems consist of four components. These are the tags, antenna, reader, and software.

2.1. Tags

One of the major components of an RFID system is its labels. RFID labels contain a microchip that stores the information about an object and an antenna (Asif, 2005: 6). The tags are divided into three types, depending on the power used by the tag: active, passive, and semi-passive.

Passive tags have no independent source of electrical power to drive the circuitry in the tag and have no radio transmitter of their own. The passive tags depend on the rectification of the received power from the reader to support the operation of their circuitry, and to modify their interaction with the transmitted power from the reader in order to send information back from the tag. Semi-passive tags, known also as battery-assisted passive tags, provide a local battery to power the tag circuitry but still use backscattered communications for the tag-to-reader (uplink) communication. Active tags have both a local power source and a conventional transmitter and are, thus, configured as conventional bidirectional radio communications devices (Dobkin, 2007: 34-35). The passive tags communicate in ranges from a few millimeters (called the near field) all the way out to tens of meters. The active tags can communicate more than 100 meters (Sweeney, 2005: 40).

Another classification is made in terms of the information the tags store. According to this classification, tags are divided into three categories: tags that are readable only (read-only tags), tags that can be read and written (read-write tags), and tags that can be written once and read many times (write-once-read-many tags). The information storage capacity of read-only tags is low. The information recorded on this tag can in no way be changed by the user and can be read during the operation only. Read-write tags have high information storage capacity. Users of this type of label are able to save data whenever they want, and that can be read at any time. Information on write-once-read-many tags may be read more than once, but cannot be changed by the user (Lahiri, 2006: 17-18).

2.2. Antenna

Antennas are used in both the tag and reader. They differ in terms of technical characteristics and shapes and the dimensions of the antenna can be of various sizes (Asif, 2005: 11). An antenna is used to provide communication between a tag and the tag reader or readers. A tag and an antenna together comprise the wireless communication interface protocol (Glover and Bhatt, 2006: 108-110).

2.3. Readers

Readers can read the information on the RFID tag that was sent to the tag via a radio frequency sender using software (Hunt et al., 2007: 9). A reader uses its antenna to query and receive data from tags by broadcasting an RF signal (Glover and Bhatt, 2006). RFID readers are connected typically to a back-end server equipped with a database of tag information(Thornton et al., 2006). Whatever their particular type, all the readers consist of three principal components (Roussos, 2008):

- One or more antennas, which may be integrated or external.
- Radio interface, which is responsible for modulation, demodulation, transmission, and reception.
- A control system to direct communication with the tag and to interact with applications.

2.4. Software

The RFID system software, allows interaction between the tag and reader. The system can be set to read numerous tags at a certain time interval or physical distance and the system performs a verification process for security purposes between the reader-tag detection and correction of erroneous data. In general, system software is readily available with RFID hardware (Bhuptani and Moradpour, 2005).

A back-end server manages a database containing information associated with the RFID tags that it manages, and can retrieve the detailed tag information (or the identity of the item attached to the tag) using the tag response as a key. In summary, when a back-end server wants to identify one or more tags, a reader emits an RF signal via its antenna. Any tag

within range of the signal responds with certain stored data, such as a tag identifier. The reader then passes the received tag data to the back-end server. The server processes the tag information to identify the tag, and can then retrieve any needed information (Thornton et al., 2006: 16-17).

3. Literature Review

RFID technologies have gained significant interest from the logistic sector and academics in recent years. Table 1 presents publications on RFID applications in the logistic sector that focus on tracking systems.

Author(s)	Contribution
Chow et al. (2006)	Real-time knowledge-based system with integrated RFID, online analytical processing, case-based reasoning, and optimization models for supporting logistic decision making in planning and operation.
Liu et al. (2006)	Resource management system for real-time tracking of the position of goods and equipment in a warehouse, also selecting a suitable resource for package handling operations.
Chuan et al. (2007)	A warehouse robot that uses RFID to identify objects and places in the warehouse by reading their tags and is able to navigate to designated locations.
Huber et al. (2007)	Focused on the impact of RFID on the shrinkage problem for tracking goods, in particular at case-level and item-level. They analyze the challenges and the difficulties of the adoption of RFID technologies in supply chains using interviews of RFID vendors.
Karaer and Lee (2007)	Focus on the value of inventory visibility obtained through RFID technologies in reverse channel management.
Poon et al. (2008)	Development consisting of RFID-tagged forklift trucks and a network of readers covering an entire warehouse.
Kok et al. (2008)	Develop an analytic model to study the impact of RFID technology on inventory management with shrinkage errors. They quantify the potential gains of using RFID against shrinkage errors.
Hariharan and Bukkapatnam (2009)	Introduce a model to enable quick detection of misplaced items in the warehouse using portable RFID devices or RFID-enabled forklift trucks. This helps to avoid errors in storage location that lead to inventory inaccuracy, incomplete orders, and may lead to subsequent lost sales.
Wang et al. (2010)	Describe a digital warehouse management system, which consists of RFID-embedded pallets and shelves to provide real-time visualized inventory control and automatic storage and retrieval.

Table 1: Literature Review

4. Application of a Product-Based Tracking System

In this section, the operation of a product-based tracking system at a pharmaceutical firm in Turkey will be described, from receiving products from the vendor of the firm, to the production process at the production plant, the in-storage management of the product and the transfer of the product to the final point, the firm's customer. In addition, after examining the current processes, a plan to present instant information to the customer about the product through the internet will be presented. The firm will design and develop a "product-based tracking system."

To be able to carry out analyses on the processes associated with follow up of the products received from customers, in the warehouse of one of the firm's customers, some examinations were carried out. The application of a product-based tracking system will be examined in two modules.

- Goods Acceptance
- Goods Delivery–Shipping

4.1. Goods Acceptance

The process of the acceptance of goods begins with the process of receiving the products from the storehouse of the vendor in Düzce and accepting them in the warehouse of the firm in Samandıra. The current process consists of five stages. These are listed below.

1. [Vendor] The pharmaceutical products are prepared in the same vessel, are passed through packaging machine, and placed in the packages on which the same series numbers are written. These packages are turned into a pallet.

2. [Vendor] A consignment note is created (with the information of the material code, name of the material, lot number, and quantity) and is checked by a firm official. As a check, a random product is drawn from the pallet and the code, the name, and the lot number of the product are compared with the information on the consignment note. After the information is confirmed, the shipping of the pallets to the warehouse in Samandıra is initiated.

3. [Firm] The consignment note and the physical goods of pallets arrive at Samandıra and they are checked for a second time. All the items in the shipment and all pallets in each item are individually checked.

4. [Firm] If the shipment information and products correspond to each other, the pallet barcodes are prepared to be affixed to the pallets. For the barcodes to be prepared, the information on the consignment note is entered individually in the system and barcodes are taken as output.

5. [Firm] After the barcodes are affixed to the relevant pallets, following the direction of the commands given by the ExcenWMS system, the pallets are carried to the relevant shelves. After the carriage operation, the information on the consignment note, barcode and shelf location is entered into the ExcenWMS system by means of manual terminals.

4.1.1. Troubles Experienced in the Process and Suggested Solutions

There are two main problems experienced in the process. The problems are checking the information on the consignment note in both Düzce and Samandıra and transferring the information to the digital environment two times.

- *Problem 1: Checking the Information on the Consignment Note*

Checking the information comparing the physical goods and the consignment note is carried out in the warehouses of both Düzce and Samandıra. The staff in Düzce checks the information accompanying the shipment and the products on the pallets before shipping them to Samandıra. When the products arrive at Samandıra, the control procedures are carried out again. Doing the control procedures for a second time leads to loss of time. Especially when intensive inputs are made due to the workload, the staff hinders the input of newly arrived products into the system. In other words, the products arrive in Samandıra but the information cannot be recorded.

- *Solution 1: RFID Tags*

If the RFID tags are used to mark the pallets, at the moment the pallets pass through the gates of the warehouse, the system will receive the product information through the tags. Since the information of the material code, name of the material, and the lot number can be stored on the RFID tags, the process of matching this information to the consignment note will be performed automatically by the system.

- *Problem 2: Entering the Information on the Consignment Note into the System*

After the information of products sent from Düzce to Samandıra is checked from the aspect of comparing the consignment note and the physical goods, it is entered into the system. For this aim, Stage 4 and Stage 5 in the currently operating process are affected.

Currently, pallets are sent from Düzce without barcodes. Therefore, in order to prepare the barcodes to be affixed to the pallets, the pallet information (material code, name of material, lot number) must be entered into the system. After the barcode is printed, they are stuck to the pallets. Once the orders on carrying the pallets reach the forklifts, the pallets are placed on the correct shelves. After the operation of placing the pallets on the shelves is finished, then the information on the consignment note and shelf locations are entered into the ExcenWMS system. The same information on the consignment note is transferred to the digital medium two times. Entering the same data into the system takes extra time. For instance, in a shipment of 13 pallets, the check of pallets and entering the information into the system can take 30 minutes.

- *Solution 2:*

Provided the pallets are transferred from Düzce in such a way that the RFID tags are affixed, the time spent in entering the information will decrease. Now, when the pallets pass through the gates in the warehouse in Samandıra, the information will be recognized by the system. All information that is necessary to be entered into the ExcenWMS system (except for the shelf information) will be kept on the RFID tags. After a physical goods check is carried out and approved, the consignment information can be transferred to the ExcenWMS in a suitable format. After the pallet is placed, the shelf information can be entered into the system. Thanks to this, the following processes will disappear.

- Entering the information on consignment note into the system,
- Affixing barcodes,
- Entering the same information (together with the barcode information) into the ExcenWMS system.

To incorporate the RFID system, the process suggested is as follows:

[Vendor] The packages containing the boxes of pharmaceutical products are palletized. After the staff in Düzce checks the consignment note and physical goods, he/she enters the pallet information into the system by means of manual terminal and attaches the RFID tag holding this information to the pallet. For the staff in Düzce, instead of establishing a fixed system, following a process is designed. A roll of RFID tags will be prepared and delivered to the staff. On the RFID tag, the barcode number will be printed and the RFID tag will keep this information in its memory. After the pallets arrive and consignment note is checked, the staff will stick the prepared tag to the pallet. The staff will use also a manual terminal to read the pallet number on the RFID tag and enter the pallet information into the manual terminal. This information will reach the web server through the GPRS in a secure environment and will be sent later to the system in Samandıra.

[Firm] As soon as the products arrive at the warehouse in Samandıra and pass through the gates of the warehouse, they will be recognized by an RFID reader and will be compared to the information on the consignment note in the system.

[Firm] During the check of the consignment note and physical goods, if there is no mismatch, the transaction is approved and the consignment note information note is transferred automatically to the ExcenWMS. Only the shelf information needs to be entered automatically into the system.

4.1.2. The Benefits of an RFID System

According to the measurements carried out by the researcher, checking the pallets loaded on a truck to compare the consignment note and physical goods, preparing the barcode information, and sticking them to the relevant pallets takes an average of 30 minutes. It is predicted that the new system would lower the time spent for these procedures to 10 minutes and

the check of the consignment note would be performed automatically by the system. If a physical check is demanded, it will be able to be done by the staff. In the part of the process running in Düzce, the staff of the firm will enter the consignment note information into the system. It will prepare the RFID tag and affix the tags to the pallets. This process will bring an extra gain of 10 minutes per truck to the staff in Düzce.

As a result, if it is calculated that 6 trucks, on average, are loaded and unloaded in a day, the gain of 10 minutes per truck will result in a gain of 1 hour a day. In addition, the record keeping during the input of products will bring traceability in the system on the basis of the pallet. The supervisors would be able to track the movement of any product on a certain date.

4.2. Goods Delivery–Shipping

In the direction of shipment information coming from Düzce, the work carried out relates to the process of collecting the product in the desired quantity from the warehouse and repackaging it for distribution are as follows:

- As soon as the shipment information arrives from Düzce, the products can be collected from the warehouse (in the desired quantity), and brought to the sub warehouse.
- In the sub warehouse, the products are packaged for shipment. For example, 10 pieces of pharmaceutical product A and 20 pieces of pharmaceutical product B are brought to the table in the sub warehouse and the products are packed into three packages.
- The destination point, number of the consignment note, and the number of total packages prepared for that shipment ("3" for this example) are written on the packages.
- The number of packages is written also on the shipment form.
- When all the shipments are finished, no product should remain in the sub warehouse. If both the shipments and the packaging of the products are finished, the packages are grouped for shipping, and moved to the shipment area.
- The attendant of transportation comes with the shipment forms and, after comparing the information on the shipment form with the information on the packages (destination point, the number of consignment notes, and the total number of packages) loads the packages on the vehicle.

4.2.1. The Troubles Experienced in the Process and Suggested Solution

There are two main problems experienced in this process. The first is mistakes in the packaging. While performing the packaging operation, there is a possibility that an order could be assembled with more or less of a product than required, a different product, or a different number of packages than what is specified on the shipment form. Mistakes made during the packaging operation could be prevented by affixing the RFID tags to the packages. This suggestion does not seem to be suitable, however, due to both cost and technological inadequacy. The studies on solving this problem are continuing.

Another problem can occur at the point of shipping. After the attendant of transportation receives the packages (as mentioned earlier), he/she loads them according to the destination point, consignment note number, and the total pieces of packages. For example, 10 pieces of packages could have been prepared for the same shipment but "9" has been written on the shipment form by the employee. In this case, the attendant of transportation will collect 9 pieces of packages. For the remaining package, it will be necessary to make the checks again.

By using barcodes on the packages prepared for shipping, the incorrect identification of the number on the packages will be prevented and the information necessary for "vehicle tracking" after departure from the warehouse will be held on the package. The system will function through software on the computer in the sub warehouse. The suggested process is as follows:

- Each item of the shipment will be listed on the program.
- The information on how many packages are available for each shipment will be entered by the user. For example, if 3 pieces of packages are available for one shipment, 3 pieces of barcode printout will be received.
- Barcodes will hold the information of destination point, consignment note number, and order/total number on them (1/3 for the first package, 2/3 for the second package and 3/3 for the last package). The prepared barcode labels will be affixed to the packages without concern for the order and content of each package.

4.2.2. Benefits

As a result of the analysis, the current process of writing information on packages is a process in which four persons can spend three hours. Two persons only can carry out the suggested process within half of an hour. When both the number of persons and time is considered, it is foreseen that the improvement will be 12 times better than the existing system. When a cost account is made, based on a staff member receiving a wage of 7 Turkish Lira per hour, a monthly gain of 1,694 Turkish Lira can occur. The actual rate of these numbers may not be realistic. The alterations to the system would bring greater returns to the company during periods when intensive outputs are experienced. During periods with a low workload, the returns would be less. Package barcodes are used in the processes of many logistic firms today. A system that will be useful in terms of increasing traceability will enable more healthy data on the processes to be obtained to conduct successful analyses.

5. Conclusions

Initiating the RFID systems and forming "product-based tracking" systems should be a service in all logistic systems

from now on. Most logistics firms today find it necessary to offer this to their customers. Thus, the processes will bring a considerable rate of cost reduction. In addition, because of traceability, instant product tracking will be possible. These value-added activities will bring more high quality service to customers at a lower cost and in short, and will increase the firm's competitiveness.

A product-based tracking system is viewed as an investment that should be taken on in the name of protecting the brand value and position of a firm. The suggested solutions will both offer serious improvements to the processes of managing logistics and warehousing and will provide added value in terms of image and quality.

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