INTEGRATION OF RFID TECHNOLOGY IN A LOGISTIC CHAIN SUPPORTED IN AN ERP

Nuno Miguel Viães Rodrigues

Instituto Superior Técnico - Taguspark
Avenida Professor Cavaco Silva, 2780-990 Porto Salvo, Portugal
E-mail: nuno.viaes@gmail.com

ABSTRACT

With the rise of the dynamic and global market, organizations are more than ever struggling with cost and resource optimization, as well as with fast paced changing business models. In the field of distribution and logistics within warehouse management, specific needs of optimizing processes related with the receiving and shipping of products are a true move towards business agility.

This document presents an approach to solve that problem based on RFID technology, the emerging set of standards from EPCglobal, available RFID Middleware tools, analysis of the current business processes (typically supported by barcode technology) and a proposal of new business processes that explores the potential of RFID technology.

This paper proposes an architecture for the implementation of an RFID system integrated with an ERP, which usually manages the warehouse, as well the integration with the suppliers and customers, in order to facilitate the exchange of important business information.

Key words: RFID, Integration, ERP, Logistics, Warehouse Management, Business Processes.

1. INTRODUCTION

This paper presents the integration of RFID technology with an ERP System, in the field of Logistics and Distribution. The focus of this work is related with the impact in the processes of receiving and shipping products in a warehouse. The field of Logistics and Distribution covers the activities related with the physical flow of products that starts with an acquisition from the supplier to the sell to a final customer, including usually the storage in a warehouse and subsequent distribution.

Several limitations related with warehouse management exist (Myerson, 2007) (Bendavid, Wamba, & Lefebvre, 2006) (Curtin, Kauffman, & Riggins, 2007) (Goldsby & Martichenko, 2005):

- Highly human intervention in repetitive actions
- Each item must be individually identified, validated and counted by means of a code-bar system
- All relevant processing information must be manually inputted to the ERP
- Time and cost demanding processing
- Error prone methodology
- Lack of item tracking capabilities

With such a great set of current limitations, and to establish a starting point for discussion, it is important to understand why a unified and integrated view of this entire environment becomes so important. Such integration drives business agility due to the highly complex and rich world of partnerships between suppliers, the warehouse and ultimately, the customers.

In order to address all those needs, two important objectives must be fulfilled: the tracking of the item throughout all the chain, and ultimately, the intelligence of the system within the warehouse. Concerning item tracking, RFID is the state-of-the-art technology, offering comprehensive and automatic product identification, and tracking throughout the supply chain – such has the benefit of optimizing all warehouse and product management at competitive benefit and cost relation.

Concerning the need to provide intelligence and control, the ERP is the natural choice: it provides receiving and shipping management of all items and helps keeping track of orders and sales. This particular ERP implementation is based on Dynamics Nav ERP from Microsoft.

With this environment, a whole new set of objectives and service metrics can be defined and easily implemented:

- Optimize the warehouse management processes (study the AS-IS processes and defined what the TO-BE processes should be, with focus on automated item identification, validation and ERP input)
- Operation time and cost reduction
- Item quantity, receiving and shipping control
- Information and order sharing between suppliers, warehouse and customers

In order to present an efficient architecture and implementation, this work focuses its effort on the study of RFID technology (existing standards), support RFID Middleware tools and warehouse management processes. A prototype that proves this concept has also been developed: integration of RFID technology with the ERP Dynamics Nav, having particular scope in the link of all actors within the supply chain (supplier, warehouse and customer) through the exchange of documents, based in standards and service oriented, with generic and isolated modules and high degree of re-usability.

After having an insight about the problem and how to solve it, the next sections will focus on related work on this field, business processes, information entities, architecture, implementation and solution evaluation.

2. RELATED WORK

This section provides information about the study done about RFID technology, the standards from EPCglobal and a review of RFID Middleware tools.

2.1. RFID TECHNOLOGY

RFID is an automatic identification technology that has the purpose of identify and capture related information about the products that circulate throughout the supply chain without human intervention in the process (Ahson & Ilyas, 2008) (Su, Chu, Prabhu, & Gadh, 2007).

Since barcode technology is currently widely used in the supply chain, **Table 1** presents a comparison between the RFID technology and barcode technology.

	Barcode	RFID
Multiple Readings	No (One at a time)	Yes
Line of Sight	Needed	Not Needed
Reading Speed	Slow: ~4s	Very Quick: ~0.5s
Maximum Reading Distance	0-50 cm	Variable (few cm to ~100m)
Automation / Reading Efficiency	High manual work and manual reading mistakes	Completely automated and reading with high effectiveness
Identification	Type of Item	Instance
Data Capacity	Low	Very High
Tracking	Weak	Great Potential

Table 1: Comparison between Barcode and RFID (Finkenzeller, 2003) (Bhatt & Glover, 2006) (Lieshou, et al., 2007) (Holloway, 2006) (Laran RFID, 2004)

Analyzing the table is possible to realize the following advantages of RFID technology: no line of sight, quick reading of several items at the same time at different distances, item level identification and the possibility to automate the process. Additionally it provides great potential to track items throughout the supply chain in contrast with barcode technology (Laran RFID, 2004).

RFID is composed by three main components: the RFID tag, the RFID reader and the antenna (that allows communication between the tag and the reader). The data captured by the reader is then sent to a component called RFID Middleware which then transform the captured data into meaningfull information that is necessary for the business applications (ex. an ERP system) (Lieshou, et al., 2007). The **Figure 1** shows the typical architecture of an RFID System.

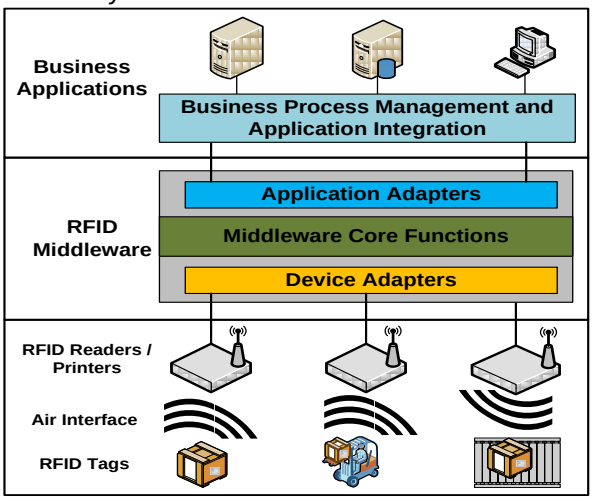

Figure 1: RFID System Architecture (Hunt, Puglia, & Puglia, 2007) (Lieshou, et al., 2007)

The RFID Tag is the component that allows the unique identification of an item through the use of a serial number. The tag can operate in different frequencies and each one as its own application, range and limitation as shown in **Table 2**.

Frequency	Range	Limitation	Application
Low Frequency	< 0.5 m	Metal	Animal Identification
High Frequency	up to 1.5 m	Metal	Access and Security
Ultra High Frequency	up to 100 m (433 to 864 MHz) 0.5 to 5 m (865-956 MHz	Water and Metal	Logistics
Microwave	> 10 m	Metal and Water	Mobile Vehicle Toll

Table 2: Properties and Applications of RFID Tags by Frequency (Holloway, 2006) (Domdouzis, Kumar, & Anumba, 2006) (Bhatt & Glover, 2006) (Su, Chu, Prabhu, & Gadh, 2007)

The RFID tag can also be passive, if no power source exists and the reader is needed to power up the tag, active if an internal power source exists and semi-active which is a hybrid solution (Bhatt & Glover, 2006). The **Table 3** summarizes the differences between the passive and active tags.

	Passive	Active
Power source	No	Yes
Range	Short	Long
Data Storage	Small	Large
Lifetime	Unlimited	Limited
Typical Applications	Low cost items	High Cost Items

Table 3: Differences between Passive and Active RFID Tags (Domdouzis, Kumar, & Anumba, 2006) (Harmon, 2002)

Additionally, the tag data storage type can be defined as Read Only, Read Write and Write Only Read Many (WORM) (Bhatt & Glover, 2006) (Holloway, 2006). Some tags also have capabilities related with security and privacy (Bhatt & Glover, 2006).

The RFID Reader is the link between the RFID Middleware and the data stored in the tags. The main function is to capture data within is reach, perform some internal operations and send to the RFID Middleware. Some readers also have the capability to write information in the tags (called RFID printers) (Hunt, Puglia, & Puglia, 2007) (Moradpour & Bhuptani, 2005).

The RFID Middleware, as shown in **Figure 1**, is the main link between the RFID Technology and the Business Applications. It must support the following main functions:

- Data Capture and Treatment: extraction, aggregation, transformation and filtering;
- Data Routing: send the information to the right business application
- Device Management
- Application of Business Rules

2.2. GS1 EPCGLOBAL STANDARDS

The development of standards for the RFID Technology is important in order to facilitate the adoption by the organizations. The GS1 EPCglobal[1] is the organization responsible for promoting the Electronic Product Code (EPC) and the EPCglobal Architecture Framework.

The EPC is a numerical scheme that uniquely identifies an item. The **Figure 2** shows its mains fields (EPCglobal Inc., 2006a):

Figure 2: EPC 96 bits

[1] http://www.epcglobalinc.org/home

The EPC code is a *"meta-coding scheme"* designed to support the needs of different industries, supporting schemes of EAN.UCC[2] family, for example the SGTIN and SSCC, used to identify a product and a pallet, respectively. The Tag Data Standard (EPCglobal Inc., 2008c) defines the characteristics of the schemas and how to code and decode them. Another important standard is the Tag Data Translation (EPCglobal Inc., 2008c) that defines how to transform an EPC code to different levels of representation.

The EPCglobal Architecture Framework (**Figure 3**) is a collection of inter-related standards for hardware, software and data interfaces, together with core services (operated by EPCglobal or third parties). The main objective is to facilitate the exchange of information about items (physical objects) identified by the EPC code between partners throughout the supply chain. The framework defines the interfaces between components (showed in gray in the **Figure 3**) in order to facilitate interoperability between different implementations, to foster the existence of a competitive market and to encourage innovation (EPCglobal Inc., 2007c).

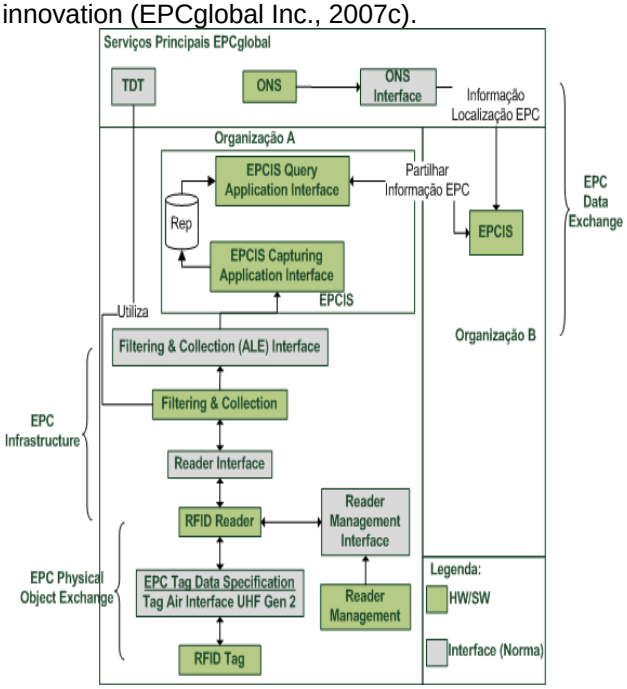

Figure 3: EPCglobal Architecture Framework

2.3. RFID MIDDLEWARE TOOLS

In order to implement an RFID System, it is necessary to use the RFID Middleware that links the RFID technology (tags and readers) with the business applications. In this section were analysed

[2] http://www.gs1.org/productssolutions/barcodes/technical/id_keys.html

four RFID Middleware tools. The functionalities and capabilities are summarized in Table 4.

	BizTalk RFID	IBM WebSphere RFID	BEA WebLogic RFID	SyBase RFID Anywhere
Device Management				
Management, Configuration and Installation	✓	✓	✓	✓
Remote Management and Configuration of devices	✓	✓	✓	✓
Low Level Processing	✓	✓	✓	-
Mobile Device Support	✓	✓	✓	✓
Event Processing				
Data Capture and Treatment	✓	✓	✓	✓
Business Rule Processing Support	✓	✓	✓	✓
RFID Events Storage	✓	✓	✓	✓
Business Integration				
Web Services Integration	✓	✓	✓	✓
Business Applications Integration (ERP, WMS, etc)	✓	✓	✓	✓
Standards				
Tags EPC e ISO	✓	✓	✓	✓
TDT	✓	-	-	-
ALE	-	✓	✓	✓
EPCIS	✓	✓	-	-
LLRP	✓		-	-
Other				
Device Simulator	✓	-	-	✓
Reporting Capabilities	-		✓	✓

Table 4: Comparison of RFID Middleware Tools (Microsoft Corporation, 2007a) (IBM, 2006) (BEA Systems, 2006) (iAnywhere, a Sybase Company, 2008)

3. BUSINESS PROCESSES

The warehouses are typically used to store the products received from several suppliers and then sold and distributed to the customers. The **Figure 4** shows four processes that handles the management of products that enter, are stored and then shipped to customers (Ghiani, Laporte, & Musmanno, 2004). As previously stated the current paper only focuses on the receiving and shipping processes.

Figure 4: Typical Processes in Warehouse Management (Ghiani, Laporte, & Musmanno, 2004)

In order to define an warehouse system that uses RFID Technology, the current receiving and shipping processes supported by barcode technology (AS-IS) were analyzed in order to find which activities could be optimized. The analysis was based on the following sources:

- Theory about warehouse management in order to understand the main concepts and some activities executed in the processes (Hansen & Gillert, 2008) (Bowersox, Closs, & Cooper, 2002) (Ghiani, Laporte, & Musmanno, 2004)
- A case study (Wamba, Lefebvre, & Lefebvre, 2006)
- Pratical Analysis of the training and technical documentation of ERP Dynamics Nav (Hamilton, 2004) (Microsoft Corporation, 2004a) (Microsoft Corporation, 2004b).

After that, new processes were defined (TO-BE).

The main differences between the AS-IS scenario and TO-BE scenario for the receiving process are:

- Reception of a document from the supplier that specifies which products were sent, which helps the warehouse in the identification and validation of products, called ASN.
- Automation of the activities related with the identification and validation of received products;
- Input of information in the ERP is made automatically
- Automatic Inventory update based on processed information by the RFID technology

For the shipping process the main differences between the two scenarios are:

- Automation of the activities related with the identification and validation of shipped products;
- Input of information in the ERP is made automatically
- Automatic generation of an ASN document to send to the customer
- Automatic Inventory update based on processed information by the RFID technology

- Automatically generate the list of products to send based on the purchase order sent by the customer

4. INFORMATIONAL ENTITIES

In the definition of the receiving and shipping TO-BE processes, there is a set of information entities that are necessary to be supported in the ERP system, so that correct process execution can be assured (state and information must be stored):

- Supplier – identifies a product supplier with RFID tags that are stored in the warehouse.
- Customer – identifies a customer that receives products with RFID tags from the warehouse.
- Warehouse – identifies the warehouse where the products are received from the supplier and shipped to the customer.
- Product (Item) – represents the product stored in the warehouse.
- RFID Item – represents RFID information associated to an instance of a product.
- Purchase order – represents an order of products from the warehouse to the supplier and from the customer to the warehouse.
- Sales order – represents information of a sale of the warehouse to the customer.
- Advanced Shipping Notice (ASN) – represents information about the products that are sent to a customer from the warehouse, and from the supplier to the warehouse.
- Receiving RFID Document – represents RFID reading processing of the products received at the warehouse.
- Shipping RFID Document – represents RFID reading processing of the products shipped by the warehouse.
- List of Products to send – represents information about the list of products that should be sent to the customer (from the sales order) – contains information about the RFID tagged products in stock in the warehouse.

Having all the business processes and information entities presented, the next section will present the proposed architecture.

5. PROPOSED ARCHITECTURE FOR THE RFID SYSTEM

Concluded the processes and information entities definition, this section presents the proposed architecture.

The defined architecture shown in **Figure 5** has the following managers and each one of them as a key role in the system:

- Database Manager – the main objective is to store and provide access to needed information during the RFID processing in the Receipt Products Manager and Shipping Products Manager.
- Receipt Products Manager **–** directly connected with the receiving products process. The main objective is to process information captured by the RFID readers at the entrance of the warehouse.
- Shipping Products Manager – directly connected with the shipping products process. The main objective is to process information captured by the RFID readers at the exit of the warehouse.
- Integration Manager – acts as a "hub" to exchange information between the Receipt Products Manager / Shipping Products Manager and the ERP Manager. Also provides to the warehouse the capability to exchange business information with the supplier system and customer system.
- ERP Manager – provides a set of services (ERP Services in the architecture) consumed by the Integration Manager, that interact with the core of the ERP Dynamics Nav. The existence of the ERP Services is to guarantee that not all the internal logic of the ERP is exposed to the outside.
- Supplier / Customer Services – set of services exposed by the warehouse to allow the exchange of purchase orders and ASN's with the supplier and the customer.

The defined architecture was designed with the following objectives in mind: modularity, extensibility, separation of concerns, ease of development and component distribution.

In order to better understand the global behaviour of all the managers the **Table 5** and **Table 6** show the interaction between them for the receiving and shipping process, respectively.

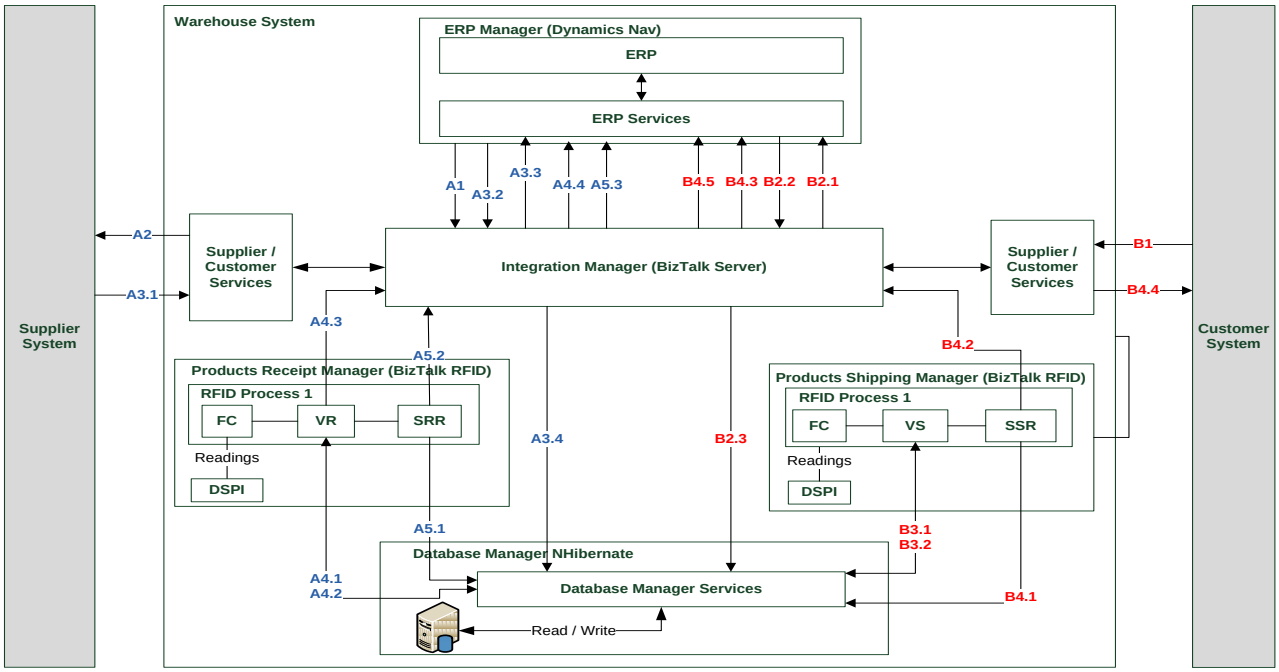

Figure 5: Proposed Architecture for the RFID System

Id	Description
A1.	A purchase order is created in the ERP and sent to the Integration Manager
A2.	The purchase order is sent to the supplier system
A3.1	The supplier sends the ASN to the warehouse system
A3.2	The warehouse system gets the purchase order from the ERP in order to validate against the ASN
A3.3	After validation the ASN is sent to the ERP Manager to be stored
A3.4	The ASN is also stored in the Database Manager to be used in the validation executed by the Receipt Products Manager
A4.1	The Receipt Products Manager gets from the Database Manager the ASN to execute the validation of received products
A4.2	After product validation using the ASN, the Receipt Products Manager sends the updated ASN to the Database Manager.
A4.3	The updated ASN is also sent to the Integration Manager.
A4.4	The Integration Manager processes the ASN and send it to the ERP Manager.
A5.1	The Receipt Products Manager sends the Receiving RFID Document to the Database Manager to be stored
A5.2	The Receipt Products Manager sends the Receiving RFID Document to the Integration Manager.
A5.3	The Integration Manager processes the Receiving RFID Document and sends it to the ERP Manager to be stored and to perform a warehouse inventory update.

Table 5: Managers Interaction for receiving process

Id	Description
B1	The customer sends a purchase order to the warehouse
B2.1	The Integration Manager receives the purchase order, process it and generate a sales order. The sales order is sent to the ERP.
B2.2	In the ERP system the List of Products to send is generated which is sent to the Integration Manager
B2.3	The List of Products to send is sent to the Database Manager to be stored so that can be user to perform the validation executed in the Shipping Products Manager
B3.1	The Shipping Products Manager gets from the Database Manager the List of Products to send to perform the validation of shipped products.
B3.2	After the validation of products to ship the Shipping Products Manager sends the updated List of Products to send to the Database Manager
B4.1	The Shipping Products Manager sends the Shipping RFID Document to the Database Manager to be stored.
B4.2	The Shipping Products Manager sends the Shipping RFID Document to the Integration Manager.
B4.3	The Integration Manager processes the Shipping RFID Document and sends it to the ERP Manager to be stored and to perform a warehouse inventory update.
B4.4	The Integration Manager using the information in the Shipping RFID Document generates and sends the ASN to the customer.
B4.5	The Integration Manager sends the ASN to the ERP Manager to be stored.

Table 6: Managers Interaction for the shipping process

6. IMPLEMENTATION

This section describes the main decisions and technical considerations regarding the prototype implementation.

6.1. MAIN DECISIONS

Two decisions were made related with the informational entities that must be stored in the ERP system. The first one is about the use of proprietary representation for the purchase order and the ASN entities. In order to perform exchange of business information with the supplier and customer EDI could be used. Still, in order to avoid increasing the complexity of the prototype, the representation used for the purchase order is directly related with the representation used in the Dynamics Nav.

The second decision is related to the simplification made for the representation of the ASN. In a typical ASN five levels normally exists: shipping level, purchase order level, pallet level, box level and item level. In the case of this prototype it was assumed that the supplier sends the products always aggregated in one pallet and each product is represented with a unique identifier (EPC code). This means that 1 order is related to 1 ASN with N products and N RFID Tags. The levels used in the representation were: shipping level (contains information about ASN id, purchase order id, pallet tag id), item level (product id, quantity) and in order to represent an instance of a product a new level was created that stores the Tag EPC code and a state. The name used was SimpleASN.

One last decision made is concerned with the tagging of the pallet when the products are shipped to the customer. Typically, this operation is performed in the previous process (picking and then packing) (Bowersox, Closs, & Cooper, 2002). Since this process is out of scope and the tagging of pallet was needed, a simulation of this operation was created in the implemented prototype.

6.2. MANAGERS IMPLEMENTATION

This subsection details what was made to implement each manager described in the architecture.

The **ERP Manager** was the most difficult to implement, since programming in the ERP Dynamics Nav wasn't a trivial task. Another problem found was related to how to insert and get information to / from the ERP. The solution was to use Message Queuing in order to send and receive messages to/from the ERP system. In order to import and export XML files, the file system was used with the help of a component in the ERP called *XMLPort*. In order to communicate to the outside services an application server called NAS was also configured. The **Figure 6** shows the found solution.

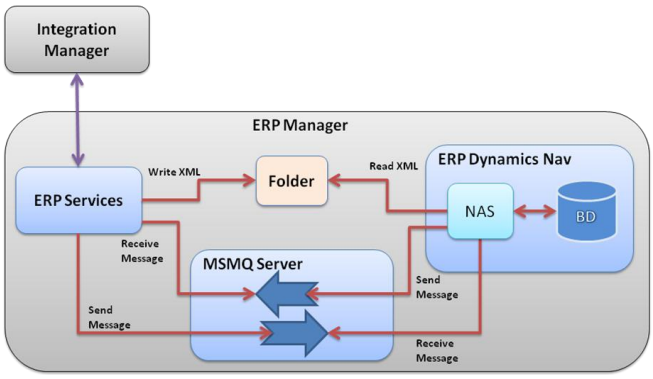

Figure 6: Integration with ERP Dynamics Nav

In the ERP System tables and forms were created in order to represent the informational entities described in **[4]**. The **Figure 7** shows the Product form with a relation with RFID Item Form inside Dynamics Nav.

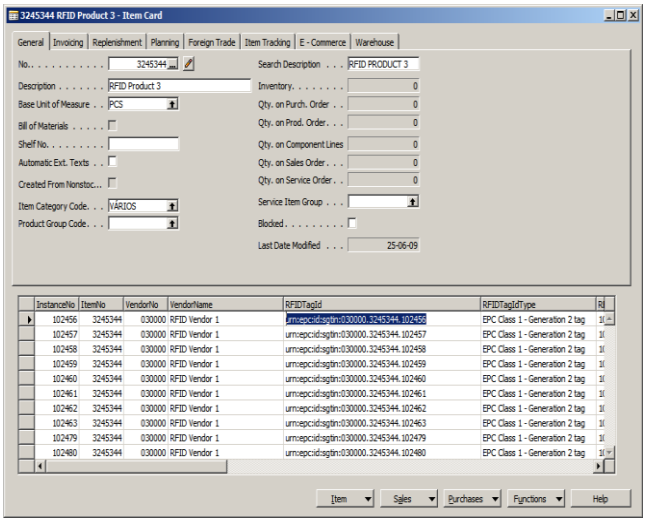

Figure 7: Product Form With Relation With RIFD Item

The *XMLPorts* used to import and export XML information were created for the purchase order, Receiving RFID Document, Shipping RFID Document, Sales Order, SimpleASN Customer, SimpleASN Supplier and List of Products to send. The ERP System supports the following operations related with the ERP Services: Get Purchase Order, Insert SimpleASN Supplier, Update SimpleASN Supplier, Insert Receiving RFID Document, Insert Sales Order, Insert Shipping RFID Document and Insert SimpleASN Client.

The **Receipt Products Manager** implementation is show in the **Figure 8**.

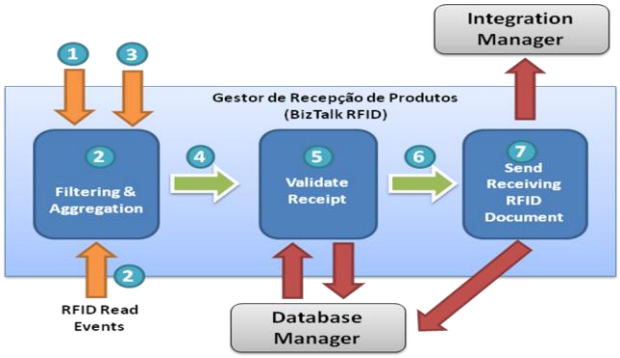

Figure 8: Receipt Products Manager internal implementation

Three main components were created:

- Filtering and Aggregation – during a certain time (event cycle), activitated in step 1 and finished in step 3, filtering of dupplicated reads, identification of EPC tags, translation of raw RFID data into meningfull information is performed (2). In the end all gathered RFID information are aggregated (4)
- Receipt Validation – the aggregated information is received and used to perform validation of the received products (5) against the associated SimpleASN.
- Send of Receiving RFID Document – after validation of the received produts, the Receiving RFID Document is generated and sent to the Integration Manager (7).

The **Shipping Products Manager** implementation is show in the **Figure 9**.

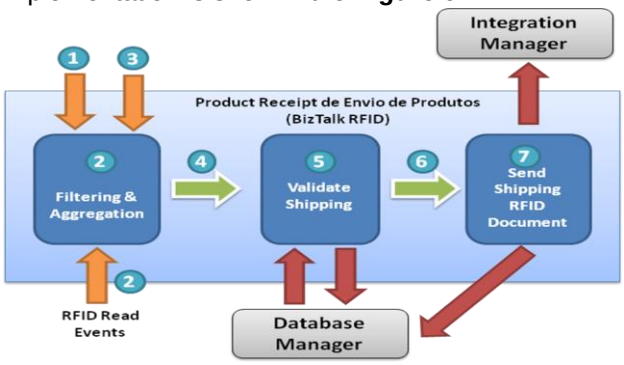

Figure 9: Shipping Products Manager internal implementation

Like in the previous manager three main components were created:

- Filtering and Aggregation – during a certain time (event cycle), activitated in step 1 and finished in step 3, filtering of dupplicated reads, identification of EPC tags, translation of raw RFID data into meningfull information is performed (2). In the end all gathered RFID information are aggregated (4)
- Shipping Validation – the aggregated information is received and used to perform validation of the shipped products againts the List of products to send (5).
- Send of Shipping RFID Document – after validation the Shipping RFID Document is generated and sent to the Integration Manager (7).

The **IntegrationManger** was created using BizTalk Server and the following operations (orchestrations) were created: send purchase order to supplier, receive SimpleASN from supplier, update SimpleASN, send Receiving RFID Document to ERP, receive purchase order from customer, send Shipping RFID Document to ERP.

The **DatabaseManager** as stated previously store information and provide access to the needed information during the RFID processing in the Receipt Products Manager and Shipping Products Manager. The entities stored in this manager were SimpleASN Supplier, List of Products to Send, Receiving RFID Document and Shipping RFID Document. The following operations were supported: Get entity, Delete Entity, Delete Entity by Id, Add Entity, and Update Entity.

7. SOLUTION EVALUATION

Having all the business processes, informational entities, architecture defined, and prototype implemented, the current section will describe how the proposed solution has been evaluated. In order to do so, two major conceptual set of tests have been performed: by manager, and integration tests within the scope of the supported processes.

7.1. PROTOTYPE VALIDATION

The following tests were done regarding the receiving process:

1. Create a purchase order and reception in the supplier system
2. Reception of the Supplier ASN with validation of sending products compared with the previous generated purchase order
3. Confirm the creation of the ASN in the ERP and Database Manager
4. Correct validation of received products in Products Receipt Manager
5. Input of information in the ERP using the Receiving RFID Document, increase of product inventory and automatic creation of receipt line

The following tests were done regarding the shipping process:

1. Creation of an purchase order in client system and sending to the warehouse system
2. Reception of the purchase order, generation of Sales order and List of Products to send in the ERP. Check if the List of Products to

send is also created in the Database Manager

3. Correct validation of shipped products in the Shipping Products Manager
4. Input of information in the ERP using the Shipping RFID Document, decrease of product inventory an automatic creation of the shipping line
5. Automatic generation and send of the ASN to the customer and reception in the customer system.

7.2. MAIN DECISION POINTS

Regarding the main decisions made in the implementation of the prototype it is possible to modify the implementation.

If an organization demands the use of an EDI Solution integrated with the proposed system, the use of Integration Manager supported by BizTalk Server, makes possible to modify the representation of the entity purchase order and ASN by simply modifying the interfaces and internally modify the mappings for all other applications.

In what concerns the ASN the following steps are necessary to perform the modification in the architecture:

1. Change the representation in Database Manager
2. Change the representation used in ERP Manager in the ERP Service, *XMLPort* and internal table.
3. In the Products Receipt Manager it is necessary to change the source code to allow the iteration of the new levels
4. In the Integration Manager it is necessary to change the XML representation used and the associated mappings.

7.3. ANALYSIS OF THE IMPLEMENTED ARCHITECTURE

The implementation of the proposed architecture was done with considering the objectives proposed earlier in **[5].** It is important to realize that the modularity and extensible of architecture allows adding new functionalities in the existing managers and also the addition of new managers to the solution. As example:

- **Support new systems interested in RFID Information** – it is possible to easily extend an existing BizTalk Server orchestration to support the new system
- **Apply Business Rules** – in the Products Receipt Manager and Products Shipping it is possible to add a new internal component in order to apply business rules;
- **Automatic Report Generation –** in the Products Receipt Manager and Products Shipping Manager all the generated RFID Information could be used to create reports about missing products, unexpected products, time it takes the receiving process, etc.

The prototype shows that the defined processes were correctly support and executed, even though some functionality could not be finished or were partial finished. (Ex. products inventory validation in the ERP system during the shipping process when the customer sends a purchase order).

Unfortunately, a quantitative evaluation to the prototype was unable to be made (tests using RFID tag readers were not possible to use). The only diverting point between qualitative and quantitative tests is the fact that in these last ones, RFID reading latency and errors are useful to assess the prototype's efficiency.

8. CONCLUSION AND FUTURE WORK

The solution presented in this paper shows that it could be a valuable asset to warehouse management. Using RFID Technology is possible to automate important activities in the receiving and shipping processes comparatively with how they are supported in a barcode solution.

This change implies not only a increase in the efficiency in the execution of the identification and validation activities but also a reduction of human errors. Additionally the produced information in the RFID processing allows automatic control and update over product inventory.

Moreover, since RFID support identification of instance of products, a greater control exists over what is in or out the warehouse and that information could be consulted directly in the ERP.

Also important, is to leverage the proximity of all the partners involved in the supply chain management. The presented solution integrates the proposed RFID System with the supplier and customer system allowing the exchange of important business information.

In conclusion, the benefits of an integrated RFID solution with an ERP system extend not only to the organization that uses the solution but also to all the partners involved in the supply chain. In the end, the one that benefits the most from this optimization is the final client.

As Future Work the followings topics were identified:

- Share information about EPC code using EPCIS standards from EPCglobal;
- Implementation of security mechanism in the proposed architecture between the manager's interactions and in the

documents exchanges between partners.

- Utilization of produced RFID information to delivery automatic reporting generation
- Integrate in the proposed architecture the Put-Away and Picking Processes referred in **[3]**
- Use EDI in the documents exchange between partners if the business requirements demand it
- Remove the SimpleASN simplification as stated in **[7.2]**

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