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BUSINESS JUSTIFICATION FOR THE IMPLEMENTATION OF RADIO FREQUENCY IDENTIFICATION IN SUPPORT OF LOGISTICS

CASE COMPANY: JAT-ASENNUS OY

INFORMATION TECHNOLOGY

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ABSTRACT

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Radio Frequency Identification (RFID) has in recent times gained enormous popularity that businesses consider as a possible technology to improve existing business processes. RFID and its related sensor technologies have the potential of changing and controlling business processes in a fundamental manner such as tracking of objects throughout the production line and subsequent life cycle of the products.

In this thesis, the practical insight was based on the case study at the ABB Oy drives factory in Pitäjänmäki, Helsinki. The analysis involved the concrete benefits of RFID technology in the manufacturing and the supply chain management of the company. According to the survey, ABB Oy Drives factory is using an Enterprise Resource Planning system known as the SAP R/3 software that was integrated with the RFID middleware to achieve the considerable potentials of RFID such as automating the material and products handlings system, lower error rates, cutting down production waste and reducing labour cost.

Moreover, when looking at the business justification aspects, it was realized that the specific cost of adoption the RFID system and benefits did not always correlate. That is, the adoption can incur considerable costs that outweigh the local benefits and vice versa depending on whether it is *local operational* or *inter-enterprise* applications. However, it was concluded based on the ABB case that a tangible and competitive advantages can be achieved by the technology if cooperating partners will come together to use the technology rather than a stand alone or local operation. With the technology, each cooperate company gained product traceability and quality assurance across the supply chain.

Keywords: Business process, Automating, Logistics, Inbound, and Outbound

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Next, a warm thank you goes to Mr. Ville Lukkari, Business Development Manager, Vilant Systems (RFID for Manufacturing and Logistics). He was such an instrumental figure in providing several critical insights that were invaluable to the development of the content of this thesis. I really appreciate his time dedicated to me in other to make this thesis success.

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Lastly, certainly not least, I want to thank my family and friends for their wholehearted support during the writing of the thesis. Especially to my daughter Julia Mensah, cheerfully put up with my long working hours in the evening and on weekends. Again, my thanks go to all whom in diverse ways supported and have not being mention.

Simon Mensah

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GLOSSARY

RFID	Radio Frequency Identification
AIDC	Automatic Identification and Data Capture
AC	Alternating Current
ELO	E-Business Logistics
XML	Extensible Mark-up Language
EPC Gen 2	Electronic Product Code Generation 2
UHF	Ultra High Frequency
JIT	Just in Time
CAD	Computer Aided Design
ROI	Return on Investment
ERP	Enterprise Resource planning system
SAP	Systems Application and Products in Data Processing
SAP R/3	SAP Integration software
EDI	Electronic Data Interchange
DC	Distribution Centre
ETC	Estimated Time of Completion

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1 INTRODUCTION

1.1 Background

Radio Frequency Identification (RFID) is a technology that has been in use in different areas especially in the grocery industry where competition and cost reduction is paramount issue. RFID is a technology where the goal is to identify goods automatically with as little human intervention as possible. This is especially interesting in logistics as mentioned in the grocery industry, however, in the thesis I will look at a manufacturing industry-JAT Asennus Oy where logistics plays an important role.

1.2 Purpose of the study

JAT Asennus Oy Company has been in business as a manufacturer and supplier of industrial automation since 1989. As a manufacturing company logistics of materials is the core backbone of the company, which facilitates its production progress. Unfortunately, the current logistical process in use is prone to errors and time consuming in planning and supervising logistics at the company.

However, the main objective of this thesis is to look at the possible way of improving the current system by the introduction of an appropriate technology "the RFID System" to the current infrastructure that almost operates manually. The result of this thesis intended to aid the company optimizing the potentials, the efficiencies, and the benefits for employing the RFID technology to increase productivity, efficiency and to have a very good material management system. In addition, to increase transparency in the supply chain to reduce the time it takes to initiate orders, receive goods and rectify errors.

Additionally, the systems if employed expected to make it possible to access precise statistical data on goods traffic (that is clean inventory). This will result in a more streamlined flow of materials and will free up capital from current assets throughout the supply chain of materials and products.

1.3 Thesis Definition

Materials and Components handling at JAT is a dynamic and complex process. That is a mixture of bulk materials and individual components for different project type as they come in every time during production complicates the logistics part of the production line. Its time consuming in the planning and supervising logistics, to have a clean inventory and sometimes lots of time are spent searching and waiting for materials and components to complete a particular project. Again, sometimes there is a possibility of delivery failures that will not be notify until the materials needed to be used that in turn creates unnecessary delays. When impacted with RFID tags delivery failures can be notice simultaneously as the materials arrive at the company.

However, because the intent of this study was to identify the potentials, efficiencies and the benefits of employing the RFID technology at the company rather than dealing with the physical components of the system or the real testing of the system at the company some assumptions and approximations were made to justify the use of the technology.

1.4 Work Description

In this thesis work, the implementation plan and the decision of employing an RFID system in the company in order to remove the bottleneck in the logistics process currently in use was looked at. In addition, a review of the current logistics process at the company and the examination of the RFID technology in marking and identifying materials that comes in the company in support of process and production improvement.

However, in considering the employment of the technology at the company the following two points were reckon:

1. The feasibility of using the RFID technology at the company - this is because the materials and products that will be track by the system are mostly metals and metal obstructions to the RFID system is the biggest drawback of using the technology in such an environment. In addition, any

impediments such as noise and other radio waves that generates because of operating other machines at the company.

2. The second point based on the cost-effect of using the RFID system. Is there are any real problems at the company that can justify the expense of employing the technology? Where the possible savings can be located? Reducing errors, increase in work efficiency or tying the office backend systems with the technology (integration).

Moreover, the restrictions encountered in this research work was that companies who have already using the RFID system and providers could not give me the exact figures of benefits for using the system rather gave an approximate values. In addition, the potentials and efficiencies of the technology is based on a case study, approximations, and assumptions since the chance of testing the system at the company could not be possible at the time of this work.

2 IMPLEMENTATION PLAN

Employing RFID systems can help alleviate some of the logistical processes in the company currently in use. Based on the potentials and efficiencies of RFID systems such as material tracking, also the papers and personnel working on a particular project can be track when technology employed at the production line. the tracking can begin right from the start of the cabinet drive, that is; when the cabinet only exist on paper till life time services; when service personnel wants to know the exact type of component or material used so that he/she can replace the same component or material after 10 years for genuine service.

2.1 Ideal Implementation Plan

An ideal process is the process that makes the number of errors as negligible as possible. The following points are the ideal processes accounted for when implementing the RFID system at the company.

- The owner of the cabinet drive issues a design with the specifications. This will be documented labelled with an RFID tag and uses an Electronic Data Interchange (EDI) system to verify if it is the latest version at key point.
- The designer will use a 3D CAD system to design the drive by using a common database to identify the best materials for the particular design.
- The designer’s design will be transform into drawings and a list of materials needed.
- Now the company can use the electronic document to order the needed materials and components for the project.
- The producers of the materials and components will receive the electronic document that contains all the information needed to produce the materials and the components. The order documents will contain any special considerations; this could be special packaging, delivery scheduling, colour specifications or anything relevant to the order.

- The producer of the materials packs the orders according to the specifications and an RFID tags retain the information about what has been done and what the next step. In addition, the producer sends an electronic shipping document to the company specifying what is in each shipment. The information can also contain information on how the other remaining orders are progressing.

- On delivery, the electronic documents are use as a basic inspection of the shipment. An RFID reader scans the items automatically on delivery and notifies interested parties.

- If the shipment passes the initial inspection, the system automatically administrates the billing procedure. In addition, the necessary information will be transfer to the back office systems.

- Finally, any service done on the drive can use the information in the RFID tags as needed.

2.2 Proposed Implementation Plan

The ideal process depicted involve a chain individuals, hence it is not likely to implement a full solution due the scope of this thesis. However, part of the ideal process will be implemented which is in anyway inherent in the possibilities of RFID. This solution will be independent of the other actors and will focuses solely at the company.

The implementation process will follow the guidelines as follows

- The company will send an order sheet in an Excel format to ABB that is, the company's major supplier of materials. This Excel form order will contain what materials should be pack together and when should be the delivery.

- Now at ABB, which is already using RFID tagging system for its inbound and outbound materials and products, will mark the order with the serial

number for each individual item and send it as shipping document to the company. Also ABB will write the number of items on each pallets to each tag on that pallet to ensure all tags are read later in the process.

- When the materials arrive at the company's premises, an RFID reader will scan all the pallets on arrival. The contents of the pallets will be check against the shipping documents that will accompany the materials. If the pallets checks out fine, the personnel responsible for the inspection will be, notify and the pallets are place at its appropriate place. Otherwise, the receiving personnel will be informing should there be an error in the pallet.

2.3 Justifying the adoption of RFID

To justify the use of RFID at the company, I will first analyse the existing business flows and compare it to the application of RFID under the same business process. The approach expects to determine accurate *return on investment* (ROI) so that the anticipation of using RFID can be realistic. The flow diagram below shows the existing logistics process of the company.

2.4 Existing process flow diagram

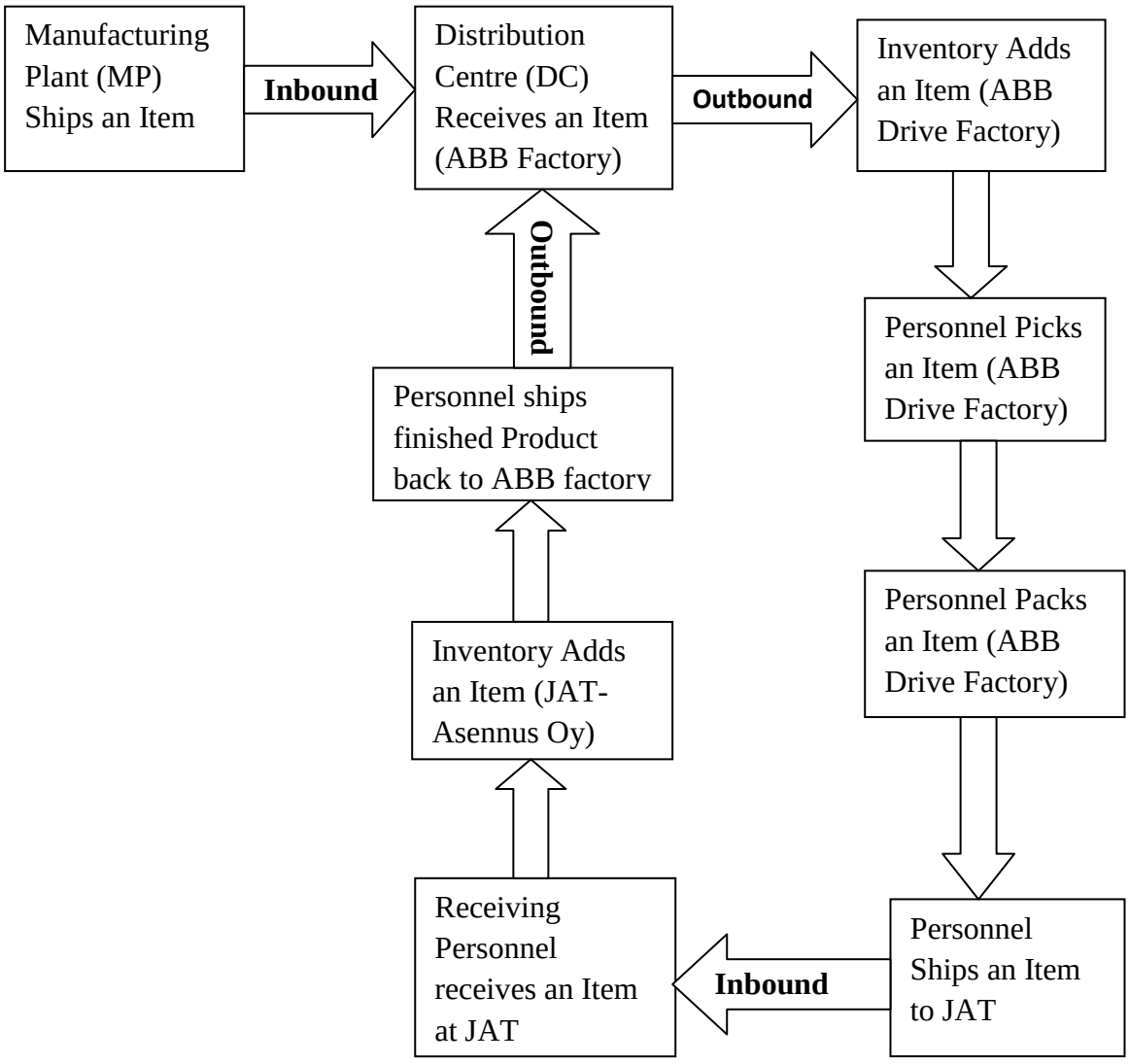

Fig 1 The Logistic process currently in use by the company

2.5 Explanation of the process

Table 1 Process

Use Case Name	JAT Asennus Oy Receiving point
Actor(s)	The Receiving Personnel (RP) – JAT Asennus Oy
Triggering Event	Arrival of an item sent from the distribution centre at ABB to JAT Asennus Oy.

1. A shipment containing the item arrives at the Receiving Dock at JAT
2. The Pallet containing the item is unloaded from the delivery truck.

Assumptions:

1. A pallet contains say 30 items packed individually.
2. Estimated Time of Completion (ETC) is the average time it takes to complete a particular step in this used case.

Description:

This use case describes the process of JAT receiving an item from the Distribution Centre (DC) of ABB oy.

Total ETC:

One pallet with a valid order and invalid items: {5 + (5*60 + (15*60 + (30*30)} seconds = 35 minutes 48 seconds.

Termination Outcome	Condition Affecting Termination Outcome
1. The item successfully received by the JAT Receiving Personnel. 2. The item could not be successfully received by the JAT Receiving Personnel	1. The item absent on the request list might be that it is not ordered.

The Major Steps Explained:

1. The Receiving Personnel manually checks the order number on the pallet to validate the order. (ETC: 5 seconds)
2. Here if an invalid order number is found, then the pallet is returned to the ABB Distribution Centre (ETC: 5minutes)
3. Else, if a valid order numbers found then the Receiving Personnel breaks the pallet. (ETC: 5minutes)
4. The Receiving Personnel manually checks the individual item codes to validate that the pallet contains all the items as per order. (ETC: 15minutes)
5. If an item is invalid, then the Receiving Personnel make a manual note of the item and sends it back to the ABB Distribution Centre. (5minutes).
6. Else, if an item is valid, then it is place on the received area from where is subsequently moved into the inventory. (ETC: 30 seconds)

2.6 Impacted with RFID

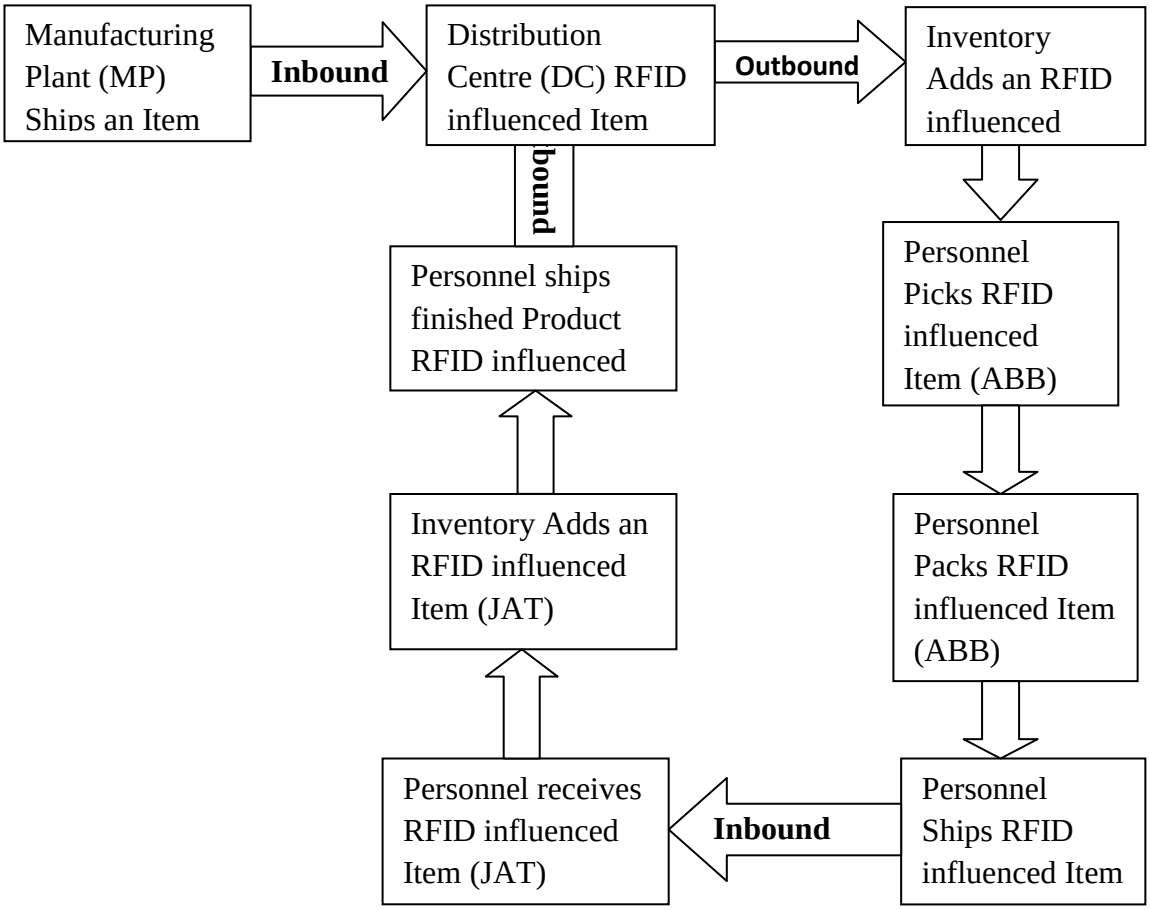

Fig 2 The existing logistics process influenced with RFID.

2.7 Explanation of RFID impact process

Table 2 The business process impacted with RFID chart explained [12].

<table>
<tr><td>Use Case Name</td><td colspan="2">JAT Asennus Oy Receiving point</td></tr>
<tr><td>Actor(s)</td><td colspan="2">The Receiving Personnel (RP) – JAT Asennus Oy</td></tr>
<tr><td>Triggering Event</td><td colspan="2">Arrival of an item sent from the distribution centre at ABB to JAT</td></tr>
<tr><td colspan="3">1. A shipment containing the item arrives at the Receiving Dock at JAT.
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<tr><td colspan="3">Assumptions</td></tr>
<tr><td colspan="3">1. A pallet contains say 30 items packed individually.
2. Estimated Time of Completion (ETC) is the average time it takes to complete a particular step in this used case.</td></tr>
<tr><td colspan="3">Description</td></tr>
<tr><td colspan="3">This use case describes the process of JAT receiving an item from the Distribution Centre (DC) of ABB oy.</td></tr>
<tr><td colspan="3">Total ETC</td></tr>
<tr><td colspan="3">One pallet with a valid order and invalid items: (10 + 5 + 30) seconds = 45 seconds.</td></tr>
<tr><td colspan="2">Termination Outcome</td><td>Condition Affecting Termination Outcome</td></tr>
<tr><td colspan="2">1. The item successfully received by the JAT Receiving Personnel.
2. The item could not be successfully received by the JAT Receiving Personnel</td><td>1. The item absent on the request list might be that it was not ordered</td></tr>
</table>

The Major Steps Explained

1. The Receiving Personnel places the packet inside the RFID portal. (ETC: 10 seconds)
2. The RFID reader automatically read the RFID pallet tag.
3. The RFID reader also automatically read the individual RFID tags on the items.
4. The results read by the reader are use to perform an automatic check for validation. (ETC steps 2, 3 and 4: 5 seconds).
5. If an invalid order number found then the pallet is, return unopened to the ABB distribution centre. (ETC: 3 minutes)
6. Else if a valid order number is found but the item is invalid, then
   - This is capture automatically by the system. (ETC: 2 seconds)
   - Pallet is broke by the RP. (ETC: 3minutes)
   - The item is send back to the DC. (ETC: 4minutes)
7. Else, if a valid order found without any invalid item then, the entire pallet placed on the received area from where it subsequently moved into the inventory. (ETC: 30 seconds)

2.8 Discussion/Analysing the processes

Comparing the estimated completion times of the current business process with the proposed RFID impact business process, it could be noticed that **35 minutes 3 seconds** can be achieved when RFID is used for a single pallet; this exclude any exceptional conditions. This corresponds to about 90% reduction in processing time for a single pallet.

Now if the receiving point at the company handles between 50 and 100 pallets a day it means a total of **29.21** and **58.42** hours a day (excluding exceptional conditions) can be achieve for an RFID impacted business case. Supposedly the company spends 10€ an hour on labour cost. This means a savings of **292.1€ to 584.2€** everyday can be achieved on labour alone. When we translates this into an

annual cost savings, it will about **75,946.00€ to 151,892.00** €; assuming 260 working day in the year.

Moreover, besides the extra labour cost that the RFID technology can reduce, other business value that can be achieve by using RFID system at the company is to minimize unnecessary orders that affect perpetual inventory accuracy. That is; orders that are manually made are bound to float inventories in the sense that manual orders are always made if a material cannot be found but it may be there though. In addition, the use of the RFID system can help track and monitor the life cycle of the product (cabinet drives) to improve safety and enhance relationship with customers. That is, it will be much easier to trace faulty parts and processes in the wake of complain.

3 BUSINESS CASES OF RFID

3.1 Introduction

RFID technology for automating goods and to simplifying the supply chain process of companies has been more effective in some part of the world. Two notable retail of goods supply chain companies who have being into the RFID technology is the Metro Group of Germany and Wal-Mart of USA. These companies and many more others have being the pioneers of the use of RFID technology [8].

Unfortunately, most industrial companies here in Finland have chosen to wait and see how the technology evolves before adopting it. But research done for this thesis revealed that the use of RFID system is gradually gaining root in companies such as ABB Oy at it drive factory, Nokia Oy, Prosec, Naisten Pukutehdas Oy with it unique NP collection, Tiehallinto (Finnish Road Administration), STX Europe's Finnish Shipyards and some few others [13].

3.2 Case Study – ABB Oy, Drive Factory, Helsinki

For the sake of this thesis, much more emphasis will be on the ABB Oy drives factory outbound and inbound RFID system because JAT Asennus's Oy is a subsidiary company to the ABB drives factory. About ninety percent (90%) of materials and components received at the company are delivery from the ABB drives factory distribution centre; Helsinki and by adopting the system it will be easier for both companies to manage the inventories of materials and the finish products.

ABB Oy drives factory in Pitäjämäki, Helsinki produces electrical drives for utility and industrial companies. The drives are frequency converters that control the rotational speed of alternating current (AC). It produces approximately 200,000 drives per year, hence the company employed RFID to better track it outbound shipments. It began using RFID technology in its order-supply chain as a pilot project in autumn 2004 and was set into full operation in December 2004 with some selected suppliers. Tekes ELO (E-Business Logistics) and Vilant Systems, the system suppliers, supported it. Developed to monitor shipments of

raw materials between the factory and its components suppliers and shipments of finished products (drives). The figure 3 below shows the architecture of the RFID system at ABB, Helsinki.

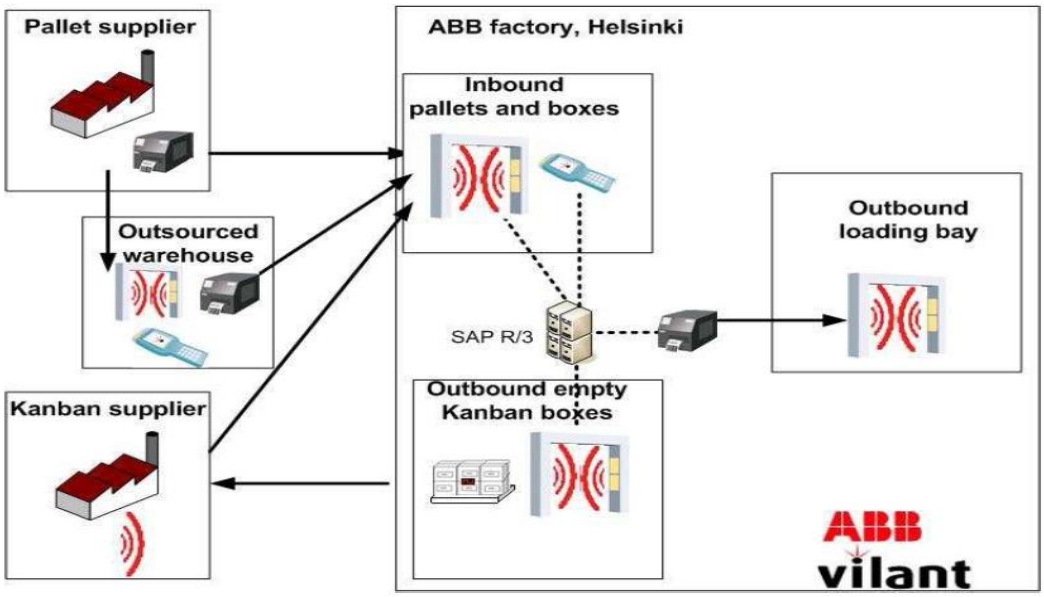

Fig. 3 ABB RFID system architecture explained [13].

ABB has as much as about 150 suppliers; the system was of three parts so that their supplier can comprehensively apply the system. The first was the Kanban system that was a process for managing material flows at the company. This process is automat by the RFID system. The fig. 4 below shows the architecture of the RFID Kanban process.

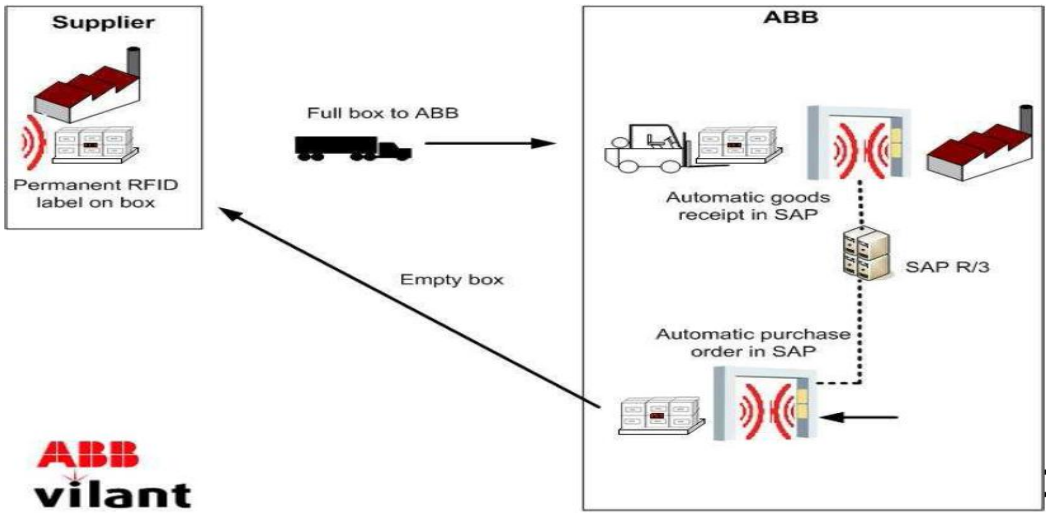

Fig 4 RFID Kanban container process explained [13].

3.3 ABB RFID system – How it works

There are standard containers that have been fixed with an RFID tag for material order, so if an empty container is moved to the shipment bay, it trigger an automatic materials order which shows up on the supplier's extranet via XML message. The supplier executing the order inputs an electronic shipment document into an RFID tag for a full container. At ABB Oy, the materials entered and registered automatically into the Enterprise Resource Planning system (ERP) via a drive of the RFID portal, thus removing the need for paper shipping documents.

According to Mr. Harri Heimonen, Director of Logistics, ABB Oy, Drives, the system has increase productivity, efficiency, and material management in the company. There has also being transparency of the supply chain by reducing the time it takes to initiate orders, receive goods, and rectify errors. Some benefits realized by ABB for using RFID systems in the company are as follows;

3.4 Benefits realized – ABB oy

- There was a great drop of time spent in receiving materials compared to the manual working.
- No paper delivery notes
- Faster order-delivery cycle
- Reduced stock, better flow
- Less errors and accurate inventory reporting

Fig 5 ABB Oy drive factory in Helsinki RFID explained [13].

Another system used alongside the Kanban RFID system is the Inbound Pallets with RFID Labels. It is used to register materials and goods on pallets from some of it suppliers. Figure 8 blow shows the architecture of the RFID system. The system is use without any changes to the Kanban RFID system employed earlier. What ABB did was that it mandated their suppliers who supply materials on pallets to stick an RFID tag to the pallet so that it could be receive automatically with the RFID system. This type of system is term as Slap-and-Slip approach.

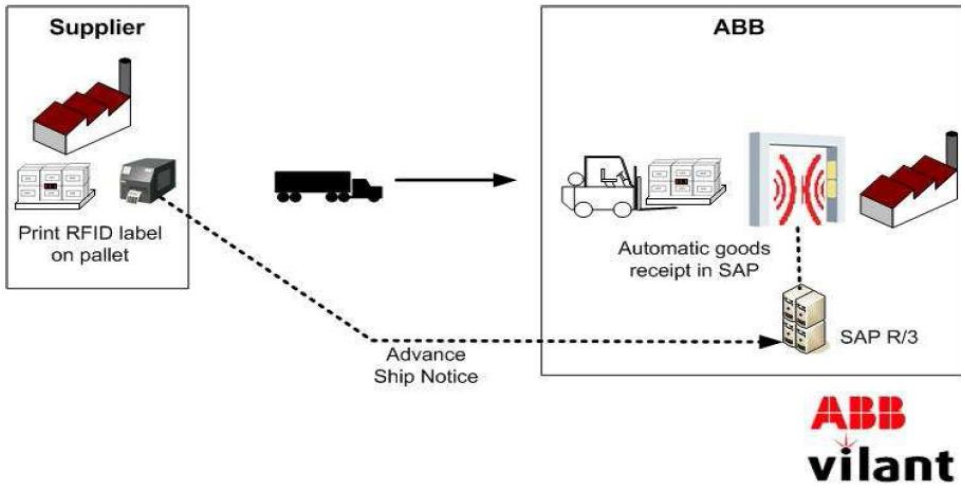

Fig 6 Inbound pallets with RFID labels [13]

Moreover, ABB wanted to track it products that leaves the production area in order to have a reliable data to compare with that of its logistics partners –thereby reducing the risk involving in outsourcing its logistics and warehousing tasks. Therefore, the outbound handling unit is to monitor loading and tracking of trucks to help reduce shipping errors. The fig. 7 below explains the system architecture of the outbound handling unit.

At the completion of the manufacturing of the drives, they are pack in a box or on a pallet (depending on the size and weight of the drive) and a worker applies a printed adhesive label containing an EPC Gen 2 UHF inlay to the box or pallet. However, as the truck being load, an RFID fixed gate readers upon interrogating the tags applied on the pallets and boxes registers the drives. The registered information is link to the database, which contains the ID number of the truck entered manually to monitor the loading progress of each vehicle.

The system produces a warning error at the gate if a worker attempts to load a wrong product onto a vehicle and it also notifies employees when a truck consignment is complete.

However ABB realized benefits such as less floor space required for shipment consolidation; (that is, more space for production is created), less loading errors

and have an automatic tracking of the products. The figures 7 and 8 show the portal of the outbound system and the outbound unit labels at ABB, Helsinki.

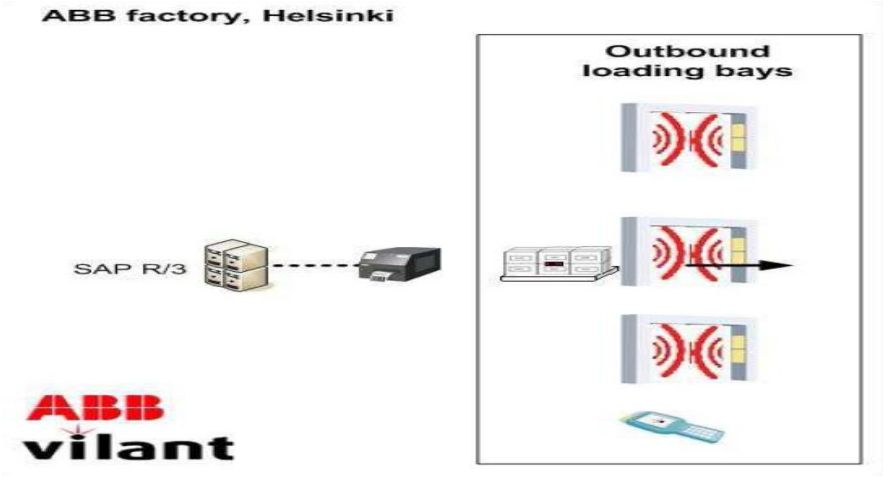

Fig 7 ABB Outbound handling unit loading and tracking [13]

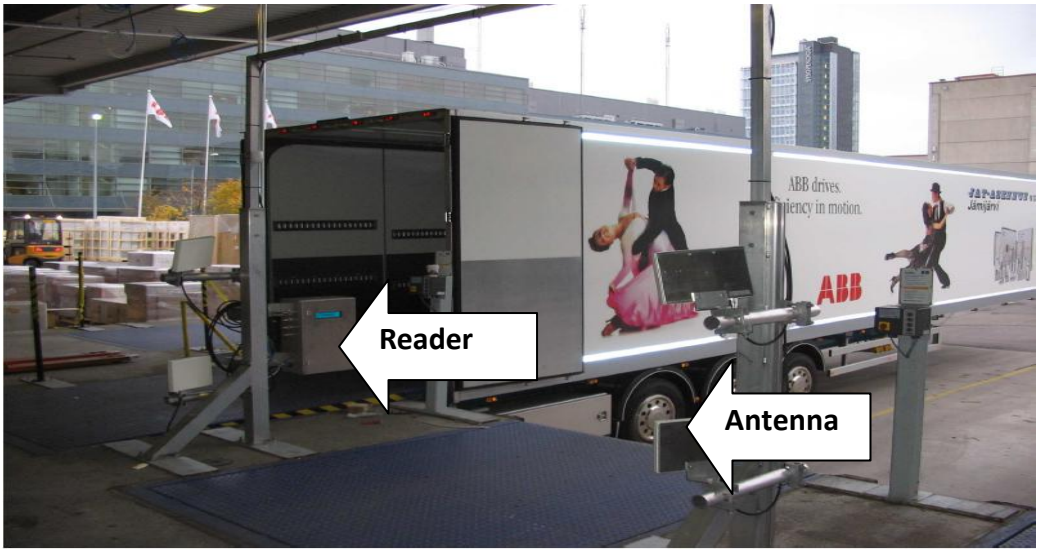

Fig 8 ABB outbound portals for registering outbound goods [13]

Fig 9 ABB RFID labels [13].

3.5 Logistics process of the Company

The flow of materials, components, and finish products is the logistical processes to ensure that the company operates effectively in order to achieve it major objectives. The logistical processes of the inbound and outbound are the primary activities on the generic value chain chart shown in figure 10 below

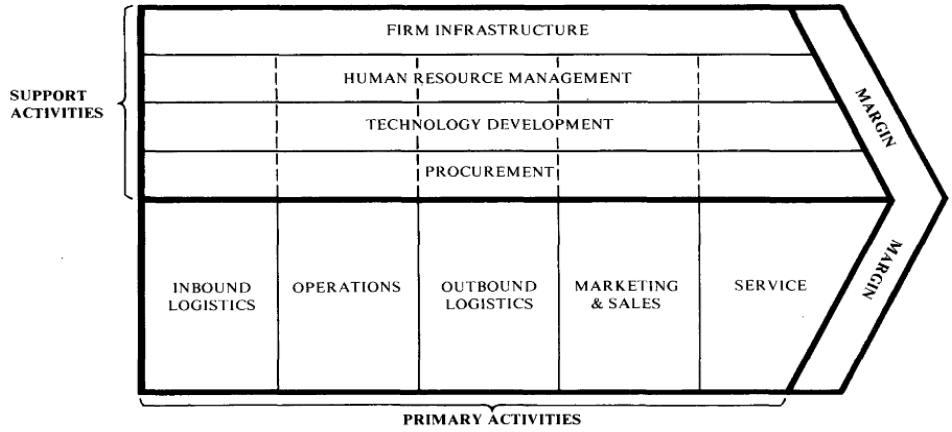

Fig 10 Generic value chain chart [7].

The inbound logistics activities of the company are associated with the receiving, storing, and disseminating inputs to the product such as material handling and inventory control. The outbound logistics activities on the other hand are associated with collecting, storing, and the physical distribution of products to customers such as finished product warehousing.

The material flow according to the logistics process currently in use is expected to facilitate materials to arrive at the time of need: that is the *JUST IN TIME (JIT)* method but it has not been as expected from the method due to human errors compound with the system.

3.5.1 Logistics of materials

The logistics process of material at the company starts when the designer checks the specifications of the cabinet drive and orders the necessary materials. Mostly, the orders are in bulk of items in large quanta in respect to the drive to been produced.

They are given a unique numbers that specifies the exact drive in which they will be installed. The order, always written as an Excel document that specifies the exact material and components needed. The order is then send to the ABB Drive

factory, Helsinki, with instructions on how the order be delivered. This includes any special packaging, that is, materials and components for a particular cabinet drives are placed on the same pallet and by certain delivery schedule.

They are then pack according to the ordering specification that is; stacked them on pallets, and crossed braced and screwed together. Finally the pallets are marked as to which company the delivery will be and is often done with a large felt pen on the outside of the wrappings or on the wooden beam or on the cross brace.

At the company, the logistics personnel receive them. A delivery note that indicates the contents always accompanies the delivery. The personnel check the papers against the actual content. In the case where the personnel fails to check the delivery properly, leads to an item unnoticed this goes on to delay production when the assembling team need it to complete a project at a later time and also represents inaccurate inventory.

4 INTEGRATION WITH EXISTING SYSTEM

4.1 Integration Plan

As the company is planning employing RFID system, there are also plans of re-using the existing applications whilst migrating to RFID enterprise infrastructure. The RFID applications (middleware) closely tied to the Enterprise Resource Planning (SAP ERP) software used in companies for business processes. Currently, the company is using SAP R/3 (ERP SAP R/3) to control its order-supply chain; hence, the integration of the RFID system application with the SAP R/3 extranet of the company is of much importance [8]. The integration processes of the systems consist of device-to-device integration, application-to-application integration, process-to-process integration, and business-to-business integration.

Fig. 11 below shows the functionalities overview of the integrating architecture. The vertical order of the components implies which functionality is commonly realized in which software system and on which hardware the software is running.

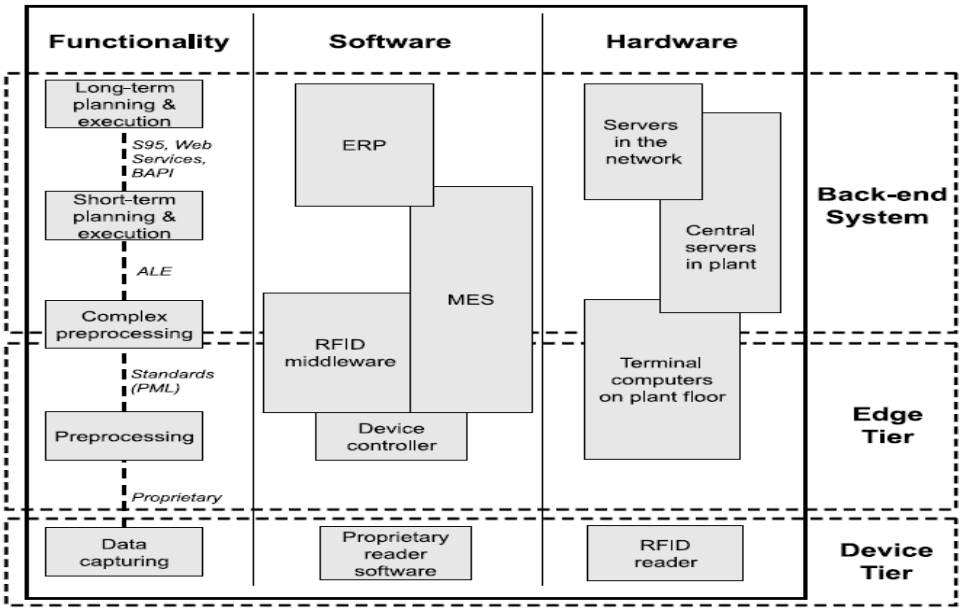

Fig 11 The functionalities system overview of the system explained [8] [12].

Figure 12 below depicts the physical connections of the various hardware components of the supposed system.

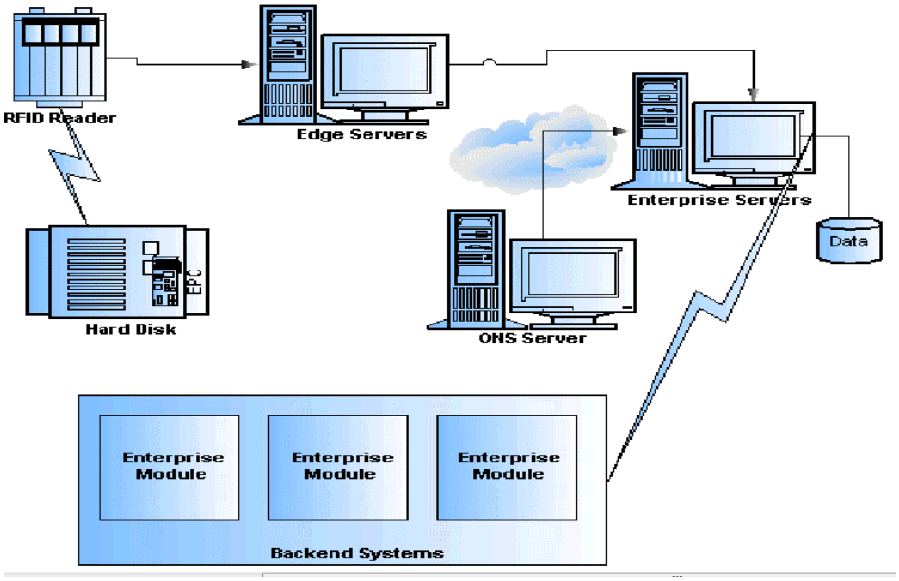

Fig 12 The physical connection of various hardware components explained [10].

However, the figure 13 below shows inter-company integration architecture of the system that in this case is JAT Asennus oy, Hämeenkyrö and ABB Drives factory, Helsinki.

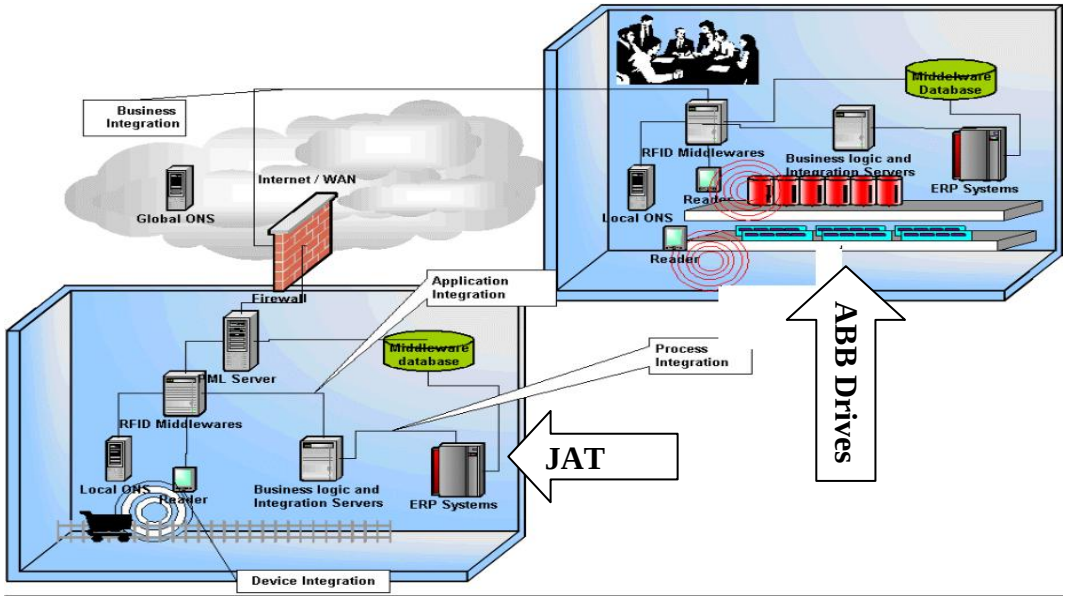

Fig 13 Inter-Company integration of the RFID system explained [10].

4.2 Benefits and Cost-effectiveness

4.2.1 Cost

The cost of implementation and running an RFID application comprises of various components. These consist of the hardware cost (tags and Readers), software cost, installation cost, tuning (integration), maintenance cost, training, cost of terminal computers. The table 3 below shows the budget for implementing an RFID system.

Table 3 Table for budgeting exercise [13]

Component	**Quantity**	**Unit Price (€)**	**Total Costs (€)**
Tags		0,15	
Readers		1,500	
Antennas		150	
Printers		1500	
Software, Integration, maintenance, training, Human resource and other cost.			This cost is in the range of **10,000** and **30,000** depending on the type of solution and the provider.

4.2.2 Benefits

Based on the case study (ABB), the RFID benefits that could be realized when RFID systems employed at the company will be as follows;

- Accelerating scan process of material by reducing reception time
- Reducing paper-based data management

- Automating material tracking
- Faster order-delivery cycle
- Reducing stock and have better flow
- Less errors
- Accurate reporting of inventory

5 RESULTS

As it has been analysed in the case used by ABB, it cannot be claimed that the insights are not the true representative or the general validity of the technology but I believe that the work done for this thesis may be helpful for the company and any other company wishing to adopt the RFID technology. My belief is based on the considerations and the insights obtained from ABB case concerning their current material handling situation and the previous system.

With the ABB case, it can be deduced that the use of RFID has great potentials in terms of efficiency and effectiveness. The efficiency potentials was realized by the possible speed-ups in production, lower error rates, reduced shrinkage, improved asset tracking and less downtime which are all contribution factors for productivity increase.

Furthermore, effective potentials noticed from the case study were that of faster order-delivery cycle with accurate reporting. Moreover, based on the ABB case, a tangible and competitive advantages and early Return on Investment (ROI) can easily be achieved by the RFID technology if cooperating partners will come together to use the technology rather than a stand alone or local operation.

5.1 Conclusions

The RFID system has some drawbacks, which always hinder its full adoption. One notable impediment is the cost of the system. The tags still have a high price except for very large orders and readers even more expensive, especially if one needs special requirements. The use of RFID in a production company like JAT uses Ultra High Frequency (UHF) tags to make the system more robust to its metal environment and this drive the price of adoption further high. The evolution of standards and accuracy and the continuous development of hardware standards also hinder the adoption of the system. The accuracy impediment factored with the limitation of the tag and readers. The communication between the tag and the reader (the radio waves) has limitations such as metal reflection and liquid

absorption of the radio signal that restricts the product and packaging that use the system.

5.2 Further Work

There are certain aspects of this thesis that will be looked at in the near future when enough funding becomes available. That means that the actual experience on the physical components of the RFID system at the company premises that might give more insight into the processes that might not be accessible from this literature study. It will also get an opportunity to perform a contextual study that will give more insight into the actual actors involving the technology.

In this regard, I can look at the economic importance in details to deduce some cost-effects that can be more reliable than looking at it from the perspectives of other projects (case studies).

Moreover, I can also evaluate well the specific need at the company concerning interference, range of read and penetrability for the various RFID frequencies in presence of metals and other obstacles.

Finally, one aspect and effective way for the technology I will be looking at in the near future is how to trace faulty components back to their manufacturing history that is of great importance for the company. With this, we can provide customer satisfaction about the products.

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APPENDIX

RFID System and Components

Radio Frequency Identification (RFID) is an Automatic Identification and Data Capture (AIDC) technology that uses a microchip (known as a tag) to transmit data upon RFID reader queries. The purpose of this technology is to identify and gather thorough information about a product, place (tracking), and transactions (inventory), quickly and easily by eliminating human errors using radio signals [9].

A technology uses radio waves to identify individual items automatically using what is known as; “digital watermark or individual signature”. It connects objects to the Internet or database so they can be track and companies can share the data among themselves.

The system simply consists of a tag (transponder) and a reader (transceiver), a middleware (the software that resides on a server between readers and the company), host computers. The tag is attach to the material to be track and as the material approaches the reader; a signal is send from the tag to the reader by means of an antenna attached it to update its database. The tag is a tiny chip with an antenna embedded and its only function is to send signal to a reader when it has received a request from a reader which operates in the same frequency and protocol [2] [6]. Figure 14 below explains the arrangement and the working process of the RFID system.

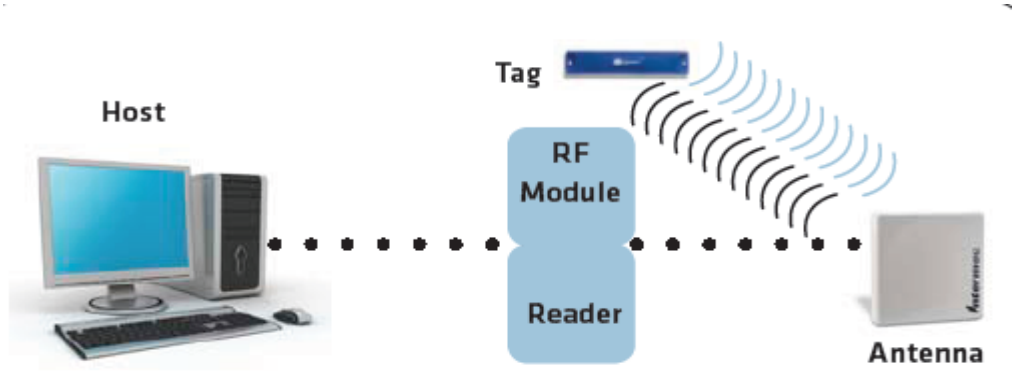

Fig 14 How the RFID system works explained [1].

The Tags/Transponders

RFID tags, ranges in size from a person's palm to a pinhead that contain a small radio frequency chip coupled to a microprocessor. That is, a device made from an electronic circuit carrying identification and other data about the item that can broadcast upon receiving a request from a reader that operates on the same frequency and protocol. Transponders or Tags classified into three types depending on its power sources. These are Passive, the Active and the semi-passive/semi-active tags [3]. Figure 15 below shows the different types of RFID tags.

Fig 15 Types of RFID passive/Active tags [5]

Readers or Transceivers

Readers are use to send information to the tag and receive back data from the tag. It communicates with the tag through an antenna, receives commands from application software, transforms radio waves into digital information, and provides power to passive tags. RFID readers can be either handheld or fixed [6]. Figure 16 below shows the types of handheld and fixed readers.

Fig 16 RFID fixed and handheld readers [3].

Antennas

Antennas are use to transmit and receive an electromagnetic waves or the radio frequency signal through wireless transfer as data.

The RFID antennas come in different forms and functionalities in terms of structure, size, operating mode, bandwidth, its gain, the polarization, its radiation patterns, the mutual coupling between multiple antennas and the antenna scattering. Figure 17 below shows some examples of the RFID system antennas:

Fig 17 RFID antennas types [4].