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Toward a reliable and responsive E-commerce with IoT

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Abstract

Modern logistics becomes mostly web-centric, its goal overpassed the productivity in traditional warehouses to aim the effectiveness and satisfy customer demands in the context of E-commerce. This article presents a modern type of warehouse based on IoT, using existing technology such RFID solution, to increase inventory reliability by reducing the risk of human errors and it covers 90% of all warehouse operations. Through this article, we analyzed the main areas of improvement for RFID solution, such it does not cover the picking area; unlike in gross storage areas where every palette may contain an RFID Tag in permanent communication with ERP/WMS. However, in the retail area the products are not tracked (possibly but expensive), leaving low visibility on real-time inventory behind with the risk of inventory shortage for items already ordered by customers on the e-commerce platform or excess inventory. The solution we proposed covers this flaw, by creating smart picking areas, based on weighing to get primary data to be quantified. This solution increases inventory reliability and responsivity by helping the retail areas resupply and mastering the picking and preparation delays.

Keywords: Logistics, Smart warehouse, IoT, Picking area, Inventory reliability, RFID, WMS, E-commerce, Inventory shortage, WMS/ERP

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1. Introduction

Recently, e-commerce actors have doubled their traffic and conversions in the period of COVID-19 [1], and this obviously adds huge stress throughout the logistics chain.
To guarantee its existence in the market and its competitive edge, the e-commerce platform is engaged to increase its ability to satisfy and retain its customers, which will no doubt depend largely on the quality of its service delivery, reactivity, and short lead time by simplifying processes and eliminating MUDAS.
Order lead time (a) = Lead time in shipping (b) + Delivery lead time (c) [2]

(a) Time between placing the order by the customer until he gets delivered.
(b) Time between placing order by customer until the de product is ready to ship (from the warehouse)
(c) Time between the de product is ready to ship until the customer gets his delivery.

This study aims to identify the contribution of IoT in logistics operations more precisely warehousing (lead time in shipping) since it is an inevitable link with many no added value tasks.
RFID is the top technological IoT solutions exploited by modern strictures, a practical solution with many advantages and limits of use, In the next chapters we will analyse the impact of RFID on MUDAs also the opportunity to overcome the limits of use of IOT in the warehouse.

2. Overview of RFID technologies

2.1. IoT

The Internet of Things (IoT) refers to the set of sensors, or other perception layers such as RFID, connected to the Internet to inform the user of the status of the system to which they are connected. But the concept is not limited to hardware, it also includes connectivity, as well as software, to perform data analysis on the cloud [3].

2.2. RFID System

This technology is based on the emission of electromagnetic fields received by an antenna coupled to an electronic chip (transponder or tag). The field serves as vector information between the chip and its reader, as well as the activation energy of these chips. A radio frequency identification application consists of a reader which transmits a signal according to a determined frequency to one or more radio tags contained in its reading field. These send back a signal. When the labels are “awakened” by the reader, a dialogue is established between tag and reader and data exchange, [4] An RFID system contains at least the following 3 elements: TAG, Interrogator, and middleware.
TAG: is mainly formed by a microchip attached to an antenna. The microchip contains information on the tagged objects. The chip can be read-only or read-write dynamically chips are more expensive than read-only chips and are used for high-value, product items. Read-only chips are generally used for inexpensive objects [5]
There are two types of tags: passive Tags and Active tags:

- Passive RFID tags: they do not have any power source and they are on sleep mode until they get excited by the interrogator (reader) energy. They have long operational life but weak communication signal and data Storage.
- Active RFID tags: the microchip has its power supply to emit a strong signal and the reading distance can reach 30 meters [6].

Readers or interrogators: come in three types: Handel, vehicle-mount, post-mount, RFID readers create a radio frequency field when they are turned on. Reader switch into read mode to interrogate every passive tag in the RF field.

Table 1. Passive reader versus active reader

	Power	Communication distance	Reading Speed
Reader for passive tags	Max 4W	few meters	_100 tags/second
Reader for active tags	10 - 20 mW	20 -100 meters	_100000 tags/second

The middleware: bridges the RFID hardware and enterprise applications. It filters the data and processes and interfaces this data with other software inventory and analysis systems ERP, WMS, etc. the role of the middleware is filtering the excess and unnecessary data, ensuring the accuracy of this data, transforming it into useful information for companies to improve their management.

2.3. RFID vs Barcode

Barcode is a data representation in code, which is readable by machines & scanners; it served logistics for more than 30 years and it is being replaced by RFID because of its advantages, Table 2.

Table 2. Bar-coding technologies versus RFID technologies.

	Bar-coding technologies	RFID technologies
Reading	Line-of-sight => One by one	Contactless => Multiple tags
Identification	Data storage is limited. Data is static (cannot be changed)	Too much data can be stored. Data is dynamic (can be updated)
Environment	Bar codes can be damaged. by physical and chemical	RFID frequency can be disturbed by metal and liquid conditions
Cost	Cheap	Expensive

3. E-Logistics in modern warehouses

3.1. E-logistics challenges

The main goal of logistics is to deliver the right product to the right place with the best QCD (Quality, Coast, Delay) It covers supply, transport, and warehousing [7]
Logistics 4.0 provides the integration of digital technology in the logistics chain, such as IoT, AI, cloud computing, RFID... Various changes: end-to-end visibility, Control replenishment of stocks, and better customer experience [8]
E-commerce retailers receive many orders with just a few lines which makes the order preparation more complicated, and hard to release and ship on time fig. 1.
Delivery delays, errors, and damage in deliveries orders can have a bad effect on the image of e-commerce structures and cause them to permanently lose their customers.

Fig. 1. E-Logistics main process

Order preparation is a true value-added operation, it involves collecting the items stored in the warehouse and grouping them together before shipping them to customers. IT is the most expensive and critical operations in a warehouse as it is very labor and time consuming [9]. The picking zone must satisfy orders during the preparation time, it needs to be filled regularly from the gross storage area.
E-Logistics is characterized by the disappearance of intermediaries such as wholesalers and especially retailers (elimination of going through a physical store), Indeed, it is directly impacted by transport, information,

warehousing, and value-added services such as co-packing and kitting. The savings generated by the elimination of these intermediaries and the expenses linked to the physical existence of a store made the opportunity to build an efficient logistics organization possible.
These savings could not be achieved without the digitalization of the warehouses, Axis of all logistics services with high benefits such as order preparation, kitting, delayed differentiation, must be carried out in a single warehouse.
Because of the huge variety of products managed by retailers and space constraints inside the warehouses, the e-commerce structures are forced to reduce inventory as well as they can satisfy customer's orders.
About 34% of American retailers' ship orders late due to out-of-stock issues because of the inventory accuracy [10] and bullwhip effect by consequence that small fluctuations in picking area be amplified along the supply process.

Real-time and reliable data is the key to success in every operational E-Logistics.

3.2. RFID in e-commerce

RFID technologies had greatly improved logistics by increasing the efficiency and speed of processes; it provides numerous advantages compared to the current identification technologies by improving information accuracy and reducing inventory losses.
RFID aims to reduce cost in several activities in the warehouse:

- Cost of re-shipping and re-stocking (reversed logistics coast) in case of wrong delivery.
- Cost of searching for inexistent products during the preparation time.
- The coast of miss out on winning because of inventory shortage.
- Cost of refund and money transfer (risk of exchange)
- Cost of labors

For wholesale delivery, pallets are automatically verified when the forklift pick it up which have a Vehicle-mount RFID reader, that increase the exactness of preparations and shipping Fig. 2. (b). the gantry reader can read the contents of the trucks after loading or before unloading the goods and does not require any installation at the truck level except for the prior marking of each pallet with an RFID tag, Fig. 2. (a).

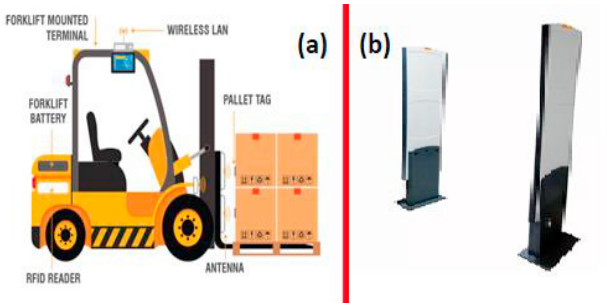

Fig. 2. (a) Vehicle-mount RFID reader; (b) the gantry reader

The gross storage area, RFID can also guarantee the data communication on real-time by intelligent shelf solution; RFID tags on pallets are connected to RF signals emitted by interrogators mounted in the shelf; the inventory is checked permanently, offering the chance to valorise the inventory and take the suitable decision on real-time.

3.3. Problem statement

We assume that RFID is an expensive solution, that can be used to track high-value products or gross containers (palette)

Ideally: We can use RFID for each product in the picking zone, that will ensure real time data

Reality: However, we can't implement RFID solution for retail in fact that the cost and labor time becomes considerable so that the final customer is not ready to pay for it.

Consequences: Inventory inaccuracy can affect the business by losing customers

Proposal: We can implement a solution based on weighing; Weighing rack.

4. Smart picking area

4.1. Weighing rack

The new concept of smart picking racks will use weighing instruments to get the inventory, it communicates data to information system via a middleware fig. 3.
Every rack is equipped by a load cell which is the transducer that converts the applied force into a proportionate electrical signal. The scales are classified based on the quality of their load cells, into four classes 'Class I' is the most accurate *[11].*
The load cells are integrated into the shelving rails. Digital communication allows the weight of each bin to be checked permanently and converted into quantity for any item in the picking area.
It can have many benefits on the E-logistics, ensuring that stocks will not drop to too low level in the picking area, in fact it triggers resupply of the picking area below a certain threshold which allows a smoother process and availability of items ordered in the preparation list.
This solution can also give to the customer an idea about the gross weight of his shopping cart before shipping.
It also allows order picker to check if the prepared order matches well with the customer order, except if several products have the same weight

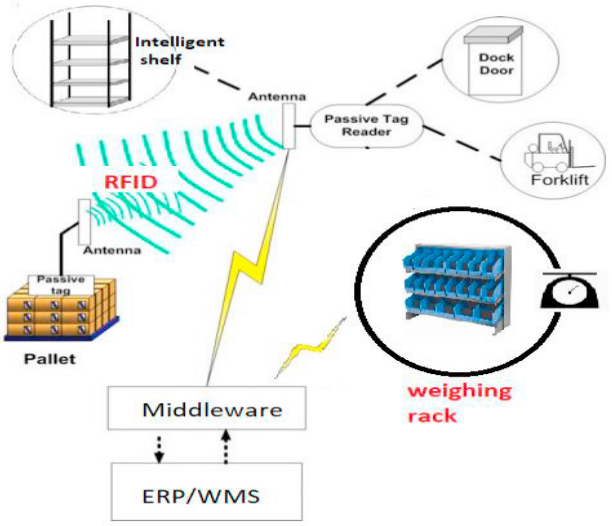

Fig. 3. Smart warehouse perception elements

4.2. Advantages of weighing:

- Unlike RFID, this does not require any consumables or TAGs.
- It doesn't require any preparation like to stick a tag or scan a barcode…
- Reliable and communicates data in real time without disruption.
- Weighing is very useful for tracking all types of materials.
- Temperature range: -200 to +300 °C.
- Load cycles: Up to 10 million times at +/- 2000 µm/m fatigue.

4.3. Disadvantage:

- Maintainability and calibration of load cells.
- Expensive investment and especially if need high level of precision required.
- Dust and moisture reduce reliability.
- Requires an information system that supports this function or at least one that can be configured and interfaced with a middleware.

The application of the Artificial Intelligence to enhance reliability comes to treat the data gathered by perception layers, to feat more information such as: stock coverage, automatic order placement, misplaced pallets, and real-time inventory to facilitate co-ordination creating a smart environment for the automated logistics [12] the huge range of data exchange needs a strong communication network.
With the emergence of 5G, a mobile integrated communication system characterized by low latency and higher speeds, comes to unleash the full potential of the perception layers in the picking area would be more autonomous and greatly connected to servers ensuring effective and real time communication [13].

5. Conclusion

This article presented the facts about RFID technology and its contribution to E-logistics and the digital supply chain transformation, its efficiency doesn't allow it to cover the picking areas.
The weighing racks in picking areas seem to be a practical solution that can be integrated into ecommerce warehouses, it will increase the mastery of a wide range of products, even small or at low cost.
This proposition needs to be confirmed by case studies to quantify gains (estimate ROI), the weighing solution may cover the sorting of parcels and other e-logistics process if we overcome its limits of use.

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