REPUBLIQUE ALGERIENNE DEMOCRATIQUE ET POPULAIRE
الجمهورية الجزائرية الديمقراطية الشعبية

MINISTRY OF HIGHER EDUCATION
AND SCIENTIFIC RESEARCH

HIGHER SCHOOL IN APPLIED SCIENCES
--T L E M C E N--

المدرسة العليا في العلوم التطبيقية
École Supérieure en
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وزارة التعليم العالي والبحث العلمي

المدرسة العليا في العلوم التطبيقية
-تلمسان-

Mémoire de fin d'étude

Pour l'obtention du diplôme de Master

Filière : Génie Industriel
Spécialité : Management Industriel et logistique

Présenté par :
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ALLALOU Hicham

Thème

la Logistique Digitale pour l'Amélioration de Système de Stockage pour le E-commerce

Soutenu publiquement, le / 09 / 2020 , devant le jury composé de :

M Maliki Fouad	MCB	ESSA. Tlemcen	Président
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Thesis

For obtaining Master's degree

Faculty: Industrial Engineering
Specialty: Industrial Management and Logistics

Presented by:

KHELIL CHERFI Manal
ALLALOU Hicham

Theme

Digital Logistics for Storage System Improvement for E-commerce

Supported Publicly on, / 09 / 2020 , in front of the committee composed of :

Mr. Maliki Fouad	MCB	ESSA. Tlemcen	Président
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University Year: 2019 /2020


بسم الله الرحمن الرحيم

Dedication

This work is dedicated

To my family

To my mother who believes in me

To my father who encourages me

To my friends who care about me

And to my teachers who left an impact on me

Most of all to allah who blessed me with these people

and the endless gifts he gave me.

Manal KHELIL CHERFI

Dedication

I dedicate this work, the fruit of my years of study

to my parents, their patience, their unconditional love, they were the ones to help me become the man I am

my gratitude for all my friends and teachers in Tlemcen, they were my second family, they helped me a lot grow and have new vision of the world.

a special thanks to EasyRelay team for all their contribution in our work.

Hicham Allalou

Acknowledgment

Before anything, we would love to thank Allah, for giving us strength, courage and ability to accomplish the present work.

We are using this opportunity to express our deepest gratitude to our supervisors ***Mr. Mohamed BENNEKROUF*** *and* ***Mr. Adel HAMZAOUI*** *they guided us and kept us on the correct path. this thesis couldn't be completed without there guidance. even through the hard circumstances that the world is going on they keep track on us, thank you for all*

We also address our great thanks to Mr. Fouad MALIKI who have always been there when we needed him, who gave all what he could and from the deepest of his heart for us and for Industrial Engineering department.

Special thanks to our teachers of Tlemcen, who worked with passion for our education, whom we have always heard of before joining ESSAT, of their competency, qualification and most of all helpfulness, thanks to them for giving us an experience behind our expectations.

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At the end, we address our sincerest thanks to our families, for their patience of us being away from them, for their trust which gave us confidence, and for their endless love that gave us everything

Thank you all....

Table of elements**:**

ABSTRACT AND KEY WORDS:

ملخص:
الهدف من هذا العمل هو تحسين نظام التخزين لمراكز تجهيز الطلبيات بتطبيق التقنيات اللوجستية الرقمية وذلك من أجل ضمان إدارة، فعالية، وشفافية التخزين، كل هذا من خلال إنشاء مركز تجهيز طلبيات التجارة الإلكترونية، ثم تنفيذ "إنترنت الأشياء" في نظام الرفوف الذكي وأخيرًا تصميم تطبيق ويب لإدارة المخزون والعمليات الأخرى داخل مركز تجهيز الطلبيات.
الكلمات الرئيسية: الرقمنة، اللوجستيات، التخزين، النظام، إنترنت الأشياء، تطبيق الويب، التحسين، مركز تجهيز الطلبيات

Abstract:
The objective of this work is to improve storage system of fulfillment centers while applying digital logistics technologies in order to ensure storage management, efficiency, and transparency, all by establishing and facilitating e-commerce fulfillment center, and then implementing in it « internet of things » for smart shelving system and finally designing a web application in order to manage stock, inventory, and other operations within the fulfillment center.
Keywords: digitalization, logistics, storage, system, IoT, web-application, improvement, fulfillment-center.

Résumé :
L'objectif de ce travail est d'améliorer le système de stockage des centres de distribution tout en appliquant les technologies de la logistique numérique, afin d'assurer la gestion, l'efficacité et la transparence du stockage, le tout, en établissant et facilitant le centre de distribution de commerce électronique, puis en y mettant en œuvre « l'internet des objets » pour un système de rayonnage intelligent. Et enfin, la conception d'une application Web afin de gérer les stocks, l'inventaire et d'autres opérations au sein du centre de distribution.
Mots clés: digitalisation, logistique, stockage, système, IoT, application web, amélioration, centre de distribution.

ABBREVIATIONS:

DSC: Digital Supply Chain

3PL: Third-Party Logistics

ICT: Internet Communication Technology

B2B: Business to Business

B2C: Business to Customer

WMS: Warehouse Management System

TMS: Transportation Management System

EDI: Electronic Data Interchange

SAV: Stock at valuation

SC: Supply Chain

SCM: Supply Chain Management

SCMCs: Supply Chain Management Components

SCMPs: Supply Chain Management Processes

SCMNS: Supply Chain Management Network Structure

SCFs: Supply chain Flows

IoS: Internet of Services

IoT: Internet of Things

CPS: Cyber Physical System

AI: Artificial Intelligence

AR: Augmented Reality

SKU: Stock Keeping Unit

UPC: Universal Product Code

FIFO: First in First Out

PnP: Pick and Pack

WSN: wireless sensors network

GPS: global position system

EDI: electronic data interface

WSN: wireless sensor network

GSM: global system for mobile communications

GPRS: general packet radio service

WiMAX: worldwide interoperability for microwave access

WIFI: wireless fidelity

M2M: market to market

QoS: Quality of Service

SOA: service-oriented architecture

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General Introduction:

Nowadays, E-commerce is developing in a remarkable rate, there are around 12-24 million ecommerce websites across the entire globe (wpforms), and it is expected by 2040 that 95% of all purchases will be done online (Nasdaq), the competition is tough.

When choosing the website from where to purchase, customers think besides the price of delivery: how long does it take to receive my purchase, is return possible, what if the product arrives damaged…

However, here comes the challenge of e-commerce business owners, which is ensure a good logistics in order to respond to customer's expectations and experience. The option of outsourcing logistics to third-party logistics firms is one of the best decisions to take for orders' fulfillment, returns management, shipment, and inventory management.

One of the most difficult decisions facing e-commerce business owners, is choosing the right third-party logistics firm, as it contributes strongly to their success or failure. On the other side, one of the many challenges facing third-party logistics providers, is ensuring an efficient logistics planning of storage, and shipping while keeping up with the technological development for better logistics' performance.

For this matter the question is: Except fast shipment, how can third-party logistics firm ensure effective orders' fulfillment operations, how does it manage its storage and what technologies can it adopt to digitalize its logistics?

In order to answer these questions, the present work consists of in one hand, a general study of a sustainable strategic plan that Third-party logistics firms make, which is e-fulfillment centers' facilities. It is a full complete study of: fulfillment center's location decision based on qualitative and quantitative analysis, orders' fulfillment process planning of inventory management, picking and packing, fulfillment center layout and finally storage system, techniques, tools and organization. In the other hand, logistics digitalization with smart shelving system and web application.

The first chapter, will be a bibliographical study of key elements and definitions of our study, such as e-commerce, e-logistics, third-party logistics firms, e-fulfillment, then digital supply chain management and industry 4.0.

The second chapter will be an introduction to the project of building e-fulfillment centers, and realization plan of all its aspects of location, process, and storage planning.

The third chapter will be implementing internet of things for smart shelves, using some technologies for better efficiency and transparency.

The fourth chapter, will be about designing a web application for fulfilment center's management, and inventory traceability.

Chapter one:

General Overview

I.1. Introduction :

This chapter is a bibliographical study that aims to provide the reader a general overview of the topic, in order to get him/her understand the constructive notions of the theme. The chapter is divided into four sections. We will be discussing firstly E-commerce, e-logistics and logistics outsourcing, to move later to E-commerce fulfillment, of receiving inventory, managing orders, picking packing and shipping to finally returns processing. Thirdly, we will tackle digital supply chain management, its development, its comparison with the traditional supply chain and its success factors. At the end, we will highlight the DSC in Industry 4.0, the digital ecosystem, industry 4.0 objectives and characteristics.

I.2. Section One : E-commerce, E-logistics and 3PL firms:

This first section is about developing the three main notions: E-commerce, E-logistics and Outsourcing logistics. We will begin with talking about e-commerce and e-logistics, we will be moving then to logistics and inventory management in e-commerce, to finally develop 3PL's topic of outsourcing: processes, advantages and disadvantages.

I.2.1.Ecommerce:

E-commerce is the combination of traditional business practices with the computer and information technology (ICT) that can create entirely new services, distinct from conventional services. It refers to an economic system in which businesses and consumers use computers and networked technologies, which generate a completely new market.

The term e-commerce (also called Electronic Commerce), often confused with the term e-Business, actually designates only one facet of e-Business covering the use of an electronic medium for the commercial relationship of a company with its customers and / or suppliers. E-Commerce is associated with e-Logistics.

I.2.2.E-logistics:

The terms electronic logistics, e-logistics, internet-enabled logistics or e-business (e-commerce) logistics have been loosely used in both academia and practice. Some consider e-logistics as a supportive delivery process for fulfilling online e-commerce orders (Joseph, Laura and Srinivas, 2004)[1].

Others believe that e-logistics implies the use of information and communication technology (ICT) to support the provision and execution of a broad range of logistics activities (Daly and Cui, 2003; Gunasekaran, Ngai and Cheng, 2007)[2]. While the former narrowly defines the e-logistics utility in an online business to customer (B2C) or business to business (B2B) setting, the latter offers a broader concept focusing on utilizing ICT to manage information and information flows in supply chains or supply networks[3].

I.2.2.1.1. Between Traditional Logistics and E-logistics:

E-logistics is considered to be e-commerce weakness in the late 1990s, because it was neglected by most start-ups. It has become later a real key success factor to master in order to be successful. However, delivery delays, errors and damages in

orders can provoke a devastating effect on the brands' image of e-commerce players, it can make them lose forever their potential clients.

E-commerce logistics, like any traditional business, answers questions of transportation, storage and information systems. It therefore does not, strictly speaking, have any specific features. However, the supply chain is "simplified", the disappearance of intermediaries has direct effects on:

- **Transportation:** "last mile" which means the movement of packages from the fulfillment center to their final destination, it is one of the most difficult challenges in SCM of minimizing cost, ensuring transparency, increasing efficiency, and improving infrastructure;
- **Information (much more automated):** with current ICT standards of exchanging data via internet or dedicated electronic networks with the help of wired and wireless technologies, the aim of this all is to reduce data errors and improve efficiency in decision-making and more;
- **Storage:** more consequent;
- **value added services:** such as co-packing or co-manufacturing[4].

I.2.2.2. The historical Development of E-logistics:

There is an observable trend in e-logistics developments over the past five decades, from unconnected applications to connected systems and networks, emphasizing 'single source of truth' (a data storage principle to always source a particular piece of information from one place), modular design and on-demand use. Merali, Papadopoulos and Nadkarni (2012) summarized the following four-step changes in ICTs since the 1960s, which have also had a major influence on the development of e-logistics[5]:

- connectivity (between people, applications and devices);
- capacity for distributed storage and processing of data;
- reach and range of information transmission;
- rate (speed and volume) of information transmission[5].

I.2.2.3. The Criteria to Take into Consideration to Define E-logistics Strategy:

- Level of service (flawless);
- Stock level;
- Traceability of products from the supplier to the end customer (WMS warehouse management system, TMS transportation management system, EDI electronic data inter-charge);
- Delays between placing the order and receiving the order by the end customer;
- Number of intermediaries between the supplier and the end customer;
- Number of delivery options offered on the site;
- Quality of return service (In textiles, return rates reach 15 to 17%);

- Stock at Valuation (SAV) quality[4].

I.2.3.Logistics in E-commerce:

We can distinguish many challenges facing e-logistics:

- Processing a large number of small low value unit packages;
- Monitoring of information on packages, from preparation to delivery;
- Increasingly demanding delivery times (deadlines)[4].

E-commerce is similar to the classic model of large distribution (dominant model):

- **Centralized model:** For most e-merchants, management of purchases, stocks and order preparation can be done in one place (at least nationally);

- **Decentralized model:** Some e-merchants (mainly those with very large and diversified volumes) use several warehouses, dedicated to specific types of products, to perform these same tasks[4].

Unlike mass distribution, there will be greater geographic proximity of the warehouse to the customer. There is no interest in terms of cost (transport service often billed at the same price regardless of the distance), but increasing the number of platforms to be closer to consumers can reduce delivery time[4].

I.2.4.Inventory management

One of the key concepts of e-logistics is the optimization of supplies and stocks:

- **Challenges:** Create a balance between sales and logistics;

- **Balanced:** The sales representative wants to offer a wide and varied choice of products; the logistics must not be penalized by a significant increase in the number of references;

- **Central question:** Today, to stay in the race, e-merchants must constantly invest in ever larger areas. (In 6 years, Pixmania has changed warehouse 3 times). La Redoute and Les 3 Suisses have built their success on their ability to manage large warehouses that store tens of millions of packages each year. Masters in the preparation of single orders[4].

- **Powerful Tools for Processing Large Volumes and References:**

Pick to Belt: Products taken directly placed on a drainage conveyor for a sorting system;

Pick to Light: Automatic devices that manage displays placed on the front face of each storage cell. An indicator light indicates where to collect, a digital display indicates

the number of items to collect, a push button allows to validate the collections. improves productivity by 20 to 30%;
Pick to Voice: Based on voice recognition, allows the preparer to "communicate" with the warehouse management system via a headset / microphone. Free the hands of the preparer, reduce picking time by 30% and reduce preparation errors[4].

I.2.5.E-commerce and Logistics Outsourcing to 3PL:

There are three different attitudes:

- **Keep your logistics in-house:** That is to say take care of it even when sales are reasonable, then hire staff to deal with the development of the activity;

- **Keep its logistics internally temporarily:** in order to better understand the logistics issues as well as the real logistics needs. This phase is generally a prerequisite for outsourcing, when the number of orders becomes too large;

- **Directly outsource its logistics:** and set up a partnership with an e-commerce logistics provider (3PL company)

.

E-merchants whose volumes are small, are those who outsource most often.

One way to streamline ecommerce supply chain, warehousing and distribution included, is by outsourcing logistics to a third-party logistics (3PL) provider[6].

Third-party logistics was propelled first in US; later on, European nations put it on to successfully deal with an organization's coordination exercises, re-appropriating the capacity and purchasing the administrations[7].

Outsourcing order fulfillment processes to a third-party logistics (3PL) company means they handle the following services on your behalf using their infrastructure, workforce, and technology. So, what exactly happens at a 3PL warehouse once a customer clicks "Submit order" on your online store? [8]

I.2.5.1. 3PL's Processes Through Services :

- **Receiving:** a 3PL cannot ship orders without inventory on hand. The "receiving" of inventory in a 3PL warehouse refers to the acceptance of incoming inventory followed by its storage. Each 3PL has its own processes and capacity for receiving and storing inventory;

- **Warehousing:** Once inventory is received, we store items in our fulfillment centers. Each item has a separate dedicated storage location, either on a shelf, in a bin, or on a pallet. Different 3PLs have different storage capacities; not all 3PL warehouse space is created equal. It is important to work with a 3PL that has more than enough storage space for your current inventory — as your product line and order volume grow, your 3PL storage must be able to scale with

you. Depending on your products, you may also need temperature-controlled storage or refrigeration. Different 3PLs have different levels of accommodations available to meet these needs;

- **Picking:** When a customer places an order, it is time for the 3PL fulfillment process to begin. Some 3PLs require you to manually upload orders to their system. Sometimes, this involves spreadsheets including order details, customers' shipping details, and more. This can be an inefficient and complex way to manage orders. Other 3PLs have sophisticated technology that integrates directly with your ecommerce platform or marketplace. These 3PL fulfillment software integrations bring orders, shipments, inventory tracking and stock levels, and more, together in one place to streamline the fulfillment process for more automated shipping. This includes automatically pushing customers' online orders to your 3PL as soon as they are placed. When an order is sent to your 3PL, it is assigned to the picking team. The picking team receives a picking list of the items, quantities, and storage locations at the facility to collect the ordered products from their respective locations;

- **Packing:** When all items in an order have been picked, it's time to get them securely packed for shipping. The packing materials used will depend on your 3PL's capabilities, your brand preferences, and the items being shipped. The most common standard packing materials include: Unbranded boxes, Bubble mailers, Poly bags, Packing tape, Bubble wrap, Paper-based dunnage. Some 3PLs will charge for packing materials as a separate line item, while others include them as part of their fulfillment services. The 3PL will choose the best packing materials to both protect your products and achieve the lowest practical dimensional weight. They will also optimize packages so that you don't have to split shipments;

  Dimensional weight is a shipping pricing technique that takes into account package dimensions to determine shipping rates. Using the right packing materials can help keep logistics costs low. If you want your brand to shine through your shipping, make sure you partner with a 3PL that allows you to use custom packaging, such as custom boxes and inserts. Oftentimes, receiving a package is the first in-person experience a customer has with your brand, so branded packaging can make a big impression

- **Shipping:** The next step is shipping your order. Most 3PLs will purchase and print shipping labels on your behalf. Some 3PLs have preferred carrier partners, while others compare shipping costs from a variety of carriers. The latter helps 3PLs offer clients the most affordable pricing possible for the delivery speed that each customer chooses. Carriers such as DHL, USPS, and UPS pick up orders from 3PL warehouses to ship. The carrier and shipping speed for each order depend on the 3PL's partnerships and policies as well as the ship options offered by the client and selected by the end customer. Once the order ships, 3PLs with the integrated technology will automatically push tracking details to merchants' online stores;

- **Returns processing:** 3PLs help in facilitating the returns process and getting your unused merchandise back into your available inventory[9].

I.2.5.2. Advantages:

- **Focus on core business processes:** The responsibility of a fulfillment center is to deliver goods to your customers. By outsourcing this mundane work, your company will likely have more time on hand to focus on core business processes. Not only this, fulfillment centers "fulfills" a lot of obligations that otherwise your business needed to address;

- **Free up your inventory space:** If not for a long time, fulfillment centers still offer a pretty decent short time inventory storage option for your main warehouse. This is especially helpful in those sales seasons where you need to meet up with the customer's expectations, and usually, suppliers are all packed. So, instead of relying on the scheduled arrival of your reordered demanding product, you can have some extra free up shelves to store your most demanding products;

- **Located close to customers for short shipping times:** Staying on top of the business food chain is not an easy task. Especially when your consumers nowadays are starting to believe that same day delivery is important;

Warehouses are located on the outskirts of the city. As such, whenever you receive an order and wish to fulfill it, the transit time, of course, is going to take a long time. Fulfillment centers are located close to the cities and usually have multiple stores operating at the same time. This is a faster, efficient and effective way for order processing.

- **May offer a customer service division:** Retail business is not only all about sales. But marketing your brand and focusing on customer relationships also. The famous principles of inbound marketing (attract – engage – delight) works like a charm in this industry. But oftentimes, we need to focus on the business processes so much that we forget about these things. Many fulfillment centers can serve as your customer service center on the frontlines to ease this burden from your shoulders;

- **Lowers your shipping costs:** Outsourcing delivery of goods to your customers not only gives you peace of mind and frees up your human resources but also lowers your shipping costs. This is because fulfillment centers do not serve only one client at a time but rather a bunch of clients. Therefore, the shipping cost is lowered;

- **Hassle free picking and packing:** Fulfillment centers not only help in delivering your product to your customers but also take care of all your shipping problems. That includes picking up the inventory from your warehouse and packing it before delivering to your customers;

- **Shipping labels and offer custom packaging:** When picking and packing are done, shipping labels come into play. For those of you who do not know, shipping labels consist of all the crucial key details regarding the package i.e., receiver's name and address, email, tracking number, package weight…etc.

  Now you might wonder, do you need to take care of shipping labels? Absolutely not!

  Fulfillment centers are the one stop solution for all your shipping needs. They address your shipping labels duty too. Also, sometimes a customer might request for custom packaging for special occasions. Such requests are also entertained for delightful customer experience.

- **Will deal with reverse logistics:** Retail sales are not always as easy as it seems. Sometimes retailers have to deal with product returns due to transit damage, faulty product, delivery of the wrong item, or simply because the order failed to deliver on time. Consumers nowadays are growing impatient and returns in the retail industry are becoming a bigger issue to address;

- **Lowers your overhead costs:** Handling your order fulfillment by yourself will cost you with fixed overhead costs. Warehouse rent, equipment, indirect labor, etc. are the names of the few. As your order volume increases, the cost per order might also go up along with these fixed costs. Outsourcing your order fulfillment to the fulfillment center is a way to escape from those overhead costs[10].

I.2.5.3. Disadvantages :

- **Loss of control:** If you have started your business from ground zero, it may be difficult for you to digest the fact that an entire branch of your business will now be handled by a third-party logistics company. Some ecommerce business owners find it difficult to give control of their fulfillment operations. Ultimately, it requires that you trust your fulfillment partner, that you've done your due diligence to ensure it's a reputable, financially-stable company, and knowing that all of your demands may not be met;

- **Lack of customization:** It is not uncommon for business owners to want to add some time of customization into their fulfillment process. Say, for example using branded boxes, adding a personalized letter or using custom packing materials. However, when you outsource the fulfillment process to your logistics partner, you have to sacrifice some of the customization[10].

After that we got familiar with ecommerce, its logistics and outsourcing logistics, now it is time to dig deeper, and discover how orders are processed. The next section will be explaining e-fulfillment or as it is also called e-commerce fulfillment.

I.3. Section Two : E-commerce fulfillment

Successful E-commerce businesses all have one thing in common: terrific e-commerce fulfillment. As consumers, when we want something, we want it now. As sellers, fulfilling those demands is easier said than done. While order's fulfillment may not be the most glamorous aspect of running an ecommerce business, it is a function that directly impacts an online merchant's bottom line, knowing that 61% of shoppers will abandon their cart if shipping, taxes, and other fees are too high, 53% of shoppers say that speed of delivery is an important factor when it comes to evaluating their online orders, 38% of shoppers will never shop with a retailer again if they had a poor delivery experience, 25% of shoppers have canceled an order because of slow delivery speed[11].

In this section, we will be talking about e-fulfillment basics and returns processing, and then we will be highlighting e-fulfillment center what is it, and how it is different from a warehouse.

I.3.1.E-fulfillment:

Also called e-commerce order's fulfillment, is the process of storing inventory, picking and packing products, and shipping online orders to customers.

E-fulfillment is a specialized part of a larger order fulfillment industry, in that it works only with online webstore merchants. There are four basic components of the e-fulfillment process[12]:

I.3.1.1. E-commerce' Store and Fulfillment Center Integration:

When you think of a fulfillment warehouse, you might imagine rows of shelves filled with products. At its core, however, every good order's fulfillment center is a technology company[13].

Your Ecommerce store should integrate seamlessly with your fulfillment center. Your orders should flow directly to the people who will pack and ship them. Here are three important features to take into consideration while choosing a good Ecommerce fulfillment center:

- Your 3PL company should integrate with every platform on which you sell. Your fulfillment center should create a custom app to connect incoming orders for any sales channels it does not support;

- The IT staff is just as important as the people who pack and ship your orders. Make sure your fulfillment provider has a robust IT department;

- Look for a fulfillment center with minimal downtime. In addition, look for responsive support to help smooth any glitches quickly[13].

I.3.1.2. Receiving and inventory management :

Pallets of your merchandise ship to your fulfillment warehouse. Then, those pallets get logged into inventory and placed on shelves, ready to fill your orders[13].

Receiving is the spot where many fulfillment warehouses fall short. When pallets sit on a loading dock, your products aren't in inventory. Of course, no inventory means no sales. This, as you may have guessed, is bad[13].

Another inventory management challenge is shrinkage. Shrinkage is a nice way of saying "loss, theft, and breakage." Most e-fulfillment centers have an allowance for shrinkage in their contracts. This means that you will eat the cost of the lost merchandise, up to a certain amount. In general, shrinkage allowances range from 2 to 10 percent of your warehoused inventory[13].

Look for these three qualities in your order fulfillment provider:

- Your e-commerce fulfillment center should place your stock into inventory within one to two days of receiving it;
- You should be able to log into your inventory management system. This real-time data is critical for maintaining Goldilocks stock levels. That is, not too much (which ties up all your capital in inventory). And not too little (which puts you at risk of running out before you can restock — a good way to lose sales);
- Your 3PL provider should have a low shrinkage allowance. Some fulfillment centers make inventory management a top priority. These providers are responsible for items lost or broken while on the shelves. In this case, you do not have to account for shrinkage when you calculate ideal stock levels[13].

I.3.1.3. Order's fulfillment Pick, pack and Ship:

When an order comes in, your fulfillment warehouse will pick the right items to put in the box. A floor worker will pack them in the perfect box. Your 3PL provider will ship them to your customer. This is the pick, pack, and ship process[13].

With centrally-located fulfillment warehouses, shipping to your customers is speedy. It's important that the 3PL provider turn your orders around quickly, too. Otherwise, you will lose the benefit of that shorter shipping time[13].

Accuracy is vital. Mistakes in picking and packing orders can cost you customers.

Here are three ways your e-commerce fulfillment center can help you meet customer expectations for fast and low-cost shipping:

- Look for a 3PL provider that offers next-day turnaround, or even same-day shipping;

- Choose a fulfillment warehouse, or warehouses, that are centrally-located. The fulfillment center should ship to most of your customers within two days or less;
- Ask for data on the fulfillment center error rates[13].

I.3.1.4. Returns processing (Reverse Logistics) :

You cannot avoid e-commerce returns. Ease of returns is important to e-commerce shoppers. This can be a major factor to drive your sales. Logging in returns is an important function of e-commerce fulfillment. The more quickly your fulfillment provider processes returns, the more quickly your customer will get a refund. Efficient returns also get your stock back on the shelf so it is available to sell again[13].

Here are three ways your e-commerce fulfillment partner can make returns a breeze for you and your customers:

- Find a warehouse that will put returns back on the shelf within one to two days. Returns that sit on receiving docks are a drag on your business and consumer confidence;
- Let your 3PL provider handle customer service for returns, so you can focus on increasing your sales;
- Create a process for handling damaged goods. Consider setting up a secondary site to sell returned merchandise at a discount. Make sure your e-commerce fulfillment provider can help evaluate returns and process orders for discount goods[13].

I.3.2.E-fulfillment Center:

The e-fulfillment center receives each client's merchandise and provides any extra receiving services needed such as kitting, labeling or sorting[14]. For each individual items or unopened cases of items if sold as cases are then stored in unique bar code labeled picking locations.

The e-fulfillment center provides special software that allows for automated importing of fulfillment orders from each client's shopping cart system plus then returns the resulting fulfillment tracking and updated inventory data back to each client's shopping cart[14].

Each order is quickly picked, packed and shipped and most of e-fulfillment centers offer rate shopping and discounted delivery options like FedEx SmartPost. Some, but not all centers offer a wide range of shipping carton sizes which is now an important feature because of new UPS, FedEx and postal DIM rules[14].

Something new in the e-fulfillment business is Amazon prep and Walmart prep services including third party shipping, special labeling and special packaging to meet Amazon and Walmart specifications[14].

This allows an e-fulfillment client to ship their own orders directly to their customers as well as support their Amazon and Walmart seller programs while avoiding expensive Amazon and Walmart warehousing and handling charges[14].

I.3.3.Between Warehouse and Fulfillment Center:

The most significant difference between fulfillment centers and warehouses is the extent of their operations and the type of customers they serve (Table 1-1) [10].

The difference between a warehouse and a fulfillment center:

Table 1 The difference between a warehouse and a fulfillment center

	Fulfillment centers	warehouse
Customers	Fulfillment centers are designed to serve customers directly. Better known to work with e-commerce business and B2C	Warehouse operations generally serve B2B customers
Operations	Fulfillment centers intend to store inventory for a minimal amount of time or till the time they can ship orders directly to the customers.	Warehouse is the storage house of giant stocks of items. Thus, the majority of logistics operations that take place at warehouse concern a freight carrier or an intermodal provider
Goals	The goal of fulfillment centers is to keep a minimal amount of in hand inventory, processing ecommerce orders, and try to get rid of it as soon as possible. Fulfillment centers are not designed for prolonged storage of inventory.	The goal of the warehouse is a safe long-time storage solution of your inventory, typically several months to a year.

From the differences spotted above, it is evident to say that every fulfillment center can be called a warehouse, but a warehouse can never be called a fulfillment center. This is simply because warehouses do not handle order processing while, on the other hand, a fulfillment center, even though they can store inventory for a short period of time, handles order processing and customer service at the same time.

Now that we know what is order's fulfillment, how does it happen, now it is high time to discover what makes this e-fulfillment efficient, always updated and synchronized with its different processes.

I.4. Section Three: Digital Supply Chain Management

The supply chain today is a series of largely discrete, siloed (partitioned) steps taken through marketing, product development, manufacturing, and distribution, and finally into the hands of the customer. Digitization brings down those walls, and the chain becomes a completely integrated ecosystem that is fully transparent to all the players involved — from the suppliers of raw materials, components, and parts, to the transporters of those supplies and finished goods, and finally to the customers demanding fulfillment[15].

This network will depend on a number of key technologies: integrated planning and execution systems, logistics visibility, autonomous logistics, smart procurement and warehousing, spare parts management, and advanced analytics. The result will enable companies to react to disruptions in the supply chain, and even anticipate them, by fully modeling the network, creating "what-if" scenarios, and adjusting the supply chain in real time as conditions change. Once built — and the components are starting to be developed today — the digital supply "network" will offer a new degree of resiliency and responsiveness enabling companies, that get their first to beat, the competition in the effort to provide customers with the most efficient and transparent service delivery[15].

I.4.1.Traditional SC model and digital SC model:

Current SCs have an accelerated life cycle and are in constant evolution; this evolution is driven by changes in the markets and emerging needs of the Fourth Industrial Revolution era. For this reason, new terms for digitalized SCs have been flourishing. This is the case for the "Digital Supply Chain" construct, referring to the evolution of how the current SCs are driven in Industry 4.0[16].

I.4.1.1. Traditional Supply chain :

Several SCM models have historically been defined by the most important scholars in this field. As an early work, we can mention the paper by Stevens (1989), who introduced one of the first schemes that allows an understanding of the materials and information that flow through the main components of the physical distribution channel such as suppliers, warehouses, factories, distribution warehouses and down to the final customers[15].

Other models that have studied and proposed essential SCM elements are the research works by Cooper et al. (1997) and those currently studied by Oettmeier and Hofmann (2016), who have proposed three general constructs[16](see **Figure I-4-1**)

- **The Supply Cain Management components SCMCs**: known as the managerial methods by which business processes are integrated and managed across the SC, e.g., work and organizational structures, information and communication structures;

- **The Supply Chain Management Processes (SCMPs):** referring to the activities that produce a specific value output to the customer, e.g., the customer and supplier relationship, demand and manufacturing flow management;

- **The Supply Chain Network Structures (SCNS):** described as the member firms and the links between those firms, e.g., upstream suppliers (tiers), services-party logistics and customers;

- **The Supply Chain Flows (SCFs):** are considered an important construct among the SCM elements, due to the relevant interconnection and systematic interaction provided through them and between each actor in the SCNS, e.g., products (goods) and services, information, knowledge and financial and return flows[16].

Figure I.4-1 Essential Constructs of Supply Chain Management (source: Digital Business Strategies)

I.4.1.2. Digitalized Supply chain :

- An intelligent, value driven network that leverages new approaches with technology and analytics to create new forms of revenue and business value, through a centric platform that captures and maximizes the utilization of real-time information emerging from a variety of sources[16]. (Kinnett, 2015)

- An intelligent best-fit technological system that is based on the capability of massive data disposal and excellent cooperation and communication for digital hardware, software, and networks to support and synchronize interaction between organizations by making services more valuable, accessible and affordable with consistent, agile and effective outcomes[17](Büyüközkan and Göçer, 2018), the table down-below **(Table 1-2)** shows the differences between traditional supply chain and digitalized supply chain characteristics.

Table 2 Traditional vs digitalized supply chain main attributes (source: Digital supply chain model in industry 4.0)

Traditional Supply Chain Characteristics	**Digitalized Supply chain Characteristics**
Show a lineal and hierarchic interaction between the SC structure without a real-time connectivity vision	Show a multi-dimensional, non-linear interaction among all of the elements within the DSC model: management components, processes, network structure, and flows (**Figure I-4-2)**
Is designed to manage logistics activities and manufacturing operations	Are designed with a more acute knowledge of customer needs to response speed and the quality needed to satisfy real demands via digitalization, supporting the quick and easy return of these products at end of life
Lack of real knowledge of the return, risk, and value flows, or absence, of an optimal stream of them, among the SC components	Present new emerging flows sharing within the network structure, such as: risk flows, virtual value and real-time information, knowledge, money, virtual goods/services and returns flows
Lack of agility and flexibility	Offer physical and/or digital goods and services
Focuses on mass production with low customization	Provide for their customers a centric platform that captures and maximizes virtual and physical value creation through a virtual and physical global value chain
Rapid response in well-defined target markets and when slow changes occur	Deliver mass, customized products and services ecosystem (digital and physical), through data mining and data trends, even predicting customer requirement lifecycles, adapting their operations to rapid and optimal responses
Has several or different communication and information systems that tend not to converge in one, or has problems updating information or achieving real-time communication	Use computational intelligence to develop machine-learning bots based on defined algorithms for self-learning, self-regulation and the autonomous generation of decision-making patterns

Great efforts to attain horizontal and vertical integration, but without reaching long-term agreements of real interdependence between the network structure	Keep open channels of communication, thus enhancing ethics, transparency and accountability
	Commit to continuous innovation to improve the performance of its key components, mainly pursuing the endless invention of Industry 4.0 technology enablers and features Seek a circular economy strategy through the technology enablers of Industry 4.0 to reach sustainable operations management in the DSCs in products, production/processes, and logistics decisions

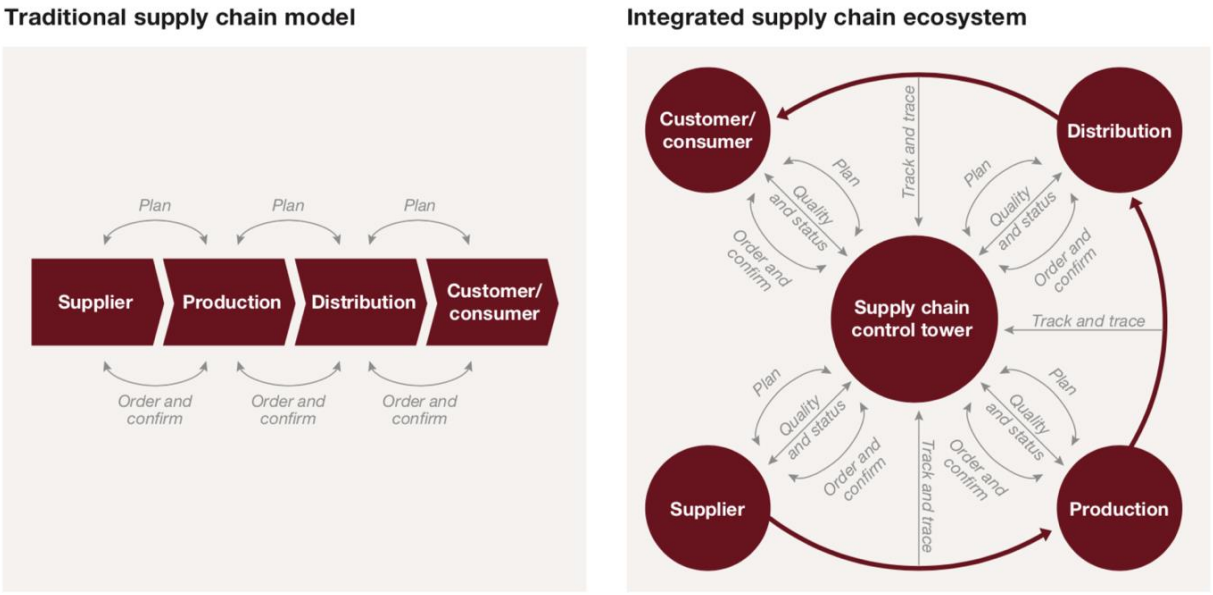


Figure I.4-2 The digitally enabled supply ecosystem vs. traditional linear supply chain (source: Pwc)

I.4.1.3. Smart supply chain enablers — success factors:

Companies setting out to build the smart supply chain face a difficult task, one that will likely prove impossible unless they develop a clear strategy that is fully responsive to the opportunities on offer in a fully digital environment. It must be based not just on the company's current operations and business model but also on new business models available once digitization has been implemented, such as creating direct sales channels and leapfrogging levels in the value chain[18].

Once the strategy is determined, companies must put into place several key capabilities needed to carry it out, in addition to the supply chain applications. These key capabilities include the following:

- **Processes:** Establish the new end-to-end processes connecting suppliers and customers that digitization makes possible, such as how to collaborate on cloud-based platforms;

- **Organization and skills**: Generate an end-to-end understanding of the mechanics of the value chain. That means switching from a firefighter mentality, solving each problem as it pops up, to becoming a supply chain "orchestrator" — seeing, managing, and optimizing the entire chain. Achieving this will also require a shift to an open, fast-learning digital culture that promotes communication across different media, programs, and user groups. Develop the talent and expertise needed to build the technology and carry out the new supply chain operations;

- **Performance management:** Develop a set of straightforward business rules covering the management of the supply chain, and the key performance indicators needed to measure outcomes;
- **Partnering:** Focus on boosting the ability to partner with other companies, as the fully integrated supply chain cannot be built without collaborating with a wide variety of suppliers, distributors, and technology providers;

- **Technology:** Devise a road map for the many technologies, old and new, that will underpin the digital supply chain, including the information integration layer, database and analytics capabilities, and the cloud[18].

The goal of the digital supply chain is to fully integrate and make visible every aspect of the movement of goods. and If the vision of Industry 4.0 is to be realized, most companies' processes must become more digitized. A critical element will be the evolution of traditional supply chains toward a connected, smart, and highly efficient supply chain ecosystem[18].

I.5. Section Four : Digital Supply Chain in Industry 4.0

As Digital Supply Chain DSC refers to the evolution of how the current SCs are driven in Industry 4.0, for many companies the supply chain is the business and it extends the vertical integration of all corporate functions to the horizontal dimension, knitting together relevant players — the suppliers of raw materials and parts, the production process itself, warehouses and distributors of finished products, and finally the customer — through a network of sensors and social technologies, overseen via a central control hub, and managed through an overarching data analytics engine[19]. In this section we will be defining first Industry 4.0, what is it and what is a digital ecosystem. We move then to Industry 4.0 objectives and famous characteristics of IoT, IoS, Cloud computing…etc.

I.5.1.Industry 4.0:

Industry 4.0, referred to as the "Fourth Industrial Revolution," also known as "smart manufacturing," "industrial internet," or "integrated industry," behind the great potential of the digital supply chain (DSC) lies Industry 4.0. Industry 4.0 orients itself on individualized customer demands over the full lifecycle of products and services. These

includes the following phases: The idea of new products and services, the development and production/ realization, the delivery and also recycling.

A transformation in production and automation was brought on first by steam and water power (Industry 1.0), then by electrification (2.0), and more recently by the digital computer (3.0). Industry 4.0, digitization, is about companies orienting themselves to the customer through e-commerce, digital marketing, social media, and the customer experience[18].

Ultimately, virtually every aspect of business will be transformed through the vertical integration of research and development, manufacturing, marketing and sales, and other internal operations, and new business models based on these advances. In effect, we are evolving toward the complete digital ecosystem[18]. **Table 1-3**

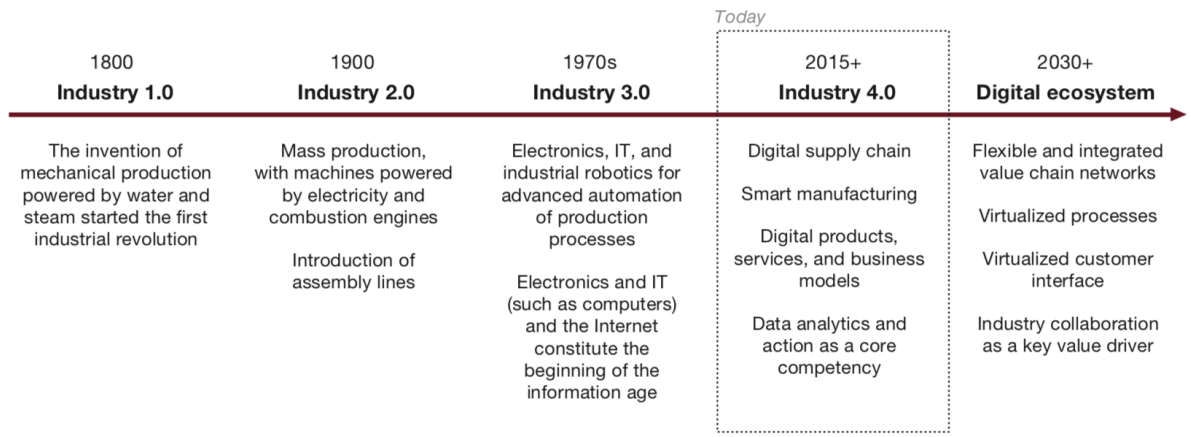
I.5.1.1. Digital Ecosystem :

it will be based on full implementation of a wide range of digital technologies — the cloud, big data, the Internet of Things, 3D printing, augmented reality, and others. Together, they are enabling new business models, the digitization of products and services, and the digitization and integration of every link in a company's value chain: the digital workplace, product development and innovation, engineering and manufacturing, distribution, and digital sales channels and customer relationship management[18].

I.5.1.2. Industry 4.0 Objectives :

Industry 4.0 is expected to enable factories to: Organize and control themselves autonomously, in a decentralized fashion and in real time (Brettel et al., 2014), reaching a state of multiple intelligent factories and smart manufacturing (Liboni et al., 2019; Lu, 2017). This system was previously envisioned by academics in Operations Management, that is a real global practice of a SCs integration, interconnected in real time, achieving optimal flexibility and responsiveness (Dallasega et al., 2018; Ryan et al., 2017; Stevens and Johnson, 2016; Tu et al., 2018a; Zhou et al., 2015)[18].

Table 3 The long road to industry 4.0, the digitalization of every aspect of business (source: PwC)



I.5.2.Characteristics of Industry 4.0:

There are nine characteristics of the fourth industrial revolution:

I.5.2.1. Cyber-Physical System (CPS) :

Industry 4.0 can be played as a Cyber-Physical System study where the advances and speed of development in communication and calculation form the Cyber-Physical System and Industry 4.0. Each production system of CPS has sensors installed in the entire physical aspects in order to connect the physical things with virtual models. Due to Cyber-Physical System to be more common in society and occurs during interaction with humans, it must be ensured that CPS behave stably and has a certain bearing when utilized with artificial intelligence (AI) (Mosterman & Zender, 2015).CPS is also the foundation to create the Internet of Things (IoT) which can be combined to become the Internet of Services (IoS).Hence, businesses will find it easier to establish global networks which joins the warehousing systems, machinery and production facilities of CPS in the future(He, 2016);

I.5.2.2. Internet of Things (IoT) :

Industry 4.0 is the new phrase for the combination of the present Internet of Things (IoT) technology and the manufacturing industry. Industry 4.0 was initiated as a result of the combination of the Internet of Things (IoT) and the Internet of Services (IoS) in the manufacturing process (Kagermann, Wahlster & Johannes (2013). Generally, IoT can provide advanced connectivity of systems, services, physical objects, enables object-to-object communication and data sharing. IoT can be achieved through the control and automation of aspects like heating, lighting, machining and remote monitoring in various industries (Zhong et al., 2017);

I.5.2.3. Internet of Services (IoS):

Internet of Services acts as important components in the automotive industry. Activities are triggered through data transfers in the information technology to make daily mobility safer, easier and pleasant. The Internet of Services (IoS) acts as “service vendors” to provide services through the internet according to the types of digitalization services. These services are available and on demand around business models, partners and any setup for services. The suppliers provide and aggregate the services into additional value services as communication among consumers can be received and accessed by them through various channels(Buxmann, Hess, & Ruggaber, 2009);

I.5.2.4. Big Data Analytics:

Under Industry 4.0, big data analytics is beneficial for predictive manufacturing and is an important direction for industrial technology development through the

rapid development of the Internet. This leads to huge amounts of information produced and obtained daily where current processing and analysis is unable to cope using traditional methods. Hence, big data has become a hot topic recently in Industry 4.0. Many other applications would be able to gain additional values when existing techniques become more mature to handle big data. Big data is the utilization of digital technology to conduct analysis. According to Forrester's definition, "Big Data" can be divided into four dimensions which are volume, variety, value and velocity (Witkowski, 2017);

I.5.2.5. Augmented Reality :

Augmented Reality (AR) has begun to be considered as one of the most promising business that technological companies should heavily invest in. This technology can bring huge support for maintenance works in business due to reduced time needed for maintenance works and reduction of potential errors in maintenance works. It can predict with high accuracy and allows the frequency of maintenance to be kept at low numbers by utilizing predictive maintenance to prevent any unplanned reactive maintenance. This will reduce costs associated with doing too much preventive maintenance (Masoni et al., 2017);

I.5.2.6. Autonomous Robots :

Current robots have higher flexibility, advanced functions and are easier to operate in multitudes of fields. In the near future, robots will interact with each other and collaborate actively with humans under the guidance of handlers. These robots will be cheaper and more sophisticated in order to achieve better abilities compared to those currently used in the manufacturing field;

I.5.2.7. Additive Manufacturing (3D Printing) :

Industry 4.0 is stimulating the utilization of advanced data technologies and smart production systems. Hence, additive manufacturing is one of the crucial tools to embrace Industry 4.0. The implementation of new manufacturing skills for the purpose of integrating information technologies plays a crucial role in the competitiveness of the economy. The advancement of cyber technology has encouraged the transition to Industry 4.0. The trend of looking for new materials available using additive manufacturing is increasing. Certain required characteristics of a material can be achieved by metallic constituents and smart materials. In fact, the implementation of Industry 4.0 hugely depends on the capabilities of additive manufacturing (Dilberoglu et al,. 2017);

I.5.3.Cloud Computing (CM):

Cloud computing is a relatively new system logic that provides a huge space of storage for the user. A small amount of money allows enterprises or individuals

to access these resources. Over time, the performance of technologies keep on improving, however, the functionality of machine data will continue to be stored into the cloud storage system, allowing production systems to be more data-driven. Company limitations can be minimized since more data sharing will occur across sites for production-related undertakings in the industrial revolution. Cloud computing is slowly becoming a consideration by many companies during their data systems build. Even if software was traditionally not kept in clouds, the amount of applications being developed in clouds is gradually increasing (Xu, 2012);

I.5.3.1. Simulation :

Simulation modelling is a way of running a real or virtual process or a system to find out or guess the output of the modelled system or process. Simulations are done by using real-time data to represent the real world in a simulation model, which include humans, products and machines. Therefore, operators are able to optimize the machine settings in a virtual simulated situation before implementing in the physical world. This decreases machine setup times and improves quality. Latest revolutions in the simulation modelling paradigm enable modelling of manufacturing systems and other systems through the virtual factory concept. Furthermore, advanced artificial intelligence (cognitive) on process control, including autonomous adjustments to the operation systems (self- organization) can also be done through simulations (Rodič, 2017)[20].

This last section concluded the latest developments in the supply chain, from Industry 4.0 and digital ecosystem to finally its characteristics which are the key components of the Industry 4.0

I.6. Conclusion :

From traditional logistics to widespread use of e-logistics. This transition is of crucial importance for the competitiveness within the logistics market. Internet of Things and

Internet of Everything have a strong influence on the logistics itself, though it may not be entirely visible to the end user. Supply chain management changes and evolves, just as much as 3rd-party logistics and 4th-party logistics expand towards 5th-party logistics. E-Logistics develops various disciplines in which cloud-based operations, m-logistics, as well as Mobile Supply Chain Management and augmented reality are important segments in the future of logistics. There are no visible limits to aforementioned development; we are witnessing a completely new paradigm of logistics and supply chain management[21].

This chapter covered, the evolution of traditional supply chain to a completely digitalized ecosystem, where all operations into the ecosystem are synchronized and connected. Digitalization touched mostly e-commerce while e-commerce itself helped it develop through its challenges imposed on technology.

Chapter two:

E-commerce Fulfillment Center Facilities

II.1. Introduction

Facilities can be broadly defined as buildings where people utilize material, machines, and other resources to make a tangible product or provide a service[22].

This chapter consists of establishing and planting a third-party-logistics fulfillment warehouse in order to manage e-commerce businesses orders. It is divided into three sections, the first one is a general introduction to the project, the second section is about the realization plan, and finally the third section discusses storage within the warehouse.

II.2. Section One: Introduction to the Project

In this first section, we will be introducing about project, talking about our motivation of creating a fulfilment center, our main long-term mission and future vision.

II.2.1. Introduction to the Project:

While the global health crisis COVID-19 led to the lockdown of the whole national commerce activities (except food), getting rid of the remaining stock of these activities became a challenge, therefore working and selling from home while getting advantage from the opportunity that internet gives to its users -connectivity- took place. Internet facilitated exchanges and E-commerce bloomed like never in Algeria, as the Algerian customer and seller got somehow the culture of e-commerce, online sales became on an upward trend. At the same time staying at home pushed people to practice their hobbies especially artisanal ones, many people relied on their creations to earn a little money by selling what they make online through two means:

- **Marketplace:** which is a virtual shopping center, where anyone is allowed to put his/her goods on sale, by creating a virtual shop in marketplace platforms such as Facebook marketplace, Ouedkniss, Jumia, Batolis, Ferahni…etc

- **Social Network:** huge number of Facebook and Instagram profiles appeared lately during the pandemic, offering the option of selling online with the delivery service.

In E-commerce, generally 50% of the activity is selling(marketing), the other fifty is logistics, and logistics is complicated. For small e-commerce businesses, Logistics need a lot of knowledge and investment on:

- **Storing goods:** Getting a place where to put and stock products, and if the products are many or big in size then renting a warehouse to store them

- **Delivery:** Ensuring qualified delivery agents, and fast delivery accessible to every province in Algeria

Both storage and delivery processes are costly and most of the time costlier than the product itself, while the cheapest solution is outsourcing logistics to a third-party-logistics (3PL) firm.

II.2.1.1. Outsourcing to Third-Party Logistics Firm's Motivation :

When the volume of orders increase and the e-seller cannot manage orders' logistics of packing boxes, printing labels, spending hours to meet demand, driving to the post office and waiting in line…and so on, the e-tailer finds him/herself spending more time on fulfillment then running his/her own business, missing the opportunity to acquire more customers, develop new products, and launch more marketing campaigns. At the other hand, if the e-tailer is fulfilling his/her orders from home, and while the orders volume is increasing, storing goods in the living room or in the garage becomes impossible to handle. Outsourcing logistics to a 3PL firm becomes the best solution offering services to any kind of e-commerce business.

The project of creating a third-party-logistics firm in Algeria that provides services locally is promising, since there are not many national and affordable 3PL providers in the market. The number of e-commerce merchants is increasing and with the restricted number of 3PL providers, their needs cannot be met, but the key success factor for a 3PL firm is not meeting the customer's needs only, but it is about improving logistics process and more precisely adapting new technologies to meet storing without damage and fulfilling the right order to the right client at the right time with the best cost.

II.2.1.2. Mission :

Our mission as a 3PL firm consists on making logistics process easier for small e-commerce businesses by giving them the opportunity to stock their goods in the best conditions and deliver them in the shortest delays.

II.2.1.3. Vision :

- Ensure sustainability and growth to national e-commerce businesses;
- Ensure Quality service and build strong B2B and B2C relationship with partners;
- Employ the latest technology and IT trends in our logistics process;
- Visibility and transparency in our operations.

In this section we clarified what pushes us to plant a 3PL firm, our motivation, mission and vision. The coming section is about a general study of fulfillment warehouse realization.

II.3. Section Two: Fulfillment Warehouse Realization Plan

We have seen previously what drives us to create a 3PL firm, in this section we will study generally our plan of realization, we will be talking first about facility location of our fulfillment centers, as it is a very important point to highlight, that takes many factors into consideration.

Secondly, services that our fulfillment center provide to its both B2B partners and B2C end-customers. Thirdly, we will explain, in details Orders' fulfillment processes, and finally we will showcase our fulfillment warehouse' layout.

II.3.1. Facility Location:

Choosing fulfillment center's location is the first thing to think and re-think about while establishing a fulfillment center, as it is a long-term strategic decision and costly investment, that take many factors into consideration other than cost:

- **Infrastructure:** although fulfillment warehouses in outskirts, away from the city are cheaper in term of renting, their cost is not the key element to look for while implementing a fulfillment warehouse, mostly, it needs to be located near highways and major roadways so that the access to retailers for orders' pick-up is easier and faster, also the distance travelled is minimized, and the delivery deadline is the fastest possible (not more than two days).

- **Customer Density:** the e-tailer prefers that his/her goods are as close as possible to his/her customers, therefore 3PL firms need to implement multiple fulfillment centers to cover the maximum areas, those fulfillment warehouses need to be in cities, not only where the population density is high, but also where e-commerce culture is. e.g. a book seller is preferably to open his store near university.

- **Coverage:** building a fulfillment center in a populated province may seem a very good idea, at the same time choosing to build it in a province which is surrounded by many other provinces nearby can be a greater idea too. All in all, covering more areas, can be more important than covering all customers in one populated area.

- **Area traffic and geography:** another key factor to take into consideration is traffic: crowded locations lead to wasted traveling time and movement difficulty. Terrain and geography are as important as the traffic factor, especially in a country like Algeria, where there is the desert and the mountains, these parameters are really to take into consideration.

Before building location's problem solving algorithm a general study and multi-level analysis need to be done on the different factors and constraints that participate in the strategic locating decision of the fulfillment centers.

II.3.1.1. General Analysis:

We cannot implement a fulfillment warehouse without data, and as a new fulfillment firm that has not begun its activities yet, there are no operations' records registered yet. Therefore, we have made a general analysis and data study of what exists already in the country, at the same time the possible factors that may influence the localization's process:

- **Potential provinces depending on orders density:** After our statistics in a local 3PL company, the potential provinces with the highest orders rate are by chronological order **(Figure II.3-1)**: Algiers, Oran, Tizi Ouzou, Bejaia, Tlemcen, Setif, Blida, Batna, Constantine, Chlef, Boumerdes, Tipaza, Tiaret (the percentages are shown below). While it is very clear that provinces of south have very few numbers of orders that are almost none.

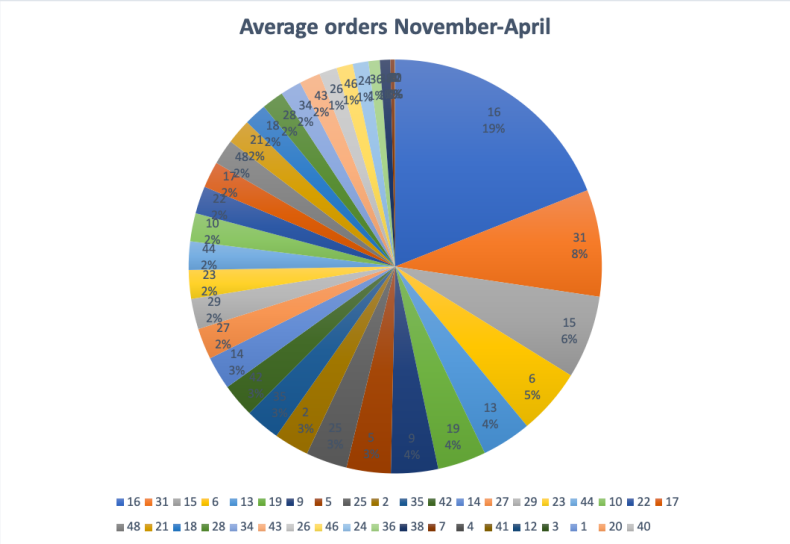


Figure II.3-1The average of orders in a national 3PL firm for November'19 to April'20 by wilaya code

- **Fulfillment centers' Localization:** As a starting 3PL firm, having three middle-size fulfillment centers in the north of the country: center zone, east zone, west zone, is good enough. Depending to the previous analysis, the three first localizations that we would choose, based on the number of orders and geographical location are:

  - Center zone: Algiers
  - West zone: Oran
  - East zone: Béjaïa

When orders rate increase, three fulfillment centers cannot cover all the national delivery, without forgetting that a 3PL company needs to gain all the national market not only the north, choosing other strategic locations will be mandatory, but the choice needs to take into consideration the pervious factors and be based on mathematical methods. To dig deep, a full qualitative and quantitative study as follows is to be done (the following qualitative and quantitative analysis need recorded data to be implemented: it remains a study).

II.3.1.2. Qualitative Analysis Method:

The location scoring method is a very popular subjective decision-making tool that is relatively easy to use. It consists of the following steps:

1) Step 1: List all the factors that have an impact on the location decision.

2) Step 2: Assign appropriate weights (typically between 0 and 1) to each factor based on the relative importance of each.

3) Step 3: Assign a score (typically between 0 and 100) to each location with respect to each factor identified in step 1.
4) Step 4: Compute the weighted score for each factor for each location by multiplying its weight by the corresponding score.

5) Step 5: Compute the sum of the weighted scores for each location and choose a location based on these scores.

Although step 5 calls for a location decision made solely on the basis of the weighted scores, these scores were arrived at in a subjective manner, and hence, a final location decision must also take objective measures such as transportation costs, loads, and operating costs into consideration[22].

We have studied some qualitative factors as follows:

- **Coverage Based on Neighborhood:** While orders' rate is important to choose potential fulfillment centers, the location is also important, the (figure II.3-2) down below (done with Tableau software) shows the placement of provinces (wilayas) with the highest number of orders on the map of Algeria, the neighborhood of each is as following:

- **Algiers Neighbours:** Blida, Tipaza, Boumerdès

- **Blida's Neighbours:** Algiers, Médéa, Tipaza, Ain Defla, Bouira, Boumerdes

- **Tipaza's Neighbours:** Algiers, Blida, Chlef, Ain Defla, Médéa

- **Chlef's Neighbours:** Mostaghanem, Rélizane, Ain Defla, Tipaza, Tissemssilt

- **Boumerdès' Nighbours:** Algiers, Blida, Tizi Ouzou, Bouira

- **Oran's Neighbors:** Ain Témounchent, Sidi-Bel-Abbès, Mascara, Mostaganem

- **Tlemcen's Neighbors:** Naama, Sidi-Bel-Abbes, Ain Témouchent

- **Tizi Ouzou's Neighbors:** Boumerdès, Bouira, Bejaia

- **Béjaïa's Neighbors:** Tizi Ouzou, Bouira, Bordj-Bou-Arreridj, Jijel, Setif
- **Constantine's Neighbours:** Jijel, Mila, Oum El Bouaghi, Guelma, Skikda
- **Batna's Neighbours:** Setif, M'sila, Mila, Biskra, Khenchla, Oum El Bouaghi
- **Setif's Neighbours:** Béjaia, Jijel, Bordj-Bou-Arrerij, M'sila, Batna, Mila
- **Tiaret's Neighbors:** Tissemssilt, Rélizane, Mascara, Saiida, Laghouat, El Bayadh, Djelfa

Wilayas that share borders with many other wilayas, have strategical locations, even if they do not have a higher orders rate, they can be better locations for fulfillment centers because they cover the maximum areas possible.

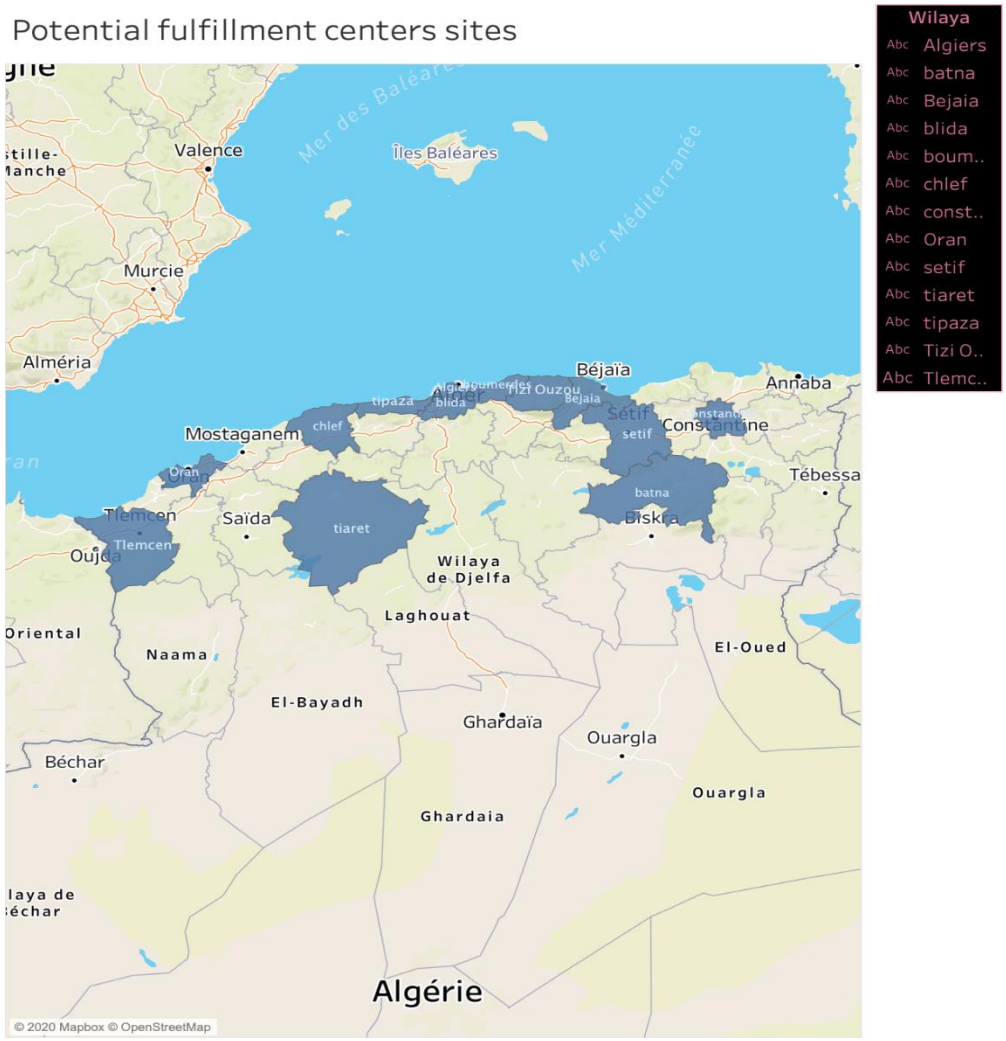


Figure II.3-2 Map of Algerian Provinces with the Highest rate of Orders

Algerian Highways Network: Algeria has in 2019, a motorway network of approximately 1,802 km in 2x3 lanes (figure II.3-3). It is the third motorway network in Africa after that of South Africa and Morocco.

Figure II.3-3 Algerian Highways Network's Situation (Source: Wikipedia)

- **West Highway:** Algiers-Maghnia (green)

➢ Length: 558 km (2x3 lanes)
➢ Accomplishment date: 2010
➢ Principle cities: Algiers, Blida, Médéa, Khemis Meliana, Chlef, Relizane, Mohammadia, Sidi BelAbbes, Tlemcen, Maghnia

- **East Highway:** Algiers-El Tarf (green)

➢ Length: 658 km (2x3 lanes)
➢ Accomplishment date: 2012 (still in process)
➢ Principle cities: Algiers, Bouira, Setif, Constantine, Annaba, El Tarf

- **Highway North-South:** Médéa-Boughezoul

➢ Length: 115 km (2x3 lanes)
➢ Accomplishment date: 2019 (still in process)
➢ Principle cities: Médéa, Berrouaghia, Ksar el Boukhari, Boughezoul

Wilayas located near highways mean fast and easy accessibility inter wilayas, therefore a potential choice to build a fulfillment center.

II.3.1.3. Quantitative Analysis:

There are many methods used for the quantitative analysis as there are hybrid methods taking into consideration both qualitative and quantitative factors in order to find the most optimal solution depending on the different set constraints, there are two aspects for the facility location problems:

II.3.1.3.1. Single-Facility Location Problems:

Determine an optimal location for one fulfillment centre's site, for example when choosing Oran as a location for a fulfillment centre, then where to locate

it exactly in Oran? here come the methods of single facility location to find the exact location of Oran's fulfillment warehouse, we proceed as follows:

- **Barycentre method:** we want to locate a fulfillment warehouse while:
  - m: points to deliver to;
  - every point i has a geo-localisation (xi, yi), and number of orders (or weight) wi;
  - Euclidean distance (square):

$$\text{Min } TC = \Sigma_i \, w_i \, [(\bar{x}-x_i)^2 + (\bar{y}-y_i)^2]$$

$$\frac{\partial TC}{\partial \bar{x}} = 2\sum_{i=1}^{m} w_i \bar{x} - 2\sum_{i=1}^{m} w_i x_i = 0$$

$$\therefore \bar{x} = \frac{\sum_{i=1}^{m} w_i x_i}{\sum_{i=1}^{m} w_i}$$

$$\frac{\partial TC}{\partial \bar{y}} = 2\sum_{i=1}^{m} w_i \bar{y} - 2\sum_{i=1}^{m} w_i y_i = 0$$

$$\therefore \bar{y} = \frac{\sum_{i=1}^{m} w_i y_i}{\sum_{i=1}^{m} w_i}$$

II.3.1.3.2. Multi-Facility Location Problems:

a simultaneous research of many optimal locations (localisation / allocation problem) for example the decision to implement multiple fulfillment warehouses (let's say four new fulfillment warehouses) while there are more than eight potential locations, here comes the question what are the four sites to choose out of eight?

- **The p-Median Problem (Weber):** It takes into consideration transportation cost, it looks for a P number of localisations, to minimize the sum of the distances separating the installations selected from the customers[23]. Algorithm steps:

1) Step 1: From the transport cost matrix, we calculate the sum of the values of each column. The lowest value is then considered optimal, the site corresponding to this column is therefore retained.

2) Step 2: We try to reproduce the previous calculation, taking into account that a first site already exists. To do this, between the value present in a column and that corresponding to the column of the site selected, the minimum value is retained.

3) Step 3: When we have done this for all the columns, we can calculate the sum of the values of each column. The lower value is then considered optimal, the corresponding site is therefore retained.

4) Step 4: We repeat step 2, taking into account that two sites already exist. Then we go to step 3 to identify the third site. We stop when we have identified the desired number of sites, otherwise we go back to step 2 to continue.

- P warehouses (factories) to be located on a set of m potential sites to
  deliver n customers.
- Each customer is delivered from a single warehouse.
- No fixed cost.
- No capacity constraints.
- Cij: the cost of transport from warehouse j to customer i.

$$X_j = \begin{cases} 1, \text{Si la localisation } j \text{ est choisie} \\ 0, \text{Sinon} \end{cases} \qquad Y_{ij} = \begin{cases} 1, \text{Si le client } i \text{ est affecté à la localisation } j \\ 0, \text{Sinon} \end{cases}$$

$$\min Z = \sum_{i=1}^{n}\sum_{j=1}^{m} C_{ij}Y_{ij}$$

Constraints:

$$\sum_{j=1}^{m} X_j = P$$

$$\sum_{j=1}^{m} Y_{ij} = 1 \qquad \forall\, i = 1,..n$$

$$Y_{ij} \le X_j \quad \forall\, i = 1,..n, \forall\, j = 1,..m$$

$$Y_{ij} \in \{0,1\} \quad \forall\, i = 1,..,n, \forall\, j = 1,..,m$$

$$X_j \in \{0,1\} \quad \forall\, j = 1,..,m$$

II.3.1.3.3. SS-Capacitated Facility Location Problem:

- Select a set of warehouses to locate on m potential sites to serve n customers.
- There is a fixed cost fj for the location of the warehouse j and it has a maximum capacity kj.
- di: customer i 's number of orders.
- Cij: the cost of transport from warehouse j to customer i.

$$X_j = \begin{cases} 1, \text{Si la localisation j est choisie} \\ 0, \text{Sinon} \end{cases}$$

$$Y_{ij} = \begin{cases} 1, \text{Si le client i est affecté à la localisation j} \\ 0, \text{Sinon} \end{cases}$$

$$\min Z = \sum_{j=1}^{m} F_j X_j + \sum_{i=1}^{n}\sum_{j=1}^{m} C_{ij} Y_{ij}$$

Constraints:

$$\sum_{i=1}^{n} d_i Y_{ij} \leq K_j X_j \quad \forall j = 1,..m$$

$$\sum_{j=1}^{m} Y_{ij} = 1 \quad \forall i = 1,..n$$

$$Y_{ij} \in \{0,1\} \quad \forall i = 1,..,n, \forall j = 1,..,m$$

$$X_j \in \{0,1\} \quad \forall j = 1,..,m$$

II.3.1.3.4. MS-Capacitated Facility Location Problem: multi-source capacitated location problem.

- Yij: the fraction (percentage) of customer i's demand delivered from warehouse j.

$$\min Z = \sum_{j=1}^{m} F_j X_j + \sum_{i=1}^{n}\sum_{j=1}^{m} C_{ij} Y_{ij}$$

Constraints:

$$\sum_{i=1}^{n} d_i Y_{ij} \leq K_j X_j \quad \forall j = 1,..m$$

$$\sum_{j=1}^{m} Y_{ij} = 1 \quad \forall i = 1,..n$$

$$0 \leq Y_{ij} \leq 1 \quad \forall i = 1,..,n, \forall j = 1,..,m$$

$$X_j \in \{0,1\} \quad \forall j = 1,..,m$$

- Yij: quantity delivered to customer i from warehouse j.

$$\min Z = \sum_{j=1}^{m} F_j X_j + \sum_{i=1}^{n}\sum_{j=1}^{m} C_{ij} Y_{ij}$$

Constraints:

$$\sum_{j=1}^{m} Y_{ij} = d_i \quad \forall i = 1,..n$$

$$\sum_{i=1}^{n} Y_{ij} \leq K_j X_j \quad \forall j = 1,..m$$

$$Y_{ij} \in N \quad \forall i = 1,..,n, \forall j = 1,..,m$$

$$X_j \in \{0,1\} \quad \forall j = 1,..,m$$

When the qualitative analysis leads to subjective localization solution, the quantitative methods lead to more exact logical solutions but still do not take the qualitative localization factors into consideration which are important to consider, therefore a hybrid analysis is the fusion of both the quantitative and qualitative analysis. Building a hybrid algorithm can be complicated as it needs to take all the recorded data and possible constraints into consideration, but most of all it generates the most optimal solution.

II.3.1.4. Services:

The fulfillment center needs to offer the following services to its partners:

- **Inventory management:** It allows e-tailers to warehouse their goods, and to synchronize inventory with their online stores through different technologies e.g. API, to view real-time inventory counts and to prevent stockouts so that customers immediately can view product's availability;

- **Two-day Shipping:** customer in nature expect both fast and affordable delivery, therefore technology used for order's fulfillment, and warehouse location are so important in order to make delivery process easier and closer to shipping destinations;

- **Distributed Inventory:** split inventory to different fulfillment centers in order to cover all the country's provinces needs since customers are geographically distributed across the country;

- **Packaging:** offer packing and labelling service to e-tailers.

II.3.2. Orders Fulfillment Process Planning:

Orders' fulfillment is a whole process in a complicated supply chain where the least picking mistake leads to a failed customer experience, choosing the right product to deliver is a result of where to store it, how to pick it and how to pack it, it is a question of checking and re-checking without wasting any time, but doing it intelligently with the help of digital tools and the connectivity of the whole system.

II.3.2.1. Inventory Management :

Managing inventory is crucial for maintaining a good B2B relations with partners, and growing e-commerce businesses.

II.3.2.1.1. Inventory Management Process:

The process is as follows **(figure II.3-5)**:

1) **Receive inventory:** products arrive to the fulfillment warehouse from partners, it happens in two ways: the 3PL firm does the pick-up of products from partners, or the partner sends his/her products him/herself to the fulfillment centre, it depends on the contract;

2) **Checking:** when the product enters 3PL warehouse it is checked whether it contains any damages and whether it is the right product according to its title. If yes, then it is validated to the next step, else it is returned to the supplier;

3) **Calculation:** when the product is accepted its weight and dimensions are calculated (height, length, width), this calculation helps later for the expedition;

4) **Assign SKU code:** SKU (stock keeping unit) is an alphanumeric code used by online or retail stores to identify a specific product. SKUs are often on scannable bar codes, and represent different product characteristics such as color, size, and brand, and are used for inventory management and tracking, they help 3PL company to know how much warehousing and storage space does it need in its fulfillment center[24]. Many 3PLs store each unique SKU in its own bin or shelf space in order to make the picking and packing process easy and efficient. A 3PL may offer the following services, all of which are based on SKUs:

    - Synchronize inventory automatically with online store;
    - Show real-time inventory levels by SKU;
    - Set reorder points for each SKU based on the quantity at which you wish to be alerted to restock;
    - Bundling different SKUs for promotions;
    - Merging the same product across ecommerce platforms;
    - Kitting SKUs to assemble them a certain way before they are shipped to customers (assembly of spare pieces of an item in one group in advance of it being ordered by a customer so that to facilitate their picking)[24].

Unlike Universal Product Code (UPC), SKU is a personalized code and it does not follow rules for example:

An SKU for a pair of purple Zara boots in the Bailey Bow style, size 37 might look something like this: ZARA-BB-PUR-37. Another example (figure II-3-5)

Figure II.3-4 SKU and UPC on Product (source: google)

5) **Scan barcode:** the barcode of the product is scanned and registered in the inventory management software;

6) **Dispatch:** after assigning the SKU and scanning the barcode, products are dispatched to be stocked;

7) **Storage:** in bins on shelves, the location of shelves where to stock them is predefined by IMS, when putting the item in the bin the operator scans bin's barcode/QR code.

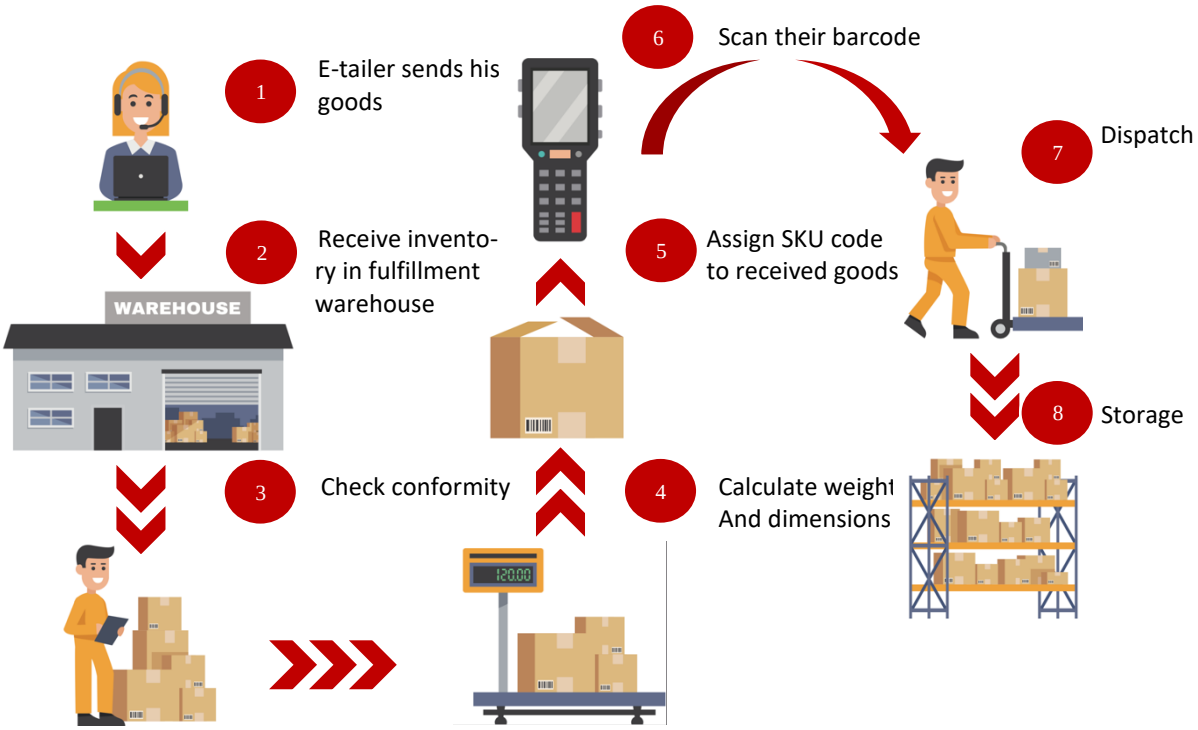


Figure II.3-5 : Inventory Management Process

II.3.2.1.2. Inventory Management Importance:

Inventory management is important to:

- **Never run-out stock:** it avoids both too much inventory and dead stock risk, in order to meet customer's demands, (ROF) helps to prevent going below the critical level of inventory, the formula to calculate reorder point is the sum of lead time demand and safety stock in days:

Reorder Point (ROP) = Demand during lead time + safety stock

➢ **Demand during lead time:** Lead time is the number of days between when you place a purchase order with your manufacturer or supplier for a product and when you receive the product, calculated:

Lead time demand = lead time x average daily sales

- **Safety stock**: is the extra "just in case" inventory you keep on hand to anticipate variability in demand or supply, calculated:

Safety stock level = (Max daily orders x max lead time) – (average daily orders x average lead time).

- **Save money on storage:** inventory cost is variable and it depends on how much space inventory takes up at any given time;

- **Give insight of buyer's behaviour**: what products they are/are not into;

- **Inventory forecasting:** predict and plan for demands, based on monthly, seasonal, trends;

- **Track costs of goods sold:** Inventory accounting is when you track and account for changes in the value of inventory over time as it is related to manufacturing and costs of sold goods. If you do not have an accurate method for keeping track of the value of your inventory, you cannot properly value your assets or goods sold and budget for the inventory you need to buy for your business.

II.3.2.1.3. Inventory management techniques:

- Set order points to prevent dead stock
- Implement FIFO system to get rid of the older inventory first
- Use inventory management software to keep track and report inventory to save time and potential human errors
- Keep most ordered items easily accessible

II.3.2.2. Pick and pack (PnP) :

Pick-and-pack process is the process that comes after the click of "BUY NOW", in an e-commerce platform, it is when the order is placed and confirmed. The picking in a small or medium size fulfillment warehouse is done by human operators (pickers), else by both human agents and robots.

II.3.2.2.1. Pick and Pack Process:

1) **Place the order:** placing the order online is the nation of the whole process, when the customer confirms his order, 3PL company gets notified to start the picking process;

2) **Preparing the pick list:** the pick list is generated automatically it can be printed, or if the pickers are provided with digital devices (tablets, mobiles), the list is displayed on them containing all the order's

information even photos of items. As soon as a pick list is generated, the order fulfillment process can begin;

3) **Get the picking routing:** when the pick list is generated the picking routing of the order is generated automatically, and displayed in pickers wearable devices;

4) **Assign picking:** if it is batch picking, the order list is assigned to one picker, else it is assigned to many pickers each one picks from his/her own zone (aisle);

5) **Order's items collection:** in zone picking, the different items collected in an order are grouped in a kart to go for packing. Else in batch method, items in an order are already grouped (as they are picked by one person) and they go directly to be packed;

6) **Scan to pack:** when the order is picked, it enters the packing line, it is scanned by a human operator in order to define the size of the box it should be packed in;

7) **Packing:** the box is selected and the order is packed and taped;

8) **Labelling:** the order is packed and then it goes in a conveyor to a machine called SLAM, this machine weighs the order, if the order's weight is not the same as it is mentioned in the system, then it can be a wrong picking, it goes to quality control department, to define the error. Else it is labelled for shipment with the receiver's information (name, phone number, address), a barcode special of the order and supplementary product information;

9) **Shipping:** the order now is ready to be shipped.

II.3.2.2.2. About the Pick List:

A pick list is a recap of the ordered items it can contain only one SKU as it can contain many SKUs of same or different products, most of all it should be clear and easy to understand, generated by WMS. It includes three main information: SKU, Quantity and Inventory storage location. The number of completed pick lists in an hour varies according to the size, layout and efficiency of the warehouse.

II.3.2.2.3. Picking Methods:

Instead of pick-to-order method, which is picking different items of an order assigned to one picker. There are two methods for fulfillment center's picking process optimization:

- **Batch picking:** for similar picking lists, the picking process happens at once for them all, it reduces errors and avoids wasting time going back and forth;

- **Zone picking:** In order to prevent overcrowding in one area, and spending too much time walking instead of picking, there is this method of zone picking it is by assigning each picker to a zone e.g. multimedia zone where all products of the type multimedia are in the same aisle, this method is product-based and storage-based. To group all the collected items of an order together, it is for a human operator or robots to bring items to operators.

II.3.3. Fulfillment Warehouse Layout:

II.3.3.1. Flow Process Chart:

The flow process chart, sometimes also known as the layout planning chart (Reed, 1961), graphically illustrates the various steps the product undergoes on its way from receiving to shipping. It lists the operations, and includes the standard time for each operation as well as the number of pieces and how they are moved. The chart could be expanded to include the operator and department where the operation takes place, remarks on how process improvements can be made, and other information[22].

The flow process chart is done according to the fulfilment warehouse dimension, machines and transportation system performance. The following Flow Process chart (figure II.3-3) is done relying on approximation to reality (the distances between departments and stations are changeable relatively to the warehouse dimensions).

II.3.3.2. Warehouse Layout:

Our fulfillment center processes high variety of products with small volume, according to layout types diagram **(figure II.3.3 2)**, our layout is of type: ***Process layout type***. Where equipment, of the same process type, are arranged in groups together. We can distinguish four departments:

1) Inventory Processing department
2) Storage area
3) Pick and Pack Department
4) Quality Control Department

The **(figure II.3-3)** down below illustrates our fulfillment center layout model.

Order ID: 342908 Chart Number: 21A324
Chart Begins: Receiving Chart of Method: Present
Chart Ends: Shipping Charted by: M.K
Sheet 1 of 1 Date: 29 July 2020

Distance	Time	Chart Symbol	Oper ID	Dept ID	M/O ID	# of pieces	How moved	Process Description
	1 min	1 ▼	H1	IP	/	variable	Human operator	Receive inventory
1 m	1.5 min	1 ■	I2	IP	O1	1	Conveyer	Checking conformity
2 m	15 sec	2 ■	I2	IP	M1	1	conveyor	Calculate weight and dimensions
1 m	40 sec	3 ■	I2	IP	O2	1	conveyor	Assign SKU code and scan barcode
0 m	15 min	1 ➡	C3	IP		variable	Conveyor/ Cart HO	Dispatch items
variable	10 sec	2 ▼	S4	St		variable		Stock items until the order is placed
Variable	10 min	2 ➡	H1	St		Variable	Cart HOs	Collect orders
6 m	7 sec	4 ■	I2	PnP	O3	1	conveyor	Scan to pack
3 m	1 min	1 ●	P5	PnP	O4	1	Conveyor	Pack orders
6 m	10 sec	2 ●	P5	PnP	SL1	1	Conveyor	Labeling, weighing
2 m	15 min	5 ■	I2	Q	O5	1	HO	Check wrong package
3 m	1 min	3 ➡	I2	PnP		variable	HO	shipping

Event	Total
▼ Storage	2
■ Inspection	5
➡ Transportation	3
● Operation	2

Department ID	Department name
IP	Inventory processing
St	Storage
PnP	Pick and Pack
Q	Quality Management

Figure II.3.3-1 Flow Process chart example of our Fulfillment Centre

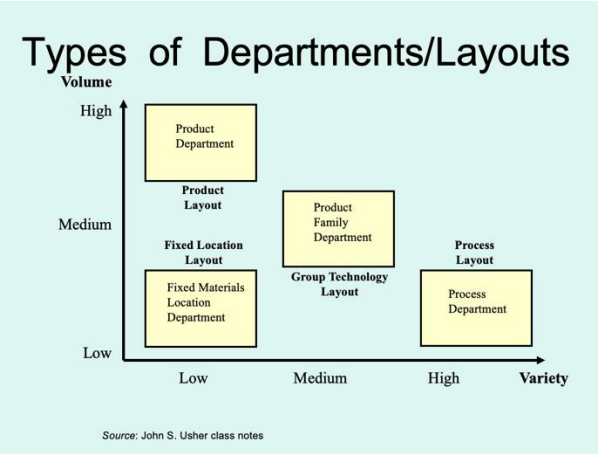


Figure II.3.3-2 Types of layouts (source : Facility Design)

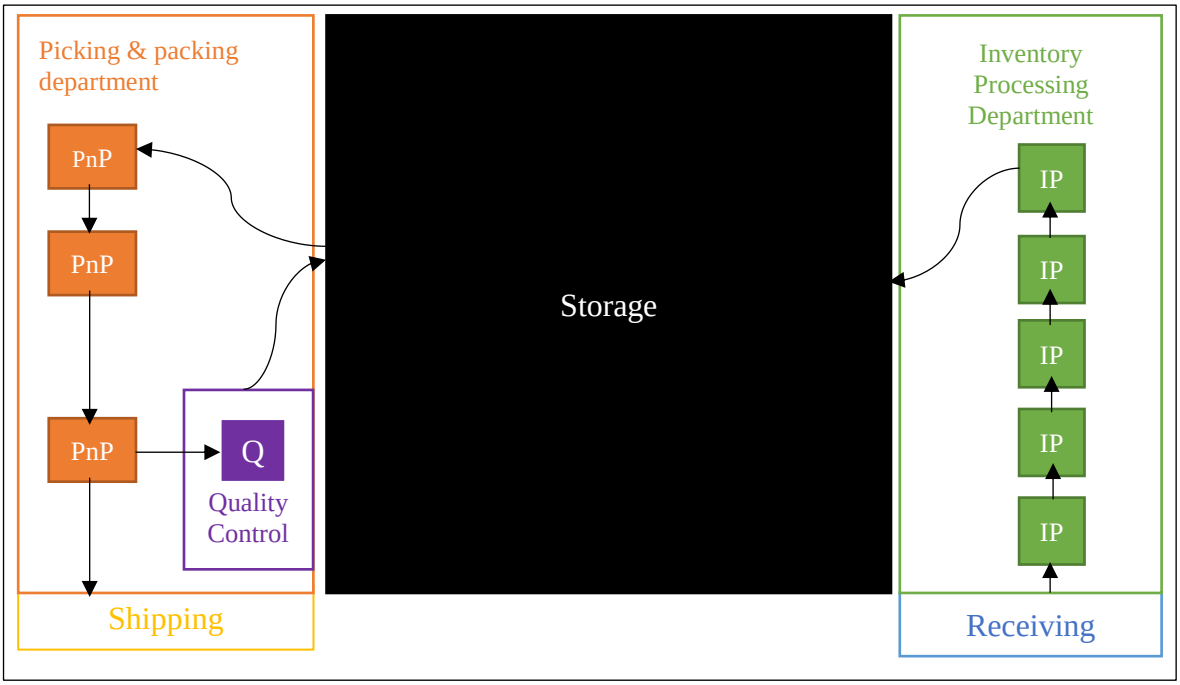


Figure II.3.3-3 Fulfillment center layout and material flow

We have seen in this section a study of facility location in both qualitative and quantitative aspects, also services that our e-fulfillment center needs to offer, we planned our fulfillment processes of inventory management, picking and packing and shipping, and finally we studied the type of the layout while illustrating it, including the position of departments with their different processes.

The next section will reveal the black box of storage, how orders are managed and organized in the storing space, and how are they put in order to prevent any loss.

II.4. Section Three: Storage

In e-fulfillment centers, every minute and every second counts in order to fulfill customers' orders by the deadline, having a good storage system and method, can help gain time and efficiency. In this section we will be defining first our storage system and storage mean (tool), and then our storage technique and organization.

II.4.1. Storage System:

A good storage system is a necessity for a 3PL company that is dedicated to a main function which is storing, we thought about efficient system that can help us optimize our processes:

II.4.1.1. Storage System :

For our Medium size fulfillment warehouse:

- We do not have high volume of loads being moved in and out the storage
- The storage is random
- A big variety of products with low quantities each

According to our constraints, we chose ***static shelving storing system***, as it is used for manual picking/placing/organizing, and can hold lightweight (few hundred pounds per shelf)

II.4.1.2. Storage mean (tool):

We know that e-commerce fulfillment warehouse contains a huge variety of goods, therefore it is difficult to locate the item, while ensuring fast picking e.g. if the item is put directly on shelf 1 that is 10 meters long how to find it without traveling all the 10 meters?

For better location and accessibility to our stored items, we choose an intermediate tool, which is ***plastic bins***, they are put on shelves and items are put in them randomly.

A storage bin is usually known as coordinate e.g. for the item of SKU ZARA-BB-PUR-37, holding numbers 01-02-03, this number indicates that this SKU storage bin is located in row 1, stack 2, level 3.

II.4.2. Storage Technique:

Storage area is like a black box, placing items and organizing their locations is what makes picking possible, else you would be just like someone looking for a sentence from a book, that he/she does not know its title, in a library full of thousands of books. Therefore, we need to have our own organizational techniques for easy storing and picking process.

II.4.2.1. Storage organization:

We propose the following organization: aisles, shelves and bins **(figure II.4-1)**

- **Aisles (zone):** each aisle is dedicated for a type of goods, for example multimedia aisle, is an aisle dedicated for phones, Xbox, CDs… Every Aisle is recognized with a unique letter A or B or C or…
- **Shelves:** each shelf in an aisle has a number for example A1 means shelf one of aisle A
- **Bins:** each bin located on a shelf needs to have special unique color (for faster accessibility) and a code containing three numbers indicating row, stack and level

II.4.2.2. Organization Inside the Bin :

when human operators pick items from bins, they leave a sticker on the bin that indicates that there is an empty space.

And when storing inventory, the human operator dedicated for storage goes to the aisle specialized for that type of item, and look for bins with stickers, he/she puts the item randomly in the suitable bin.

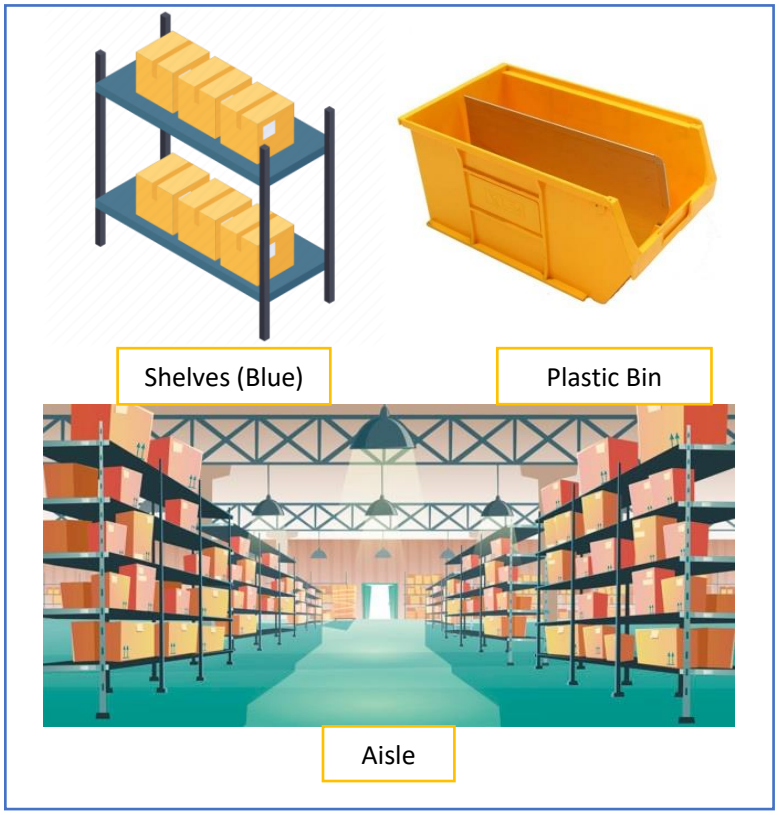


Figure II.4-1 Illustration of shelves, Plastic bin and Aisle

The storage organization that we have done, allows us to do fast and efficient orders' picking while ensuring a good inventory storing and management.

II.5. Conclusion :

This chapter was about e-fulfillment center's facilities project, we have defined in it our motivation of creating e-fulfillment center, its mission, vision, and services. We have gone through the whole detailed planning of facilities location analysis and study, of the different processes of orders' fulfillment, and a study of suitable layout. And finally, the inventory organization and orders management in the storing system.

Chapter tree:

Smart shelves Solution

III.1. Introduction

Growth in e-commerce has changed the kind of warehouse management, some businesses chose to grow their staff and some others adopted more technical solutions such as digitalization.

According to Mr Paul Lim, Founder and President of SCA, the digital revolution that is sweeping across Asia will provide a wealth of new opportunities for logistics / SCM players. 3PLs position themselves as the experts of logistics. To succeed and sustain with the new digital opportunities in logistics / SCM, 3PLs need to transform their businesses before others do.[25]

Digitalizing 3PL providers' logistics within their fulfillment centers includes technologies such as cloud technologies, IoT, IoS, advanced robotics…these technologies as they can gain them efficiency, speed and precision in their operations, they may at the same time cost them more than necessary, therefore choosing the adequate technology solution to adapt, according to the needs, is the first thing to consider.

In this chapter we will see how Internet of Things enable us to adopt a smart shelving solution based on RFID and Sensors technologies.

III.2. Section One : Internet of Things

"IoT" industry's buzzword, Internet of things is impacting every facet of the modern world, technology precisely. The concept of IoT is to synchronize tools wirelessly in order to improve the different flows of information flow (Communication, data…) and of material flow (equipment, operations…). Today, the internet, coupled with wireless technology has a hand in multiple daily operations. In fact, IoT touches most areas of the supply chain in some form but has rapidly had an impact in warehousing and fulfillment centers, specifically.

Before talking about how we are digitalizing our logistics and storage system within our fulfillment centers, we would first talk and clarify more IoT.

III.2.1. IoT Architecture:

The IOT system architecture is generally divided into three layers: the perception layer, the network layer, and the service layer (or application layer)[26]. Figure III.2 1

Perception layer: It is the information origin and the core layer of IOT. All kinds of information of the physical world used in IOT are perceived and collected in this layer, by the technologies of sensors, wireless sensors network (WSN), tags and reader-writers, RFID system, camera, global position system (GPS), intelligent terminals, electronic data interface (EDI), objects, and so like.

Network layer: This layer, also called transport layer, including access network and core network, provides transparent data transmission capability. By the existing mobile communication network, radio access network, wireless sensor network (WSN) and other communications equipment, such as global system for mobile communications (GSM),

general packet radio service (GPRS), worldwide interoperability for microwave access (WiMax), wireless fidelity (WiFi), Ethernet, etc., the information form perception layer can be sent to the upper layer. At the same time, this layer provides an efficient, reliable, trusted network infrastructure platform to upper layer and large scale industry application.

Service layer: This layer, also called application layer, includes data management sub-layer and application service sub-layer. The data management sub-layer provides processing complex data and uncertain information, such as restructuring, cleaning and combining, and provides directory service, market to market (M2M) service, Quality of Service (QoS), facility management, geomatics, etc. by service-oriented architecture (SOA), cloud computing technologies, and so on. The application service sub-layer transforms information to content and provides good user interface for upper level enterprise application and end users, such as logistics and supply, disaster warning, environmental monitoring, agricultural management, production management, and so forth[26].

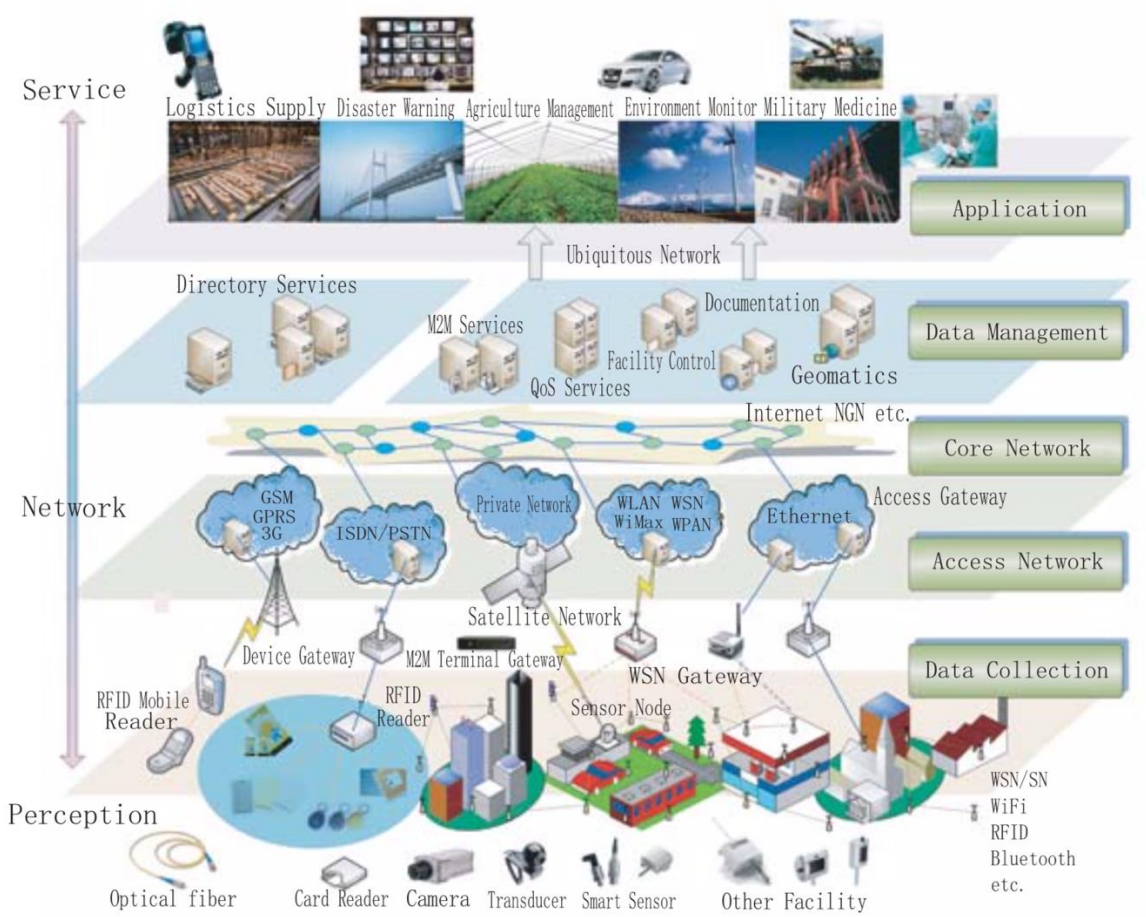


Figure III.2-1 The System Architecture of IoT (source: RFID and its application on IoT)

III.2.2. Impact of IoT Application:

IoT is reshaping mostly supply chain and logistics in industries, and warehouses, the application of IoT in our fulfillment center's will allow us:

- Build smart shelving system giving real-time data on inventory, stock level, space availability within the bins
- Locate our items, and provide full traceability of storing units (bins)
- Gain time while dispatching inventory in the storage place, and prevent loss
- Ensure effective and efficient inventory storage

III.2.3. IoT Solution Integration "Smart Shelving":

In order to improve our storage system under the concept of digitalization, we propose ***smart shelving storage system***, which is based on IoT technology.

We have seen previously (chapter 2), when dispatching inventory in the storage space:

- Bins with available space are displayed for the dispatch agent
- Dispatch agent has to store the item in one of the mentioned bins
- All items when they get into our fulfillment center go through dimensions' calculation and weighing
- All the necessary data of the item is registered then

The question now is, how can we keep traceability of items inside the bins, how can we avoid loss, and how can dispatch agent know which bin is the most suitable for storage, regarding his item's dimension?

Instead of going through all the bins, with available place (sometimes is not found with enough space for his item) how can a smart storage system ensure for him the best location to put his item?

That's what our proposed technology solves, based on connectivity and communication enabled by IoT between bins and the dispatch agents.

Smart Shelves are electronic, connected shelves designed to automatically keep track of inventory, this technology helps logisticians to manage better their storage, locate items quicker and facilitate order picking, it is widely used in retail industries and supermarket mostly to notify about stock level on shelves.

Our proposed technology of smart shelves is based on WI-FI connected equipment adapting RFID tags and sensors. And that is what we will see in the next section.

III.3. Section Two : RFID Solution :

RFID is a radio frequency identification system that allows information to be written, stored and reread on electronic labels integrated into the products to be traced. In this section, we will introduce our adopted solution of RFID for intelligent shelving and its working principle.

III.3.1. RFID technology:

This system consists of an electronic chip equipped with an antenna (the RFID tag) and a reader:

- **RFID tag (or transponder or tag):** It is equipped with a chip connected to an antenna. The antenna allows the chip to transmit information (serial number, weight, etc.) which can be read using a transceiver reader.
- **RFID reader**: Once the information has been transmitted, the reader only has to convert the radio waves into data and these can be read by RFID software.
- **RFID software:** or RFID middleware, is the brain of RFID chain, it transforms the raw data sent by the RFID chip into comprehensible information. RFID software is necessary to process the information contained in the RFID chips and integrate this information into the company's databases

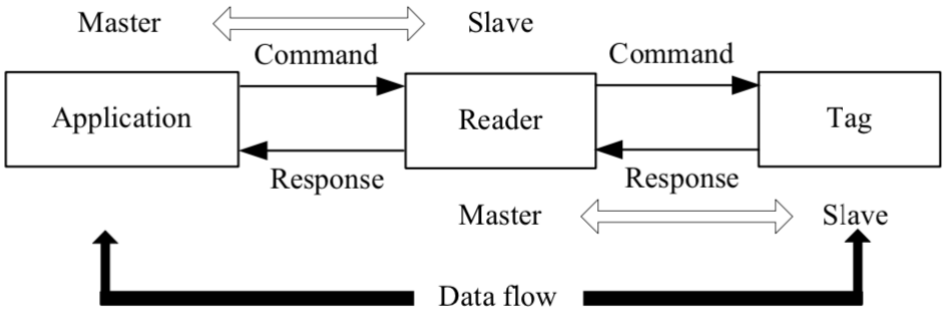


Figure III.3-1 The components of RFID System (source: RFID and its application on IoT)

III.3.2. Solution:

What do we propose, is a fully integrated RFID system including antennas, cables and RFID reader, we will be tagging all the bins on shelves with RFID tags, while having built-in shelf antenna on each shelf, to transmit radio waves and connect the tag to the reader, each bin will have its serial number or identification number associated with RFID tag's EPC number in our database. Data that this tag can transmit (except the serial number) is the bin's identification (according to what we have seen in chapter two), the total items contained in the bin with their full information, weight of the bin. Theses anetnnas will be linked to the RFID reader using RFID cables, this latter is connected to the terminal of

internet, it will read data transmitted from the tags (in its read range) and presents this data to RFID Software. Figure III.2-1:

We have seen in this section about the RFID integration in our storage system for real-time data availability of the inventory, stock level, and stored items traceability in the stoge bins. How is this technology implemented and how does it work.

The next section will be about another technology broadly used in IoT, which is sensors, we will discover how do we adapt sensors and a technological solution for space availability mesurement within the storage bins units.

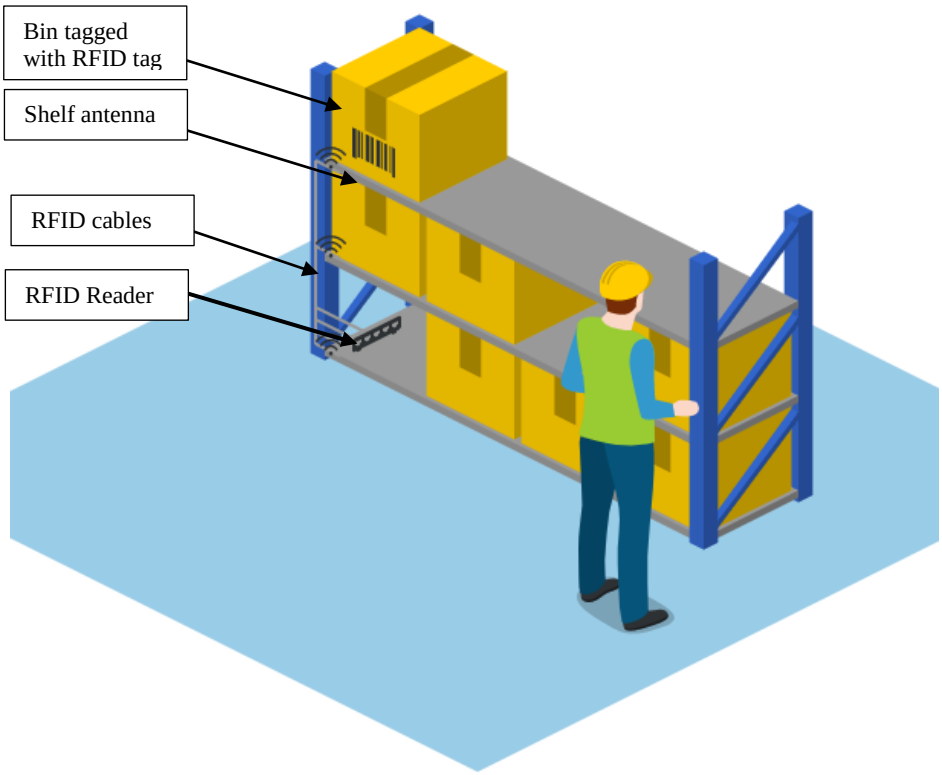


Figure III.3-2 Smart shelves with RFID system integrated

III.4. Section Three: Sensors Solution

Sensors, are so commonly used in IoT in order to fetch real-time data. In the broadest definition, a sensor is a device, module or subsystem whose purpose is to detect events or changes in its environment and send the information to other electronics, frequently a computer processor. A sensor is always used with other electronics[27].

We have seen previously shelves connectivity with our warehouse system for traceability, now in this section we will see both connectivity and time gaining solution for inventory dispatch operation which is sensors solution, how does it work, advantages, disadvantages and implementation's study.

III.4.1. Solution:

We propose implementing ***proximity sensors,*** on the surface of the bins, in order to detect available space, knowing that proximity sensors are able to detect nearby objects without touching them, by emitting a beam of electromagnetic radiation, those sensors need to be placed along the plastic bin's surface as the figure down below shows:
fig III.4-1:

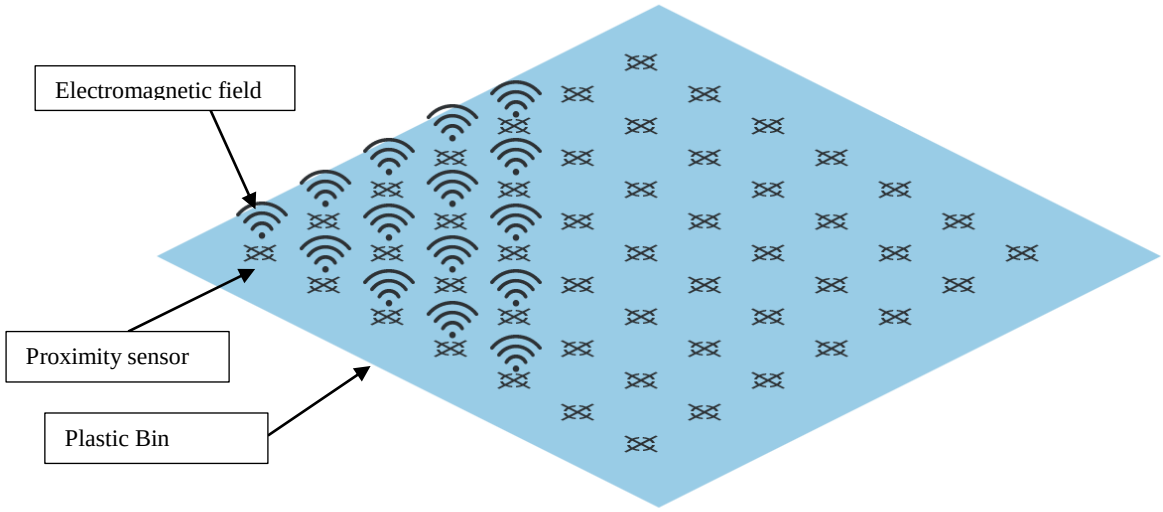


Figure III.4-1 Sensors' Integration on storage bins

- The electromagnetic radiation gives information about the available empty space within the bin when detecting non-presence of object (when there is nothing placed in its field)
- The number of sensors to be placed depends on the dimensions of the plastic bin, each sensor needs to cover small field for a better precision on the bin's availability. For example, if our sensor covers bigger area (field), even if there is a very small item put in that area, while there is enough space for other items, it indicates that there is an object placed, therefore no space available. Therefore, placing many sensors, covering small area is necessary for better precision of availability, fig.
- There are many types of proximity sensors, for our study we chose ***"Capacitive sensors"***
- Capacitive proximity sensor produces an electrostatic field, when an object (conductive/non-conductive) approaches the sensing area, the capacitance of

both plates increases, resulting in oscillator amplitude gain, the resulted amplitude gain triggers sensor output switch, Capacitive sensors only oscillate when the target object is present[28]. Fig

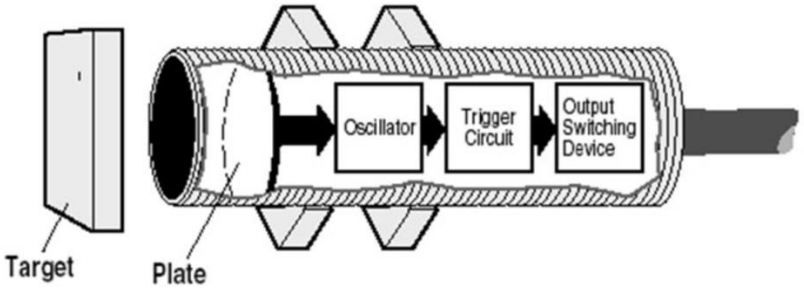


Figure III.4-2 Capacitive Proximity Sensor (source: Automation Insights)

III.4.1.1. Advantages:

- Capacitive sensor can detect presence of objects in their coverage area
- It detects metal, non-metal, liquid, wood, plastic…
- Suitable to harsh environment conditions
- Long life service
- Small detection area

III.4.1.2. Disadvantage:

- More expensive than inductive sensor

III.4.1.3. Sensors Implementation:

This smart solution needs to be studied both sides: technical and business, therefore the following table shows this solution's specifications for one storage bin:

Needs	characteristics	Quantity	Price
Plastic Storage Bin	23 x 15 x 12.5cm	1	Price ≥ 5€
Capacitive proximity sensor	Sensor area size: 25 cm^2 Proximity sensing range: 28 cm Table	14	~ 98 €

Sensor Area Size (cm^2)	Proximity Sensing Range (cm)
0.25	15
1	17
4	19
9	22
16	25
25	28
36	31
49	33
64	37
81	39
169	50

Figure III.4-3 Proximity Sensing Range Based on Sensor Area Size

Note: according to the area of detection, the dimension of available space is calculated

We have seen in this section in details our chosen solution of capacitive proximity sensors, hence this technology's implementation seems quite expensive, still it provides precision on available space measurement in the storing bins.

III.4.2. Conclusion :

Internet of Things is a revolutionary advancement in technology, providing the possibility of connecting things all together, using internet while reducing human efforts and ensuring real-time information flow. We have applied in this chapter IoT in our storage system through RFID technology for inventory traceability, and Sensors technology for dispatch process improvement by providing visibility on bin's availability and space as a digital logistics solution for storage system's efficiency. The next chapter, we will introduce another digital logistics tool for our storage management.

Chapter four:

Web Application Solution

IV.1. Introduction :

ERP, WMS, TMS… are all digital tools for logistics flows management, they are important in order to keep track of the different operations within the industry, warehouse or enterprise in general.

One of key success factors of order fulfillment process, therefore 3PLs firms is: good inventory management within the storage space. And that is what we will be working on in this chapter. We will be presenting a fulfillment center management system based on web application, we will detail the stages of development of our platform as well as the languages and technologies that have accompanied this development. The main interfaces of our platform will be presented and discussed.

The first section will be showcasing the design and modeling of the web application, and the second section will be an explaining and realizing this web application.

IV.2. Section One: Application's Design and Modelling

A web application refers to application software hosted on a server and accessible via a web browser.

Unlike traditional software, the user of a web application does not need to install it on their computer. All they need to do is log into the application using their favorite browser. The current trend is to provide user experience and functionality equivalent to software installed directly on computers. The technologies used to develop web applications are the same as those used in creating websites[29].

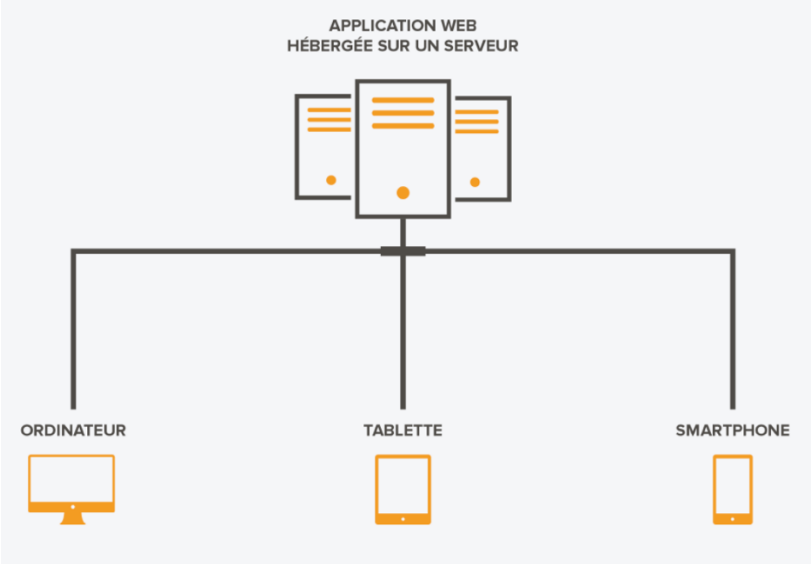


Figure IV.2-1 Web Application Principle

Before building any web application, there must be a design, a mapping a modeling of all functions, this modeling is UML based, it includes use case diagram and class diagram.

IV.2.1. UML:

The Unified Modeling Language (UML) is a general-purpose, developmental, modeling language in the field of software engineering that is intended to provide a standard way to visualize the design of a system. The creation of UML was originally motivated by the desire to standardize the disparate notational systems and approaches to software design. It was developed by Grady Booch, Ivar Jacobson and James Rumbaugh at Rational Software in 1994–1995, with further development led by them through 1996 [30].

UML offers a way to visualize a system's architectural blueprints in a diagram, including elements such as:[30]

- any activities (jobs);
- individual components of the system;
- and how they can interact with other software components;
- how the system will run;
- how entities interact with others (components and interfaces);
- external user interface.

UML has many types of diagrams, which are divided into two categories. Some types represent structural information, and the rest represent general types of behavior[30].

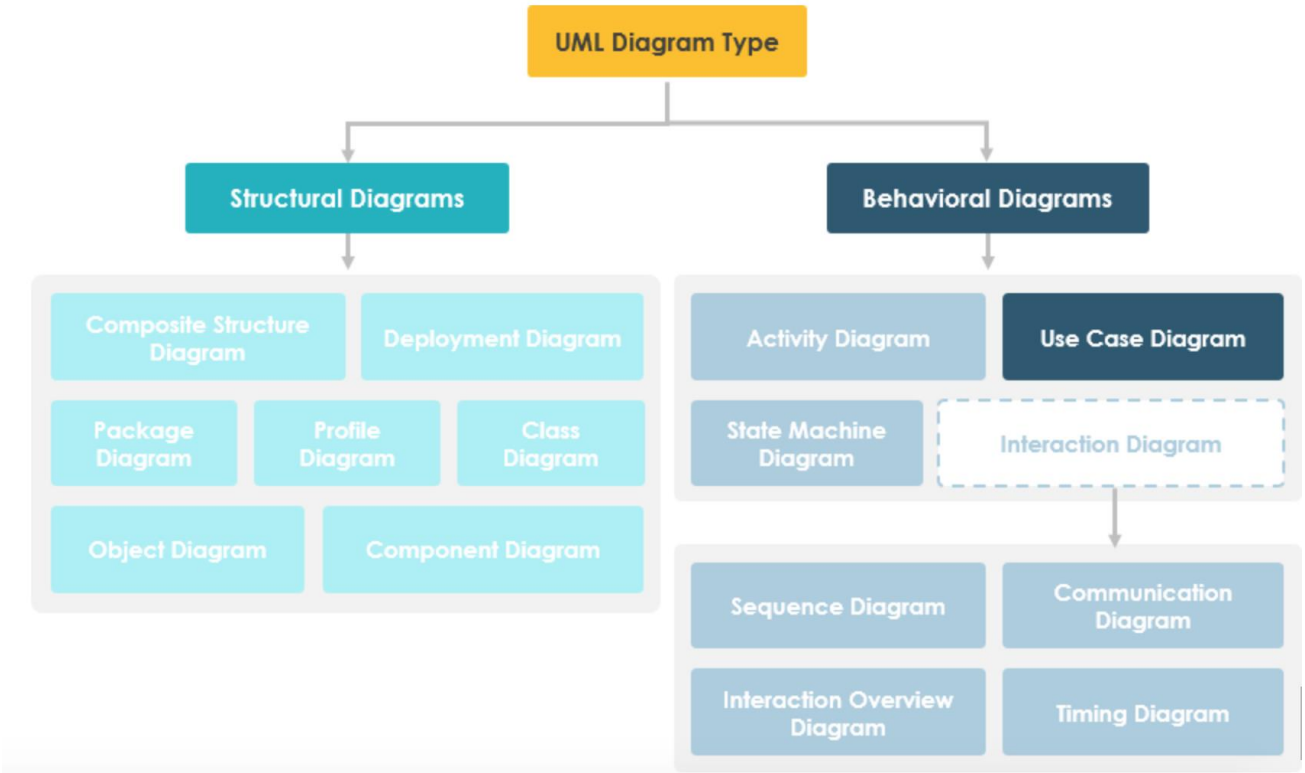


Figure IV.2-2 UML Diagram types (source: visual-paradigm)

IV.2.1.1. Use Case Diagram Overview :

Use case diagram is one of UML's behaviour diagrams, a key concept of use case modeling is that it helps us design a system from the end user's perspective. A use case diagram is usually simple. It does not show the detail of the use cases:[31]

- It only summarizes some of the relationships between use cases, actors, and systems.
- It does not show the order in which steps are performed to achieve the goals of each use case.
- Use cases specify the expected behavior (what), and not the exact method of making it happen (how).

IV.2.1.2. Purpose of Use Case Diagram:

Use case diagrams are typically developed in the early stage of development and people often apply use case modeling for the following purposes[31]:

- Specify the context of a system
- Capture the requirements of a system
- Validate a systems architecture
- Drive implementation and generate test cases
- Developed by analysts together with domain experts

IV.2.1.3. Use Case Diagram's Elements:

Table: Notation Description with Visual Representation of Use case Diagram (source: visual-paradigm)

Notation Description	Visual Representation
Actor: someone interacts with use case, he has a responsibility towards the system (inputs) and has expectations from the system (outputs)	
Use Case: System function (process - automated or manual), named by verb + Noun (or Noun Phrase) i.e. Do something Each Actor must be linked to a use case, while some use cases may not be linked to actors.	
Communication Link: The participation of an actor in a use case is shown by connecting an actor to a use case by a solid link. Actors may be connected to use cases by associations, indicating that the actor and	

the use case communicate with one another using messages.

Boundary of System: The system boundary is potentially the entire system as defined in the requirements document. For large and complex systems, each module may be the system boundary. For example, for an ERP system for an organization, each of the modules such as personnel, payroll, accounting, etc. can form a system boundary for use cases specific to each of these business functions.

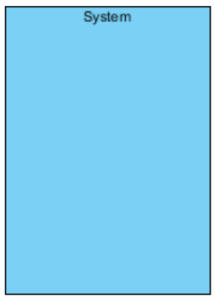
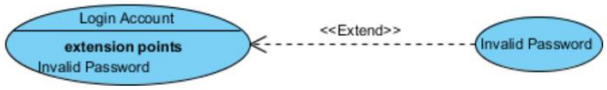
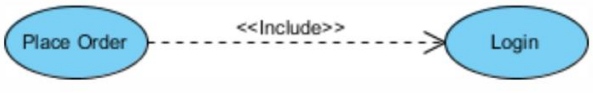
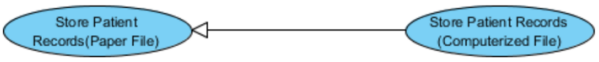


Table: Use Case Relationships with their Visual Representation in Use Case Diagram **(source: visual-paradigm)**

Use Case Relationship	Visual Representation
Extends: Indicates that an "Invalid Password" use case may include (subject to specified in the extension) the behavior specified by base use case "Login Account". Depict with a directed arrow having a dotted line. The tip of arrowhead points to the base use case and the child use case is connected at the base of the arrow. The stereotype "<<extends>>" identifies as an extend relationship	
Include: When a use case is depicted as using the functionality of another use case, the relationship between the use cases is named as include or uses relationship. A use case includes the functionality described in another use case as a part of its business process flow. A uses relationship from base use case to child use case indicates that an instance of the base use case will include the behavior as specified in the child use case. An include relationship is depicted with a directed arrow having a dotted	

line. The tip of arrowhead points to the child use case and the parent use case connected at the base of the arrow.
The stereotype "<<include>>" identifies the relationship as an include relationship.

Generalization: A generalization relationship is a parent-child relationship between use cases. The child use case is an enhancement of the parent use case.
Generalization is shown as a directed arrow with a triangle arrowhead. The child use case is connected at the base of the arrow. The tip of the arrow is connected to the parent use case.



IV.2.1.4. The Actors of our Study and Their Roles:

Before designing our use case diagram, first thing first, is identifying the different participants (actors) and their roles, in order to better understand the representation:

Admin:

- the admin has privilege to manage all the centers
- the admin will have the important operations of the month,
- the level of the stock in all the centers, and the number of products in all the centers

Fulfillment Center Manager:

- the center manager has access only to the center he's assigned to
- and has the same view as the admin but only to the center relevant information

Seller:

- the seller has only access to view
- view the orders
- view the bills
- view the pickups planning's
- and view the articles in the stock

Pickup Agents:

- the pickup agent has access to the pickups planning's assigned to him to validate and change the status

IV.2.2. User Case Diagram Representation:

For our representation of user case diagrams, we used Entreprise Architect software, Sparx Systems Enterprise Architect is a visual modeling and design tool based on the OMG UML. The platform supports: the design and construction of software systems; modeling business processes; and modeling industry based domains. It is used by businesses and organizations to not only model the architecture of their systems, but to process the implementation of these models across the full application development life-cycle.

Figure IV.2-3 Entreprise Architect Logo

IV.2.2.1. Use case diagram 'Users Management':

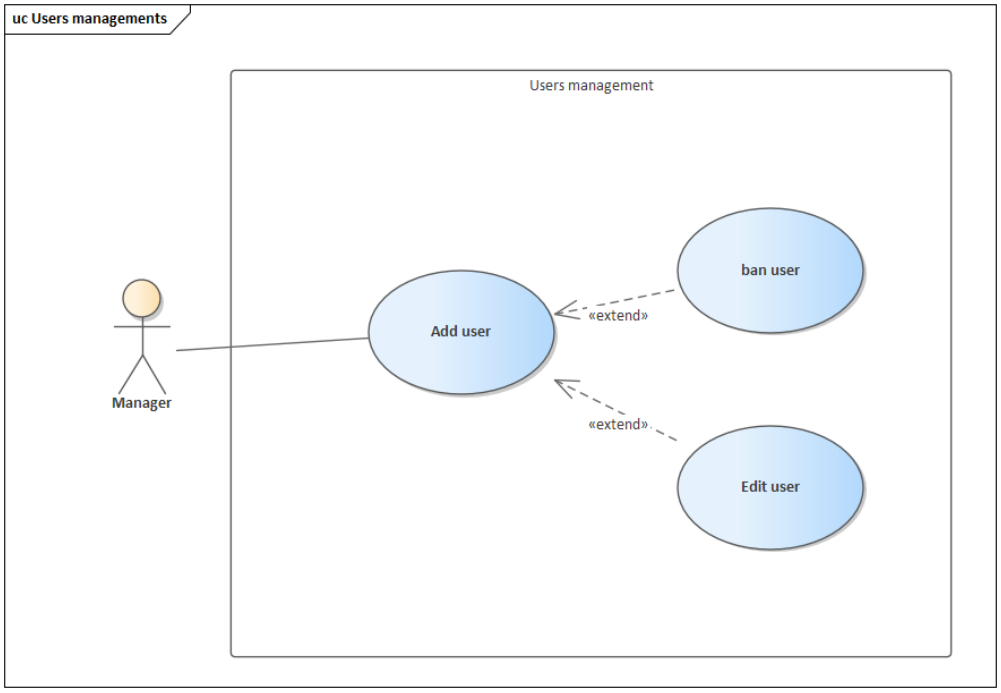


Figure IV.2-4 User Management Use Case Diagram

IV.2.2.2. Use case diagram 'Articles Management':

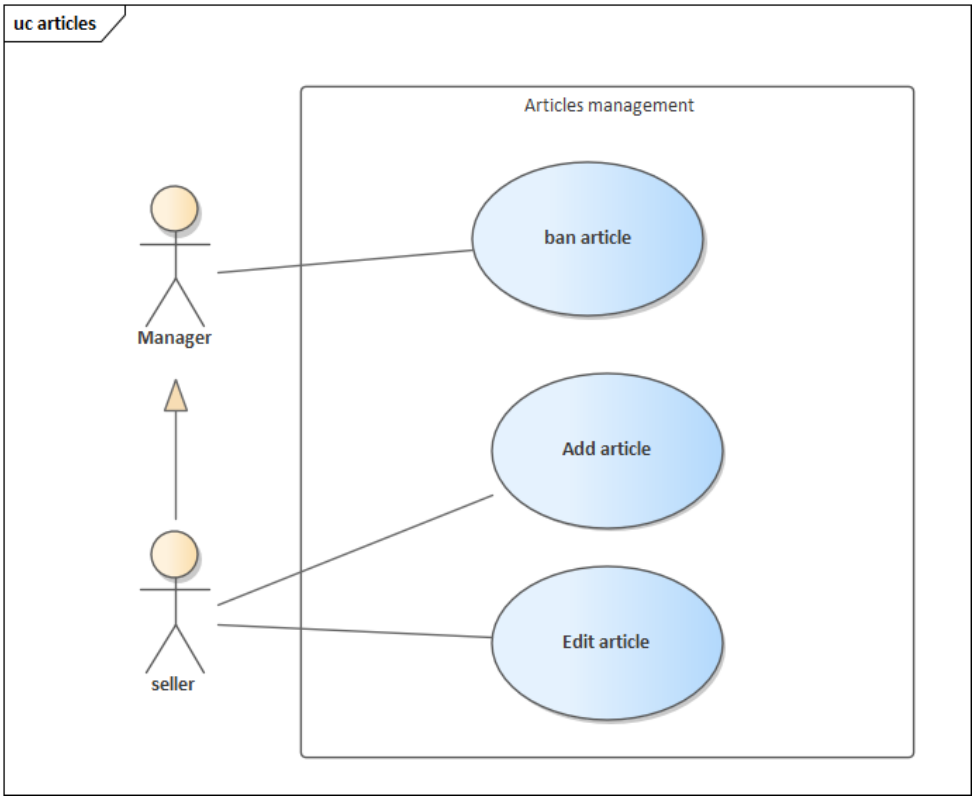


Figure IV.2-5 Article Management Use Case Diagram

IV.2.2.3. Use case diagram 'Billings Management':

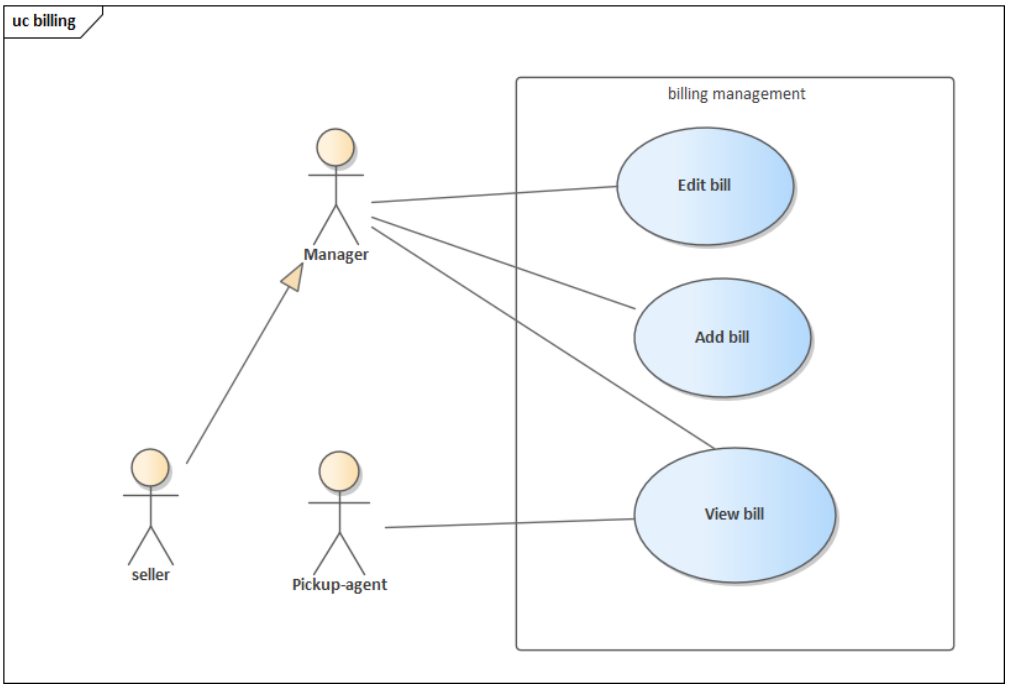


Figure IV.2-6 Billing Management Use Case Diagram

IV.2.2.4. Use case diagram 'Sellers Payment':

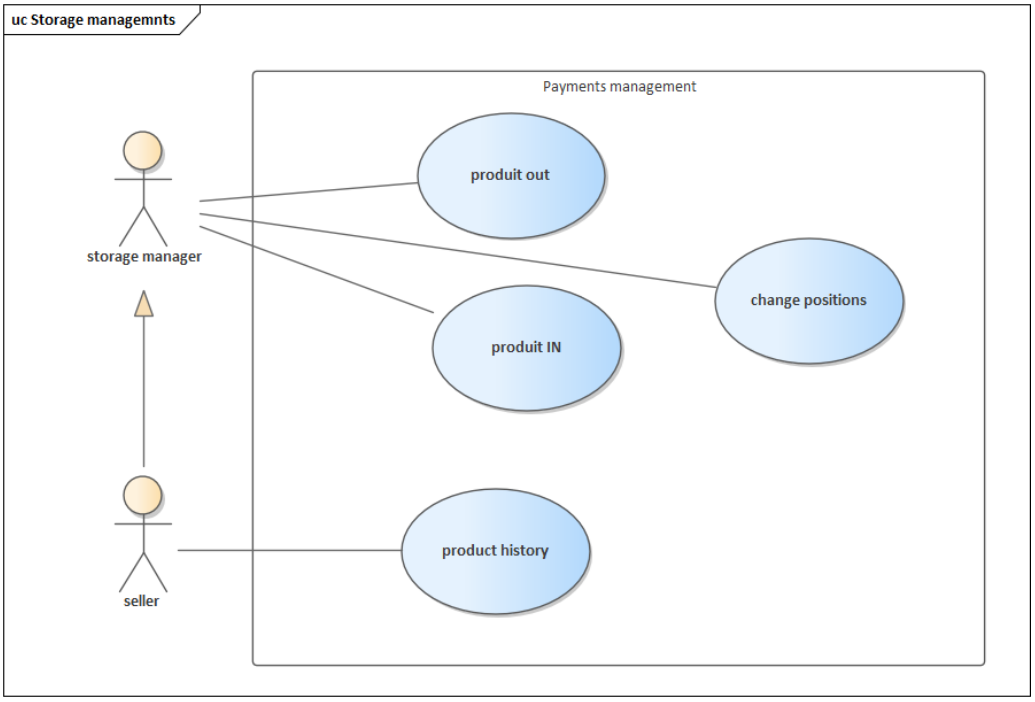


Figure IV.2-7 Sellers Management Use Case Diagram

IV.2.2.5. Use case diagram 'Pickup management':

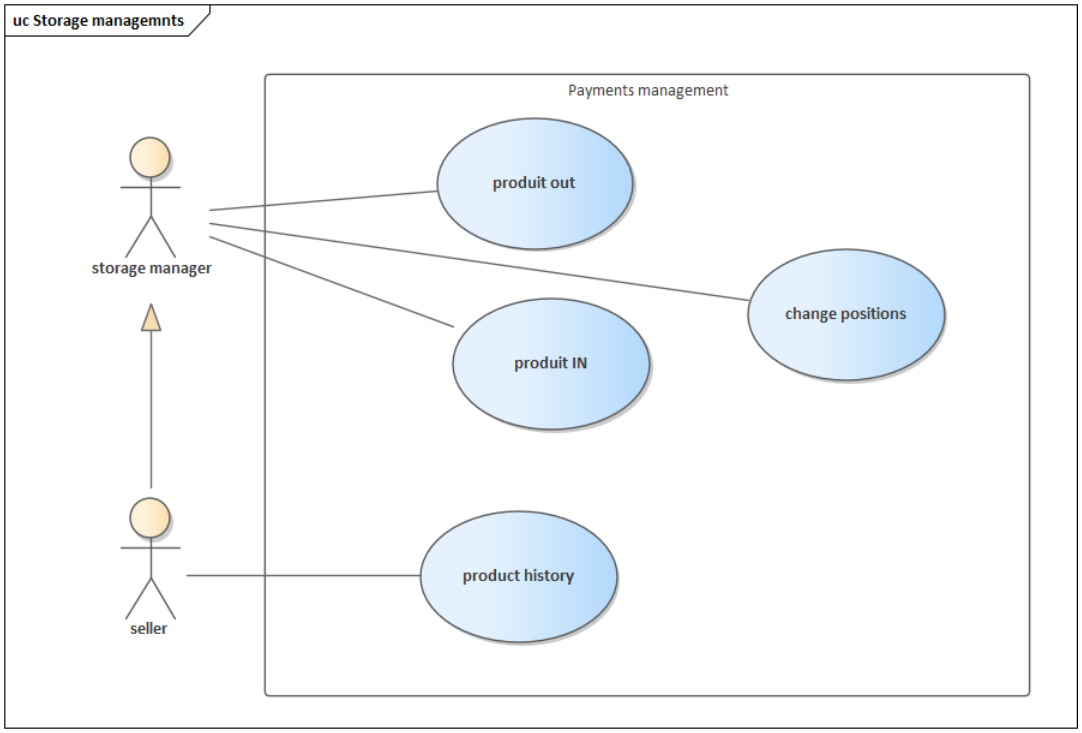


Figure IV.2-8 Pickup Management Use Case Diagram

IV.2.2.6. Use case diagram 'Storage Management':

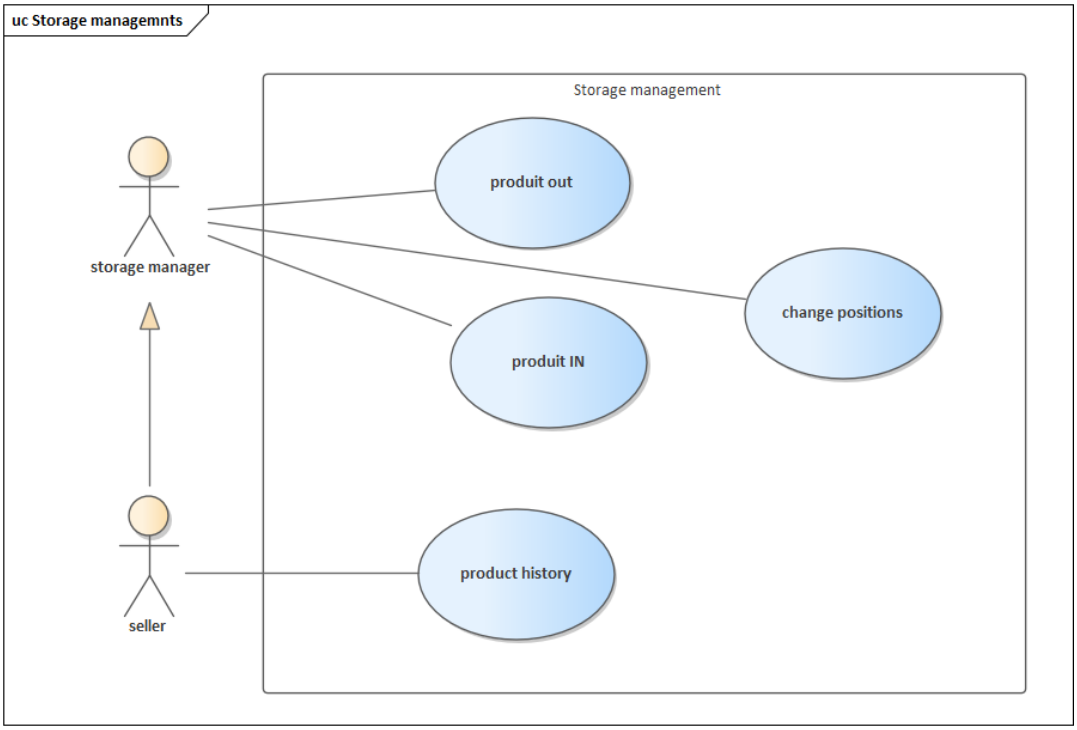


Figure IV.2-9 Storage Management Use Case Diagram

IV.2.3. Class Diagram Representation:

A class diagram is a type of static structure diagram that describes the structure of a system by showing the system's classes, their attributes, operations (or methods), and the relationships among objects[32] :

1. Shows static structure of classifiers in a system
2. Diagram provides a basic notation for other structure diagrams prescribed by UML
3. Helpful for developers and other team members too
4. Business Analysts can use class diagrams to model systems from a business perspective

A UML class diagram is made up of:

- A set of classes and
- A set of relationships between classes

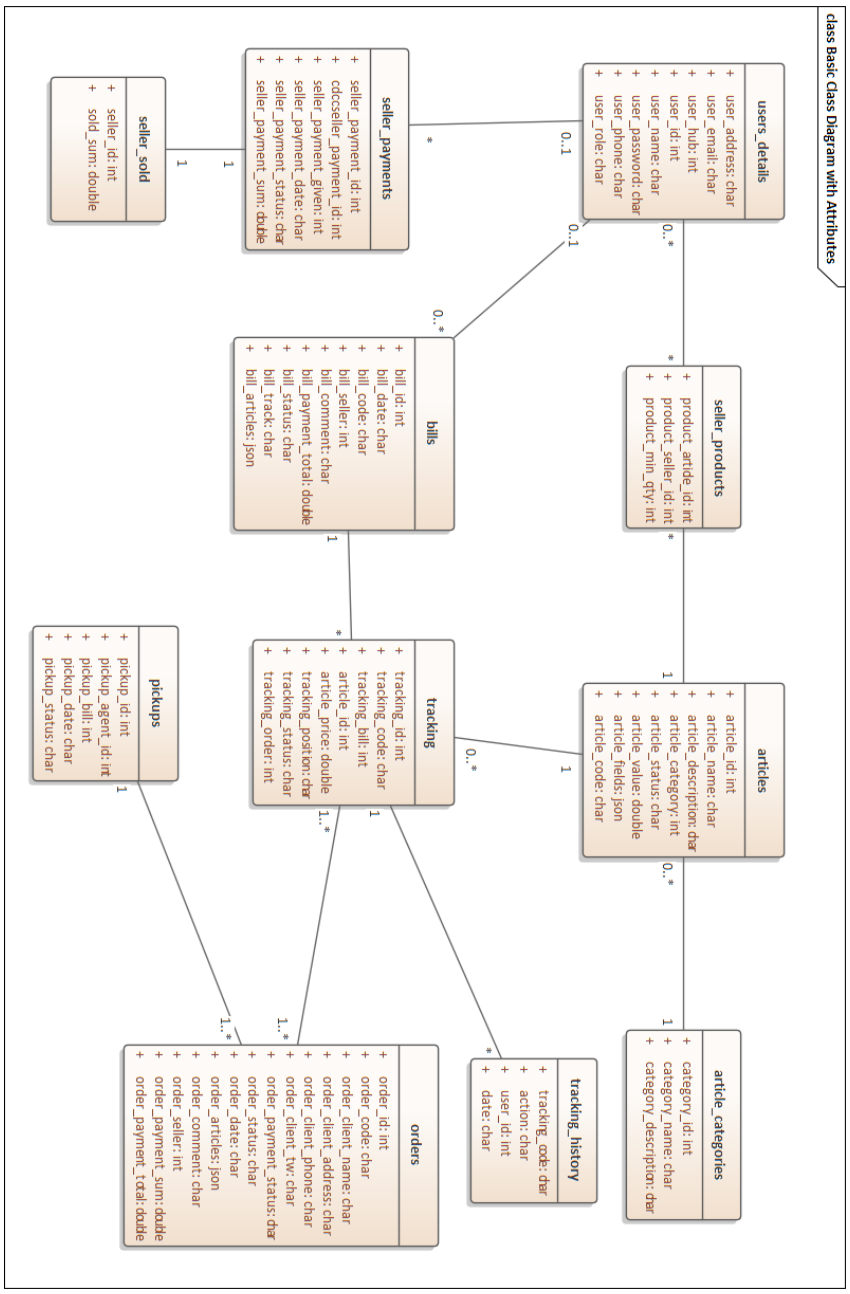


Figure IV.2-10 Class Diagram Representation

This section we have seen the two main UML models for our web Application realization, which are Use case diagram and Class diagram.

The next section will be about the realization of the web application based on some IT tools, and languages.

IV.3. Section Two : Application Realization

Our application is web based centralized, which can be accessed through any device with internet and Browser (google chrome, Mozilla Firefox, etc.), and it is built in php in a way that it can be reused with other web applications via REST API.

The app has multiple actors each actor has his own privilege, once authenticated, he will be directed to the main page and have access to what he is assigned to. This application allows us to manage our different resources and flows. All in all, it represents our fulfillment center management system.

IV.3.1. Programming Languages Used:

During the development of our platform, a multitude of programming languages have been implemented so that the latter can be implemented as it was described during the design phase.

Our platform is an implemented as a web application Client server. We looked at PHP / MySQL for server-side scripting because of our experience with this language. The client side of our application has been designed using JavaScript languages with its XMLHTTPRequest (Ajax) library, CSS3, Bootstrap and HTML5.

In the following is a brief description of each of the languages used:

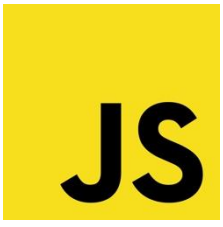
IV.3.1.1. PHP :

Hypertext Preprocessor also known as PHP is an open-source server-side scripting language. PHP is mainly used to build interactive website, alongside databases: web pages interact with the users via input or queries[33]

IV.3.1.2. HTML :

Hypertext Markup Language (HTML) is the standard markup language for documents designed to be displayed in a web browser. Web browsers receive HTML documents from a web server or from local storage and render the documents into multimedia web pages[34].

IV.3.1.3. JavaScript :



Alongside HTML and CSS, JavaScript is one of the core technologies of the World Wide Web. JavaScript enables interactive web pages and is an essential part of web application. The vast majority of websites use it for client-side page behavior, and all major web browsers have a dedicated JavaScript engine to execute it[35].

IV.3.1.4. Ajax:

Ajax is short for "Asynchronous JavaScript and XML" is a set of web development techniques using many web technologies on the client side to create asynchronous web applications. With Ajax, web applications can send and retrieve data from a server asynchronously (in the background) without interfering with the display and behavior of the existing page. By decoupling the data interchange layer from the presentation layer, Ajax allows web pages and, by extension, web applications, to change content dynamically without the need to reload the entire page[36].

IV.3.1.5. MySQL :

MySQL is an open source relational database server. A database server that stores data in separate tables rather than putting everything together in a single table. This improves speed and flexibility.

Tables are linked by defined relationships, which make it possible to combine data between multiple tables during a query. SQL in "MySQL" stands for "Structured Query Language": the standard language for database processing[37].

IV.3.1.6. Design Tools :

To finish with a final formatting and have a "responsive" site, we made a design using CSS and Bootstrap:

IV.3.1.6.1. CSS3:

CSS (Cascading Style Sheets). It is a language used for formatting the website. It represents a new way to apply styles to HTML elements by style sheets, also called CSS files, include code that allows to manage the design of a page in HTML[38].

IV.3.1.6.2. Bootstrap4:

Bootstrap is a free and open-source CSS framework directed at responsive, mobile-first front-end web development. It contains CSS- and (optionally) JavaScript-based design templates for typography, forms, buttons, navigation, and other interface components[39].

IV.3.2. Technologies Used:

Programming languages alone cannot allow us to advance rapidly in our development. For that, we used a few tools. We have chosen PHPStorm IDE for a good implementation and visibility of the code, as well as its free for student. As we know PHP cannot run without an environment, so we used for Xampp Server so that we could work locally.

IV.3.2.5. PhpStorm :

PhpStorm is a PHP, HTML, XHTML, CSS, JavaScript IDE with integrated databases managements module. It contains a complete range of tools to allow the developer to create, validate, debug and format to have the cleanest possible code.

IV.3.2.6. Xampp :

Xampp It is a set of software used to easily set up a Web server, an FTP server and an electronic mail server. It is a free software distribution (X Apache MySQL Perl PHP) offering good flexibility of use, recognized for its quick and easy installation. Thus, it is within the reach of most people since it does not require specific knowledge and, moreover, works on the most common operating devices.

IV.3.3. Fulfillment Center Management System :

To set up our platform, we had to create different interfaces. In the following we will showcase our main interfaces:

IV.3.3.5. Authentication page :

This is the first page that users' access to, it allows them to authenticate and access the app by indicating and username and typing the password. Figure IV.3-1

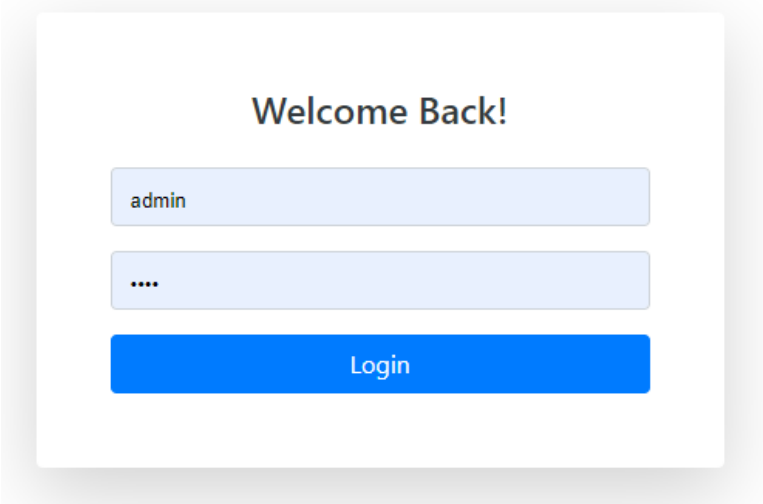


Figure IV.3-2 Authentication page

IV.3.3.6. Main page :

After the authentication, the user will be guided to the home page. The main page is used to show the statistics depending on the authenticated user and some relevant information, Figure IV.3-3.

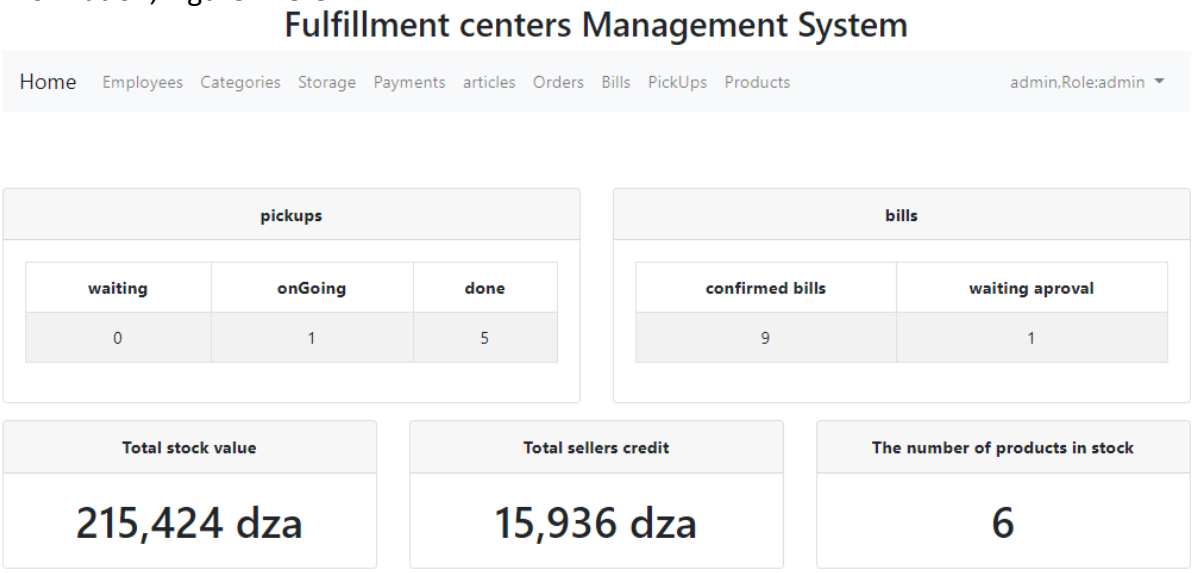


Figure IV.3-4 main page - admin

- The admin has access to all the company's resources, so he will be given full privilege to open all the centers.
- In the case of manager, he will be shown the same page but only access information of the center he is part of only.
- the seller will view only the relevant information to his operations, Figure IV.3-5

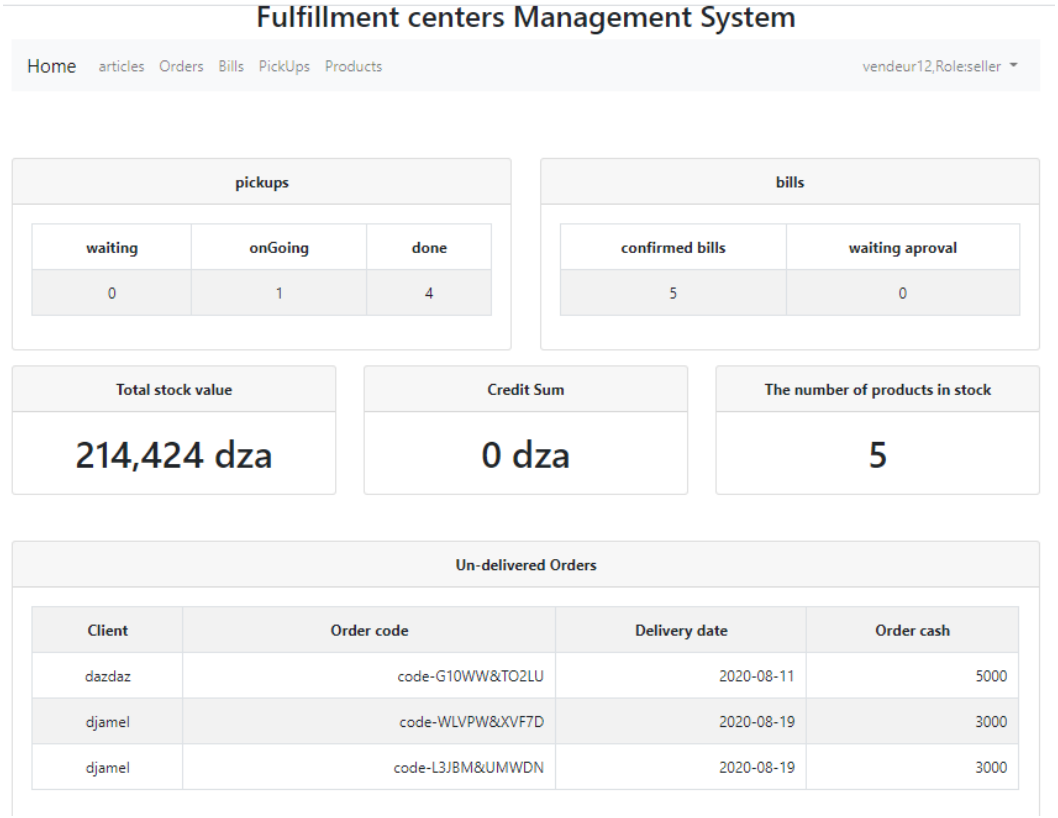


Figure IV.3-6 main page - seller

IV.3.3.7. Employees page:

This page is only accessed by the admin and the center's manager, the operations are edit, ban and un-ban

- the admin can alter / add employees in all the centers
- the center manager can only handle employees in the same canter

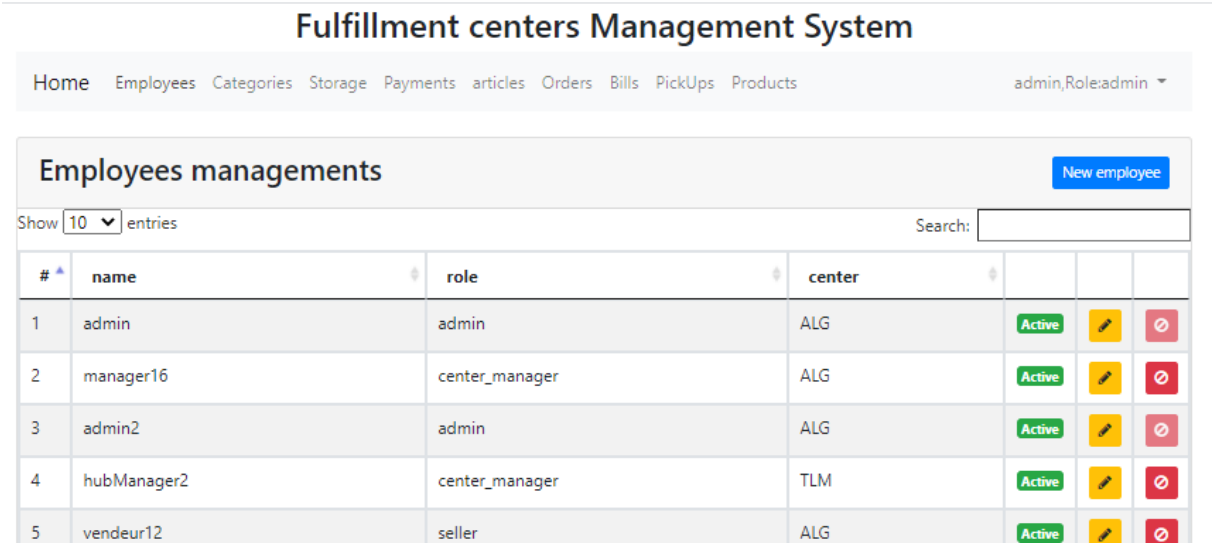


Figure IV.3-7 Employees Page

1) **Add employee window:** Input the employee personal information's, the employee role and the affected center in case the current user is admin, else it will be affected to the same center as the input user

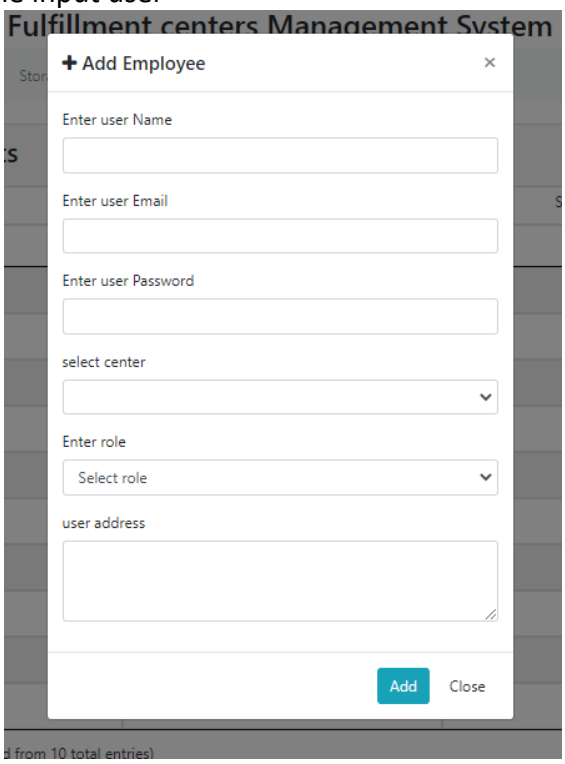


Figure IV.3-8 Add Employee window

IV.3.3.8. Payments Page :

This page is accessed by the admin and the center manager to added /edit and validate payments, the seller can only view the payments operations

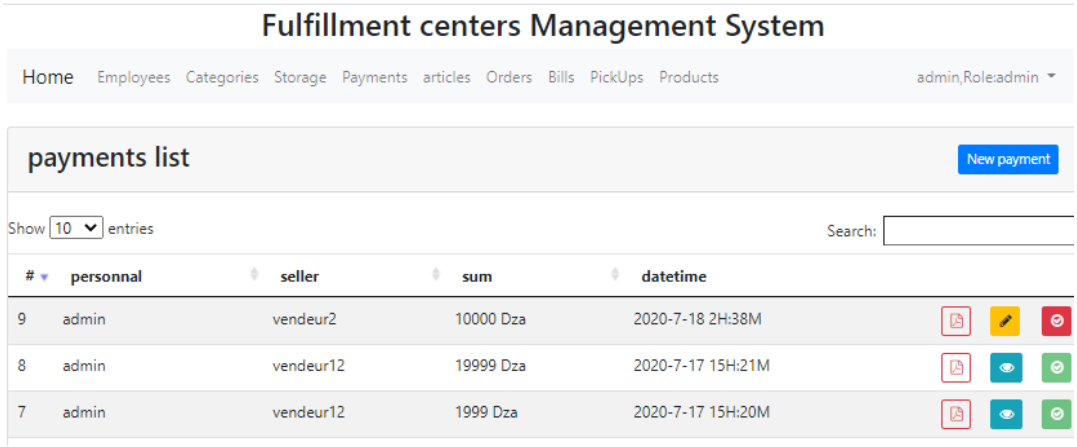


Figure IV.3-9 Payments Page

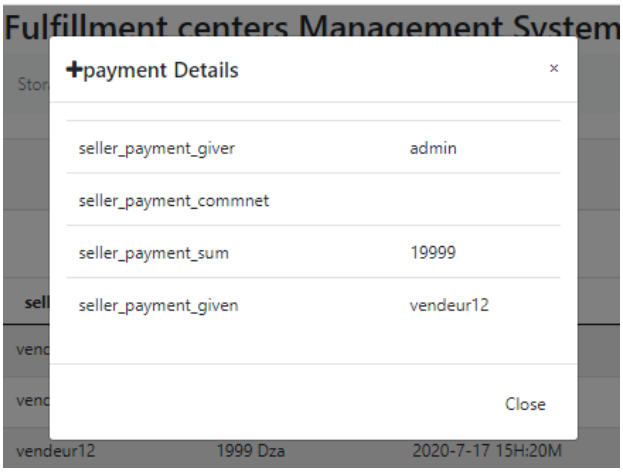


Figure IV.3-10 Payment Details window

Payment Details window:

- View payments details
- the payments giver
- the payment receiver
- and the sum

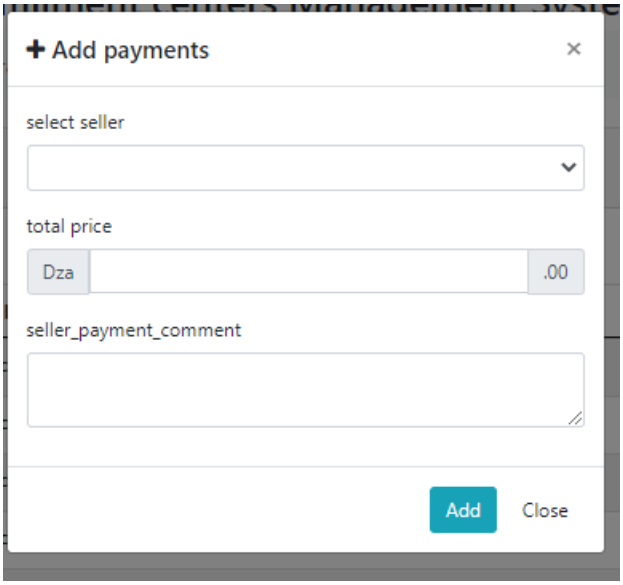


Figure IV.3-11 Add new Payment window

Add new payment window:

This window allow the use to input the value to be payed to the sellers, noting that by adding the sum it will need further validation to be accepted in the system.

IV.3.3.9. Articles page :

this page is accessed by the admin and the center's manager to add and edit the articles, specifications. The seller can access it to see the number of articles that he has in the storage

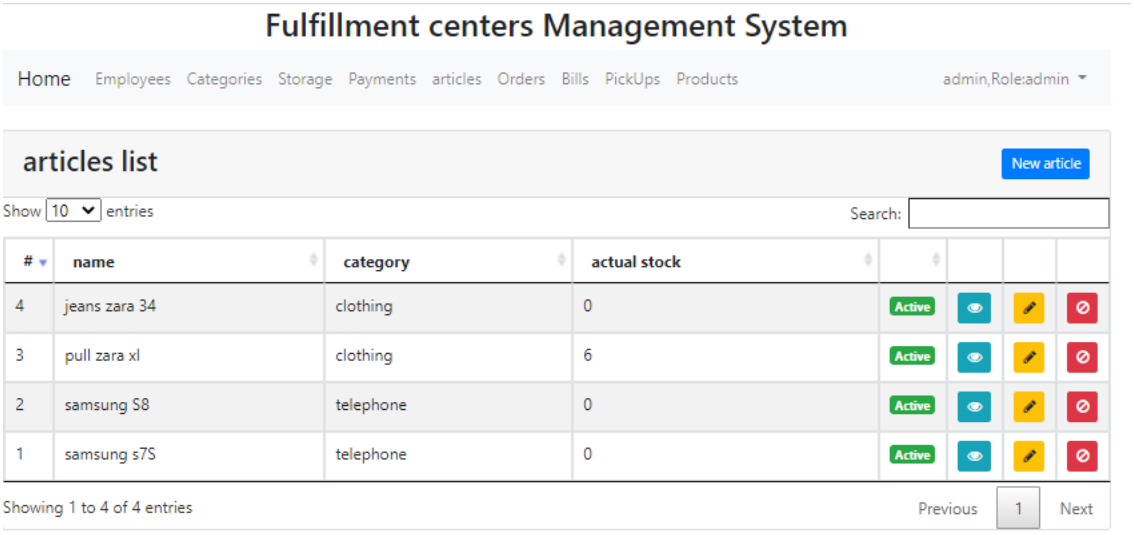


Figure IV.3-12 Articles Page

Add Articles Window:

- 1: by clicking over here more fields will be added in order to add more detailed information
- 2: by clicking over here the field will be removed

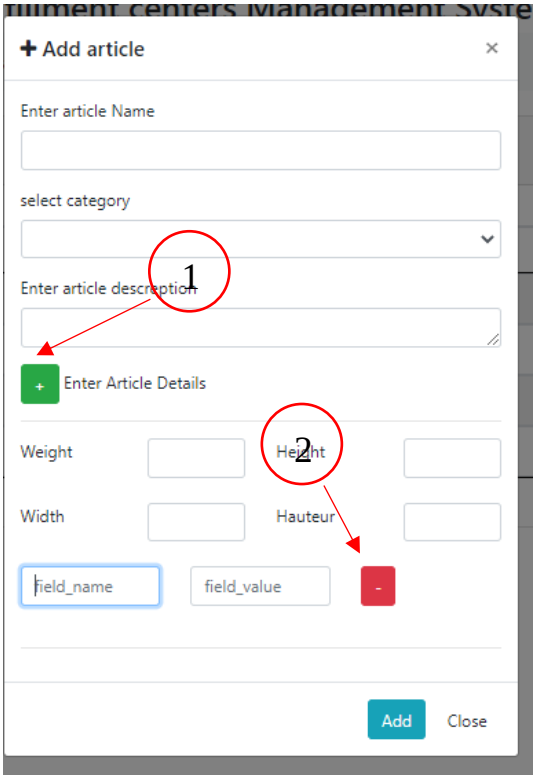


Figure IV.3-13 Add Articles window

IV.3.3.10. Ordres page :

This page is access by the center manager and the customer service stuff, in order to visualize the stats of the orders and have full control over them **Figure IV.3 11**, since our study (did not concern the delivery all the orders should be unpaid), the order can have 3 status:

- Initially is ‘waiting approval’, when the order is placed by the client, it will wait for confirmation ‘confirmed’ or refusal ‘refused’

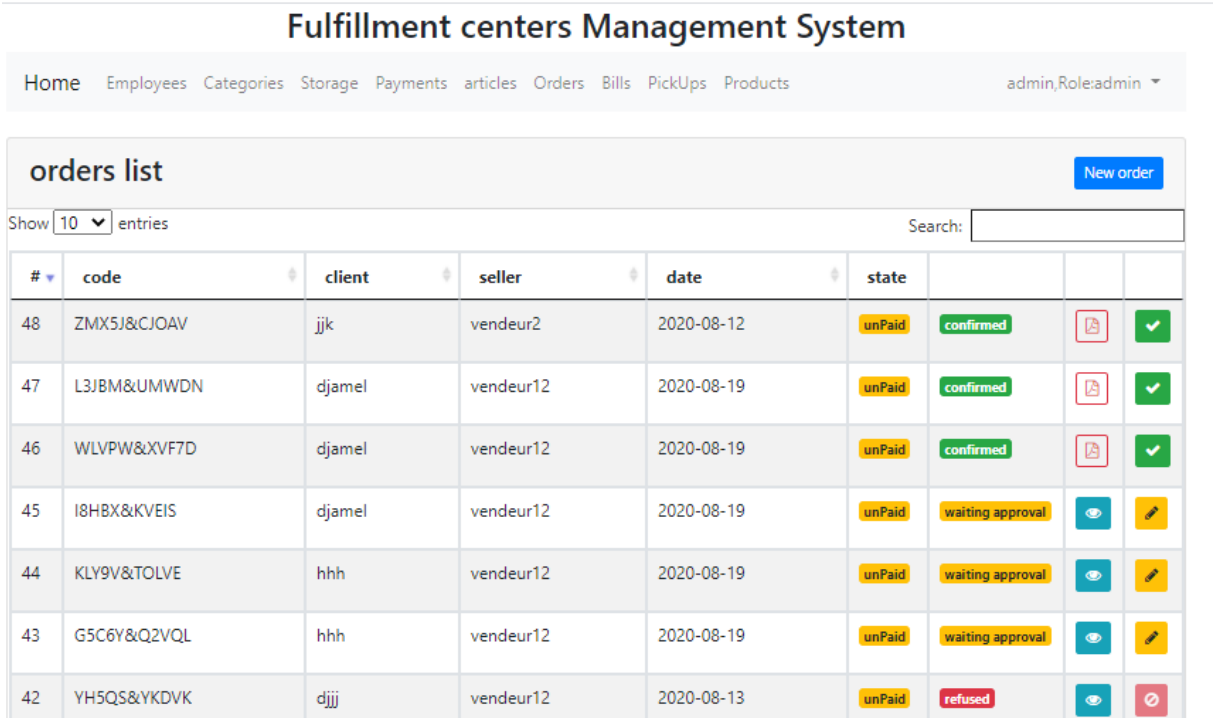


Figure IV.3-14 Orders Page

- **new order:** This page is used by the center users to add new orders, usually this operation is done in the web market, and the order is added automatically in the app, but we have implemented this for experimentations, the user must input the relevant information of the order, noting that one order can have multiple products

  1: added more products 2: remove product

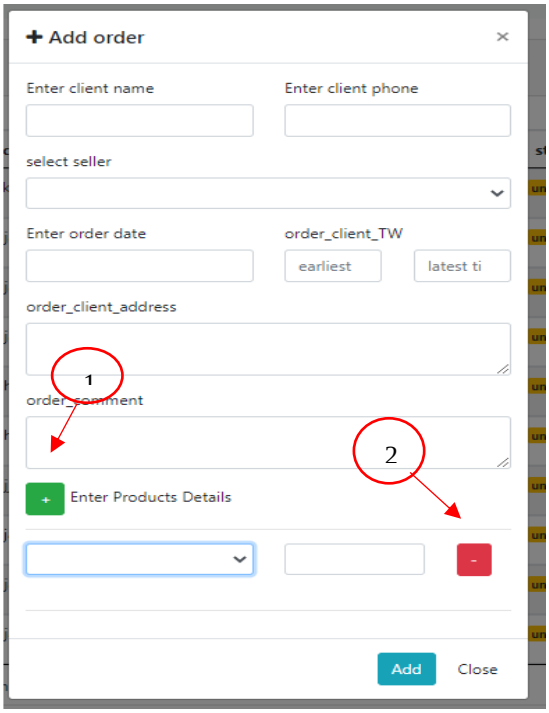


Figure IV.3-15 New Order's window

IV.3.3.11. Products page:

This page is for the full tracking of each ordered product, the products cycle starts from the seller state till made it to the center than being delivered to the clients; the affected product mean they are reserved for clients the nonAff (non-affected) are available products for sale

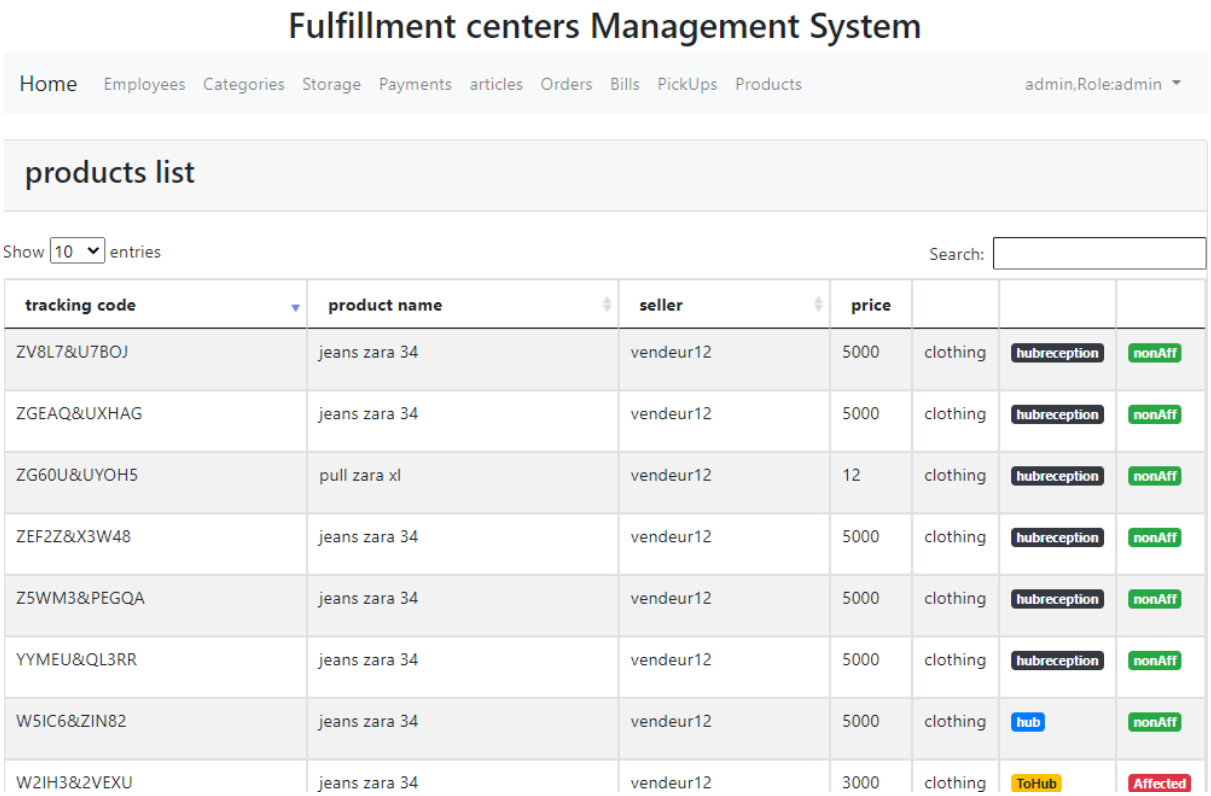


Figure IV.3-16 Products page

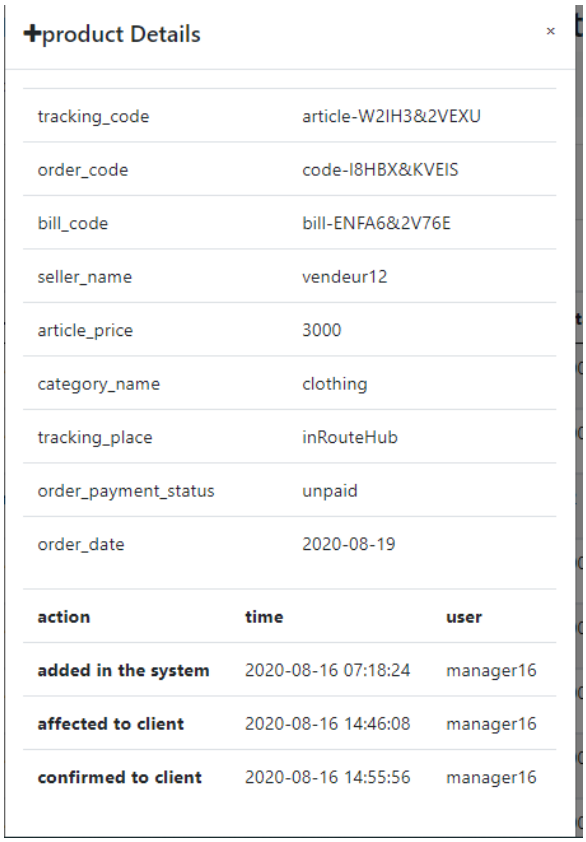


Figure IV.3-17 Products Details Window

The product details window:

by clicking in the product its location will be displayed.
This page contains detailed information about the product and the full history of changes in the products life

IV.3.3.12. Pickups page :

this page is for the picking the products from the sellers, the pickups planning is made by the manager.

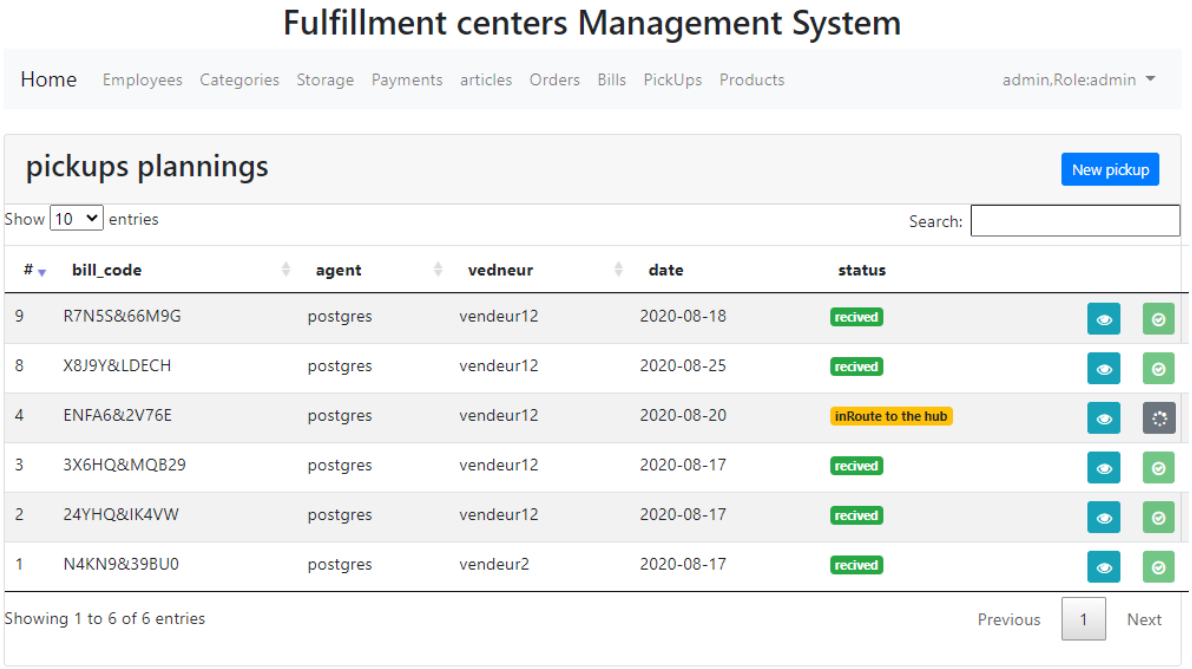


Figure IV.3-18 Pickups Page

- The manager and the pickup agents are given the authorization to change the state of the pickup (waiting, in way to the seller, done).

All in all, building a web application may seem easy, but it actually goes through design and modeling based on our managerial perspective and thinking, concretized by the application of various IT tools such as languages, design tools, and Techniques.

IV.4. Conclusion :

This chapter was a proposition of another digitalization solution for our fulfillment center logistics' improvement in general, and storage system in particular. By realizing a web application for our resource's management, we ensure just-in time visibility on our inventory and stock levels, easy communication between different actors and their operations and effective management of warehouse's flows.

GENERAL CONCLUSION:

The purpose of our study was to apply digital logistics' solutions for storage improvement in e-commerce.

Most of e-commerce business owners opt for outsourcing their logistics to more specialized, well-experienced firms, whom main mission is to manage e-commerce inventory and shipment, these firms are called 3PL logistics providers. Therefore, for this study we decided to treat this study from roots.

First of all, we have done a full study of establishing a fulfillment center: its location, processes, layout, and storage, all while applying facility design concepts and methodologies.

After that, we have applied IoT for smart shelving solution using RFID and sensors technologies.

And Finally, we built a management system for our fulfillment center, in order to manage different flows, stock and inventory.

This project is a study, it is not based on real life data, we tried as possible to adapt it to the market and to Algerian e-commerce industry which is not very flourishing compared to china and USA (leaders of e-commerce).

The IoT application is kind of hard for a logistician as it does not need only supply chain knowledge, it also needs a very intensive knowledge in network, electronics and automation, we have tried to clarify it the maximum we could for, so that us and any logistician can understand it, noting that it needs a deeper study of its integration.

We also tried to include Key Performance Indicators and dashboard, for the management system that we have built, in order to track performance and fix goals, but since we have no data, we could not make it based on nothing.

At the end, working on this thesis gave us enthusiasm, we found ourselves striving for more knowledge of the magic world of industry 4.0, digitalization and connectivity (machine to machine and machine to human), this project also enabled us to improve our coding skills, and other soft skills. It totally deserves the invested efforts we have done on it.

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