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MASTER THESIS

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# Developing a warehouse management system in an omni-channel environment

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# Declaration of Authorship

We, Gustav Linde and Jonathan Åkerblom, declare that this thesis titled, 'Developing a warehouse management system in an omni-channel environment' and the work presented in it is our own. We confirm that:

- This work was done wholly or mainly while in candidature for a research degree at this University.
- Where any part of this thesis has previously been submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated.
- Where we have consulted the published work of others, this is always clearly attributed.
- Where we have quoted from the work of others, the source is always given. With the exception of such quotations, this thesis is entirely our own work.
- We have acknowledged all main sources of help.
- Where the thesis is based on work done by ourselves jointly with others, we have made clear exactly what was done by others and what we have contributed ourselves.

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Jonathan Åkerblom

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Date:

City:

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*“If we knew what it was we were doing, it would not be called research, would it?”*

Albert Einstein

LUND UNIVERSITY

## *Abstract*

Faculty of Engineering, LTH  
Department of Engineering Logistics  
Master of Science in Engineering

### **Developing a warehouse management system in an omni-channel environment**

by Gustav Linde & Jonathan Åkerblom

#### **Motivation**

The so called multi-channel strategy was coined back in the 90's as a way to describe retailers' use of two or more channels for selling products and services to customers. In the middle of the first decade this concept started to evolve, due to emerging topics around integration between the sales channels. This ultimately lead to the introduction of the omni-channel approach. Its main idea is to span more marketing, sales, and distribution concepts, as well as put emphasis on achieving seamless integration between channels. In the latter part of the first decade researchers identified technology as the main obstacle for truly achieving synergies in any multi or omni-channel strategy. Apart from ERP systems, information system support within operations is often done with a warehouse management system (WMS). Early advances within the omni-channel segment has largely been made up of best-of-breed solutions. Whereas today, in the middle part of the second decade, most of the large WMS vendors are following their trail. There is now a pressure to adopt solutions that can manage the requirements from omni-channel supply chains with complex order-fulfillment capabilities. Recent studies have shown that new logic is required from these systems to effectively manage omni-channel fulfillment. This indicates that it would serve a great purpose in knowing what the most fundamental and critical requirements are of a system, that is to be used by actors that wish to operate efficiently in the omni-channel domain.

#### **Problem descr.**

The collaborating partner in this thesis, PerfectIT, is a Swedish software vendor and has developed a proprietary cloud-based retail business system, which crudely supports integration between channels and WMS related functionalities. Its customers are either more or less engaged towards multi and omni-channel strategies. To be able to compete they put certain requirements on the system which it can not accommodate as of today. Since PerfectIT desires to develop their current solution with WMS capabilities, this thesis will investigate what the implications are on a WMS when developed towards retailers that operate in an omni-channel environment. The inherent problems are:

- What functionalities should be considered in a WMS solution for efficient warehousing in an omni-channel environment, and
- How can they be realized and implemented?

#### **Approach**

Two theoretical lenses have been applied because of the borderland between the logistics and information system (IS) disciplines. The systems approach within the logistics discipline was key to acquire knowledge about concrete supply chain systems through the use of mapping and modeling. From the IS discipline the authors have applied design science research (DSR) to develop practical knowledge for the design and realisation of information system initiatives. An inductive critical realist approach to research was held since the authors aim to understand the systems made up around omni-channel order-fulfillment and the issues related to information system support, and then use that as a precursor to improvement (suggest how this could be achieved). These suggestions are

theoretical propositions, described as design theories, on what a proposed system should accommodate to solve and achieve identified requirements.

A qualitative multiple-case study with interviews and observations was carried out at four (4) companies of different sizes and complexity of their supply chains, all of which were active as e-commerce retailers and were working with or towards omni-channel order-fulfillment capabilities. Secondary data was collected through literature review and screenings with multiple sources. The results were ultimately analyzed individually and cross-wise to increase the internal validity.

## **Conclusion**

The most important findings within WMS feature design, with respect to omni-channel sales and operations, is to build a foundation on top of random (floating) storage locating that goes beyond tracking balance on positions. It is needed to redefine what visibility and traceability really means when building supporting systems for operations in an omni-channel environment. The crucial part is having an intelligent and clear data structure that takes into account the fundamental elements of item and order structures, as well as all types of storage positions that these may reside within.

The authors call these logical positions, since they may be everything from a box in a load carrier, to a cage in a defined area. The authors also call items and orders logical entities, since they can represent collections of things in many forms, e.g. the items of an article in a stock unit or the items of an order. These logical positions and entities may have several (levels) of logical states placed on them. Here the authors wish to emphasize a reasoning on purposeful handling and decoupling. By knowing what state different entities are in, and having a rule-based decision engine, it could help guide processes that are otherwise tied to or dependent on specific operators.

Based on the analysis results the authors have come up with a number of design theories that a generic system is to take into account in order to accommodate the overarching requirements and dilemmas related to omni-channel retailing.

- ability to tie logical entities (goods as well as orders) to logical positions and states.
- ability to handle partitions of logical positions or entities across hierarchies.
- ability to purposefully guide material flow, buffering, and value-adding processes of logical entities.

## **Keywords**

WMS, Multi-channel, Omni-channel, E-commerce, Retail, Cloud-based, SaaS, Warehouse operations, WHM, Information System, Design Science Research, Software requirement specification engineering

# *Sammanfattning*

Lunds Tekniska Högskola, LTH  
Avdelningen för Teknisk Logistik

## Utveckling av ett lagerhanteringssystem i en omnikanal-miljö

Av Gustav Linde & Jonathan Åkerblom

### Motivation

Den så kallade multikanals-strategin myntades redan på 90-talet som ett sätt att beskriva återförsäljares användning av två eller mer kanaler för att sälja produkter och tjänster till kunder. I mitten på det första årtiondet började det här begreppet att evolvera på grund av framväxande diskussioner kring integration mellan säljkanalerna. Det här ledde till introduceringen av omnikanals-strategin. Dess huvudsakliga idé är att omspanna fler marknadsförings-, sälj- och distributionskoncept, samt med tonvikt på sömlös integration mellan kanaler. Under den senare delen av första decenniet kom forskare fram till att teknologin som faktor är det huvudsakliga hindret för att kunna uppnå verkliga synergier inom någon multikanals- eller omnikanals-strategi. Förutom affärssystem (ERP), kan stöd med informationssystem kring processer göras med ett lagerhanteringssystem (WMS). Tidiga framsteg inom omnikanals-segmentet har i stort sett varit från "bäst-i-klassen"-system. Medan idag ser man att de större WMS-leverantörerna följer deras spår. Numera finns en större press att tillgodose lösningar som kan hantera kraven av omnikanals-försörjningskedjor i omnikanals-miljöer med komplexa förmågor att uppfylla kunders ordrar. Nyare studier har visat på att ny logik krävs från dessa system för att på ett effektivt sätt hantera denna s.k. "omni-channel fulfillment". Detta indikerar att det torde tjäna ett stort syfte att veta vilka de mest fundamentala och kritiska kraven är på ett system som ska användas av aktörer som önskar att verka i omnikanals-domänen.

### Problembeskr.

Samarbetspartnern, PerfectIT, är ett svenskt mjukvaruföretag som har utvecklat ett moln-baserat affärssystem för återförsäljare inom e-kommers. Det stödjer på ett obearbetat sätt integration mellan kanaler och lagerhanteringsrelaterade funktioner. Företagets kunder är antingen mer eller mindre engagerade mot multikanals- och omnikanals-strategier. För att kunna konkurrera ställer de särskilda krav på systemet som det inte kan tillgodose i dagsläget. Eftersom PerfectIT strävar efter att utveckla deras nuvarande lösning med funktioner inom lagerhantering (WMS), kommer det här examensarbetet undersöka vilka implikationerna är på ett lagerhanteringssystem om det utvecklas mot återförsäljare som verkar i en omnikanals-miljö. Några av de inneboende problemen till detta som författarna önskar svara på är:

- Vilka funktioner bör tas i beaktning i ett lagerhanteringssystem (WMS) för effektiv lagerhantering i en omnikanals-miljö, och
- Hur kan dessa realiserats och implementeras?

### Metod

Två teoretiska linser har applicerats på grund av gränslandet som arbetet utgörs av mellan disciplinerna logistik och informationssystem (IS). Systemteori inom logistik-disciplinen var avgörande för att erhålla kunskap om konkreta försörjningskedje-system genom kartläggning och modellerande. Från IS-disciplinen applicerades designteori (DSR) för att utveckla praktisk kunskap för design och realisering av initiativ inom informationssystem. Tillvägagångssättet för forskning var induktivt och baserat i den kritisk-realistiska paradigmen. Framst eftersom författarnas syfte var att förstå systemen kring order-uppfyllan i omnikanals-miljöer och de problem som relateras

till informationssystem, och sedan använda det som en förelöpare till förbättring (att föreslå hur det kan uppnås). Dessa förslag är teoretiska propositioner, beskrivna som designteorier, om vad ett föreslaget system borde tillgodose för att lösa och uppnå de identifierade kraven.

En kvalitativ multipel fallstudie med intervjuer och observationer hölls på fyra företag av olika storlek och komplexitet av försörjningskedja. Alla var aktiva som återförsäljare inom e-kommers och jobbade med eller mot förmågor kring order-uppfyllan inom omnikanals-miljöer. Sekundär data samlades in genom litteraturstudier och screenings med multipla källor. Resultaten analyserades individuellt och korsvis för att öka den interna validiteten.

## Slutsatser

De viktigaste fynden inom design av funktioner till ett lagerhanteringssystem, med avseende på omnikanals-försäljning och lagerverksamhet, är att bygga en grund ovanpå flytande lagring som går bortom att hålla koll på saldot på positioner. Det finns ett behov av att omdefiniera vad synlighet och spårbarhet egentligen betyder när man bygger stödjande system för lagerverksamhet inom en omnikanals-miljö. Den avgörande biten är att ha en smart och klar datastruktur som tar hänsyn till de fundamentala elementen av artikel-, enhets- och orderstrukturer, samt alla typer av lagringspositioner som dessa kan befinna sig i/på/inom. Författarna kallar dessa logiska positioner eftersom de kan vara allt från en låda på en plats inom en lastbärare av något slag, till en bur inom ett definierat område. Författarna kallar även enheter och ordrar för logiska entiteter eftersom de kan representera samlingar och mängder av saker i många former, t.ex. enheterna av en artikel på en viss lagringsenhet eller enheterna i en order. Dessa logiska positioner och entiteter kan ha (flera nivåer av) logiska tillstånd ställda på dem.

Här vill författarna betona ett resonemang kring syftesmässig hantering och frikoppling. Genom att veta vilka tillstånd som entiteter befinner sig i, och genom att ha en regelbaserad beslutsmotor, kan man guida processer som annars kanske är knutna till eller beroende av specifika operatörer. Baserat på analysens resultat har författarna kommit fram till ett antal designteorier, som ett generiskt system borde ta hänsyn till för att tillgodose de övergripande kraven och dilemman som är relaterade till återförsäljningsindustrin inom omnikanals-miljön:

- förmåga att knyta logiska entiteter (goods samt ordrar) till logiska positioner och tillstånd.
- förmåga att hantera partitioner av logiska positioner eller entiteter, tvärsöver eller inom hierarkier.
- förmåga att hantera en regelbaserad beslutsmotor för att guida materialflöde, buffring och värdeadderande processer av logiska entiteter.

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# Abbreviations

<b>SKU</b>	<b>S</b> torage <b>K</b> eeping <b>U</b> nit
<b>WH</b>	<b>W</b> arehouse
<b>DC</b>	<b>D</b> istribution <b>C</b> enter
<b>WHM</b>	<b>W</b> arehouse <b>M</b> anagement
<b>WRM</b>	<b>W</b> arehouse <b>R</b> esource <b>M</b> anagement
<b>WMS</b>	<b>W</b> arehouse <b>M</b> anagement <b>S</b> ystem
<b>OF</b>	<b>O</b> rders - <b>F</b> ulfillment
<b>COI</b>	<b>C</b> ube per <b>O</b> rders <b>I</b> ndex
<b>VAS</b>	<b>V</b> alue <b>A</b> dded <b>S</b> ervices
<b>PUP</b>	<b>P</b> ick <b>U</b> p <b>P</b> oint
<b>QC</b>	<b>Q</b> uality <b>C</b> ontrol
<b>QA</b>	<b>Q</b> uality <b>A</b> ssurance
<b>WIP</b>	<b>W</b> ork <b>I</b> n <b>P</b> rocess
<b>FPA</b>	<b>F</b> ast <b>P</b> ick <b>A</b> rea
<b>B2B</b>	<b>B</b> usiness <b>T</b> o <b>B</b> usiness
<b>B2C</b>	<b>B</b> usiness <b>T</b> o <b>C</b> onsumer
<b>SRS</b>	<b>S</b> oftware <b>R</b> equirements <b>S</b> pecification
<b>SME</b>	<b>S</b> mall & <b>M</b> edium <b>E</b> nterprises
<b>MRP</b>	<b>M</b> aterial <b>R</b> equirements <b>P</b> lanning
<b>DRP</b>	<b>D</b> istribution <b>R</b> equirements <b>P</b> lanning
<b>GOH</b>	<b>G</b> arments <b>O</b> n <b>H</b> angers
<b>IS</b>	<b>I</b> nformation <b>S</b> ystem
<b>DSR</b>	<b>D</b> esign <b>S</b> cience <b>R</b> esearch

## Important Definitions

**Item** is defined as a single physical unit of an article.

**Product** is definition as item. It is also a single unit of an article but the term is used more frequently regarding the logistics of items targeting end consumers.

**Article** can consist of either one or many units. The same type of items have identical article numbers and will be referred to as one article. Article is therefore not a denotation of quantity but of type of item.

**SKU** is a distinct physical unit of goods for sale that has an ID number. The exact definition might vary depending on type of storage warehouse and type of goods determined to constitute a SKU.

**Stock Unit** A stock unit is a changing amount of items that are part of the same article. A stock unit could be any type of storage container or location that only holds items of the same article. Meaning that the term stock unit will be used to describe an arbitrary amount of items of the same article and also that two separate stock units of the same article can contain different quantities of items.

**Unit load** Is defined as an arbitrary amount of stock units stored at the same location. Usually a varying number of stock units constituting of different articles stacked on a pallet.

# Chapter 1

## Introduction

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*This introductory chapter will provide the background of the thesis, which will lead to a problem description, a purpose and research questions. After that the collaborating company will be introduced and delimitations for the thesis will be stated. The chapter will end with a short outline to the thesis.*

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### 1.1 Background

The retailing industry is evolving and along with it the needs and demands of its consumers. The sector emerging in the coming years will be very different from the retail environment that was prevalent in the beginning of the century (Mcgoldrick and Collins, 2007). According to Hardgrave (2013) this industry is quickly heading towards a shift in power. The onset of new technologies, made possible through the expeditious expansion of the internet (Zwass, 1996), has now enabled consumers to order products directly from a retailer or manufacturer and it has also democratized the flow of information. The power to make demands has gradually shifted from the retailers towards the end consumers instead. These new demands involve expectations on a high level of service satisfaction and expanded capabilities to fulfill the consumers orders (Cilt(UK), 2014a; Zwass, 1996).

This change began in the mid 90's when the term multi-channel retailing was coined. Its definition revolves around retailers using at least two different channels of sale for offering products and/or services to customers (Lin, 2012). The interest in the multi-channel approach was at that time mainly driven by the possibility of increased sales but also to meet new customer demands arisen from their changes in shopping behaviour and expectations (Lewis et al., 2014).

The result was that Brick-and-mortar retailers, meaning retailers with physical stores, started adding an online channel of sales (Yan and Pei, 2012; Yang et al., 2013). While their internet-based counterpart started acquiring physical stores (Lewis et al., 2014; Ono et al., 2012). But at this point of time these different channels of sale were mainly considered to function in isolation from each other (Cilt(UK), 2014b; Frazer and Stiehler, 2014; Strang, 2013).

But the multi-channel strategy would continue to evolve. A catalyst for this started with the introduction of Amazon Prime (Driscoll, 2015; Strang, 2013). The online retailer giant Amazon announced back in 2005 that they could offer their customers free two-day shipping on qualified items which had a significant impact on Amazon's success (Strang, 2013). This made huge ripples throughout the entire retail industry and affected the brick and mortar retailers in particular. Customers now started to expect shorter delivery times of their orders, at lower costs. As a competitive response brick and mortar retailers started constructing innovative solutions that used one of their primary assets, their stores (Strang, 2013). By using their stores in combination with aspects of their newly added online sales channel, certain shortcomings in one channel could be compensated by capacities of the other (Lewis et al., 2014).

This would be the first steps towards multi-channel integration. With a more customer centric view in focus, newer technological opportunities and with the need to compete, the previously siloed multi-channel retail industry started to evolve into what is today known as an omni-channel approach (Lewis et al., 2014; Müller-Lankenau et al., 2005). Its main idea is to span more marketing, sales and distribution concepts and put emphasis mainly on what multi-channel implementations lacked - a seamless integration between all the different channels of sale (Frazer and Stiehler, 2014; Rossi, 2015). A successful implementation of the omni-channel approach would allow customers to switch effortlessly between channels during a single transaction and allow for possibilities such as product pick-up and returns of online orders in a physical store. (Piotrowicz and Cuthbertson, 2014; Wallace et al., 2004). A common denominator in this is the concept of order-fulfillment across channels, which relates to the possibility of customers orders flowing independently to and from the consumers through any set of nodes of the supply chain. Both the brick-and-mortar retailers that adopt internet channels and direct-to-consumer operations, and e-commerce retailers that adopt store channels, need to adapt their fulfillment operations in order to achieve an omni-channel oriented environment (ARC Advisory Group, 2014)

In recent years researchers have identified technology as the main obstacle for truly achieving this kind of synergies in any omni-channel strategy. Mainly due to the need for acquiring resources and systems and the difficulties in achieving the desired integration between channels (Lewis et al., 2014; Lin, 2012; Müller-Lankenau et al., 2005). Many existing technical software solutions that can manage distribution centers (DC) with complex requirements on order-fulfillment capabilities are aged and in need of replacements or major upgrades. (McCrea, 2013; Trebilcock,

2012). Furthermore, these software systems traditional architectures have often been made up of a whole eco-system of information systems, which all need to be able to communicate in some manner to solve problems in the borderlands of each others' areas (see fig. 1.1). Each component has the responsibility of some information and task execution. This is a rather stale system support structure and causes both information silos as well as bottlenecks in possible system support functionalities

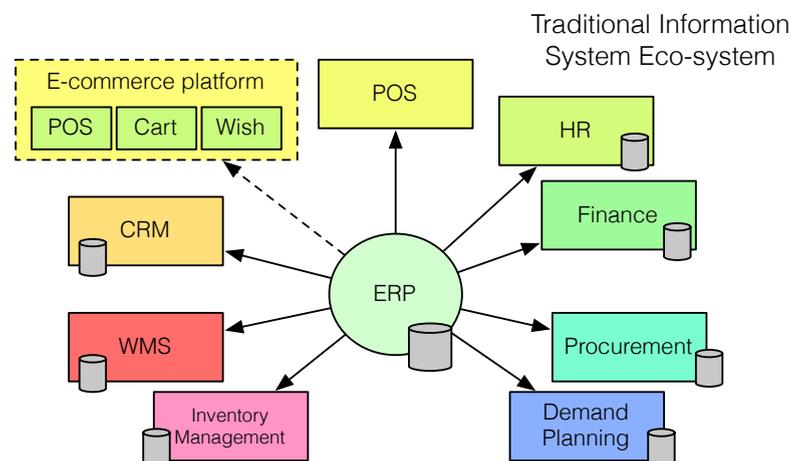


FIGURE 1.1: Traditional eco-system of information systems

A key part in this system structure for an successful implementing of an omni-channel approach is the WMS (warehouse management system). It presents the biggest opportunity for flexible handling of different order-fulfillment methods. The primary requirement of a WMS is to manage resources and operations as well as the material flows within a warehouse (ARC Advisory Group, 2014; Mulcahy and Sydow, 2008; Richards, 2011). ARC Advisory Group (2014) further defines WMS as a software solution that operates in real-time and allows for the utilization of radio frequency, RFID, voice recognition, and/or real-time location systems.

The software industry has also started undergoing a shift into adopting cloud-based systems, which has been in line with both the need for streamlining and achieving greater supply chain visibility. According to ARC Advisory Group (2013), cloud computing is the use of internet for on-demand accessing of software and hardware to perform work. This new cloud based technology has also shown to make the transition from siloed operations to integration easier. Through greatly facilitated software deployment and by having inventory data and customer information stored in a centralized databank, the bridging between different sales platforms and system components is facilitated (Amato-McCoy, 2012). Also many solutions now work on a SaaS-based (software-as-a-service) platform, that is basically on-demand systems that are supervised by the vendor and have no physical on-site implementation(Michel, 2014).

A way to counter the need for multiple information systems is a software solution where most desired functionalities can be achieved under one roof and accessed by any imaginable system of engagement (see fig. 1.2). This relates to the concept of an enterprise-wide interaction platform, where a lot of the functionalities that usually are their own components or systems are consolidated in a business logic level. Under a paradigm like this the warehouse management functionalities are commonly related to inventory and order related management functions. With functionalities that use data from the same sink, both purposes of increasing sales and increasing flexibility can be achieved at the same time, be it for HR purposes or warehouse management purposes.

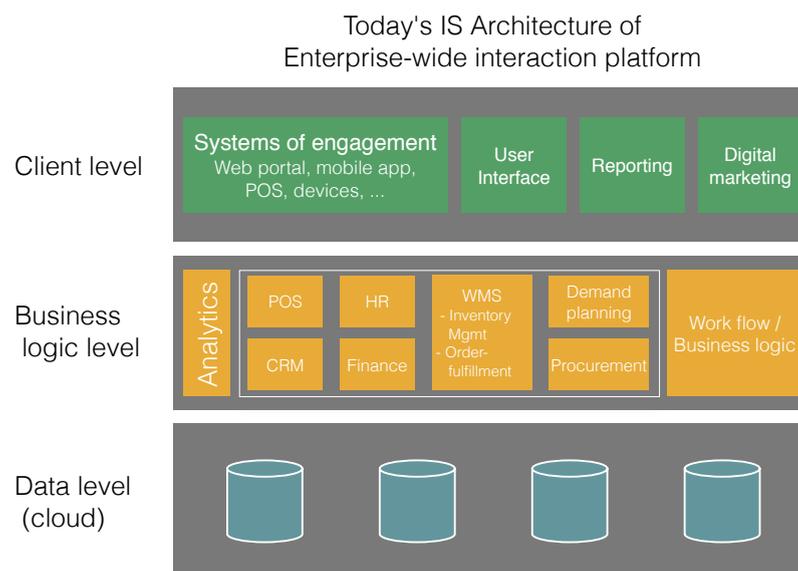


FIGURE 1.2: Traditional eco-system of information systems

In the situation of most multi-channel DCs, the challenges centres around picking operations. Mainly since the traditional operations are usually not structured to accommodate a multitude of order types with a multitude of articles and lines in very short time windows (Napolitano, 2013). Another concern is retail replenishment to stores, which is either done in a pull or push manner (Napolitano, 2013). The pull concept typically relates to point-of-sales information that results in a pick for a consolidation shipment to the store. The push concept relates to responses to promotions or surges in demand.

Another aspect is the points of distribution (Napolitano, 2013), as spreading the available e-commerce inventory across all stores inherently creates the possibility of having orders consisting of articles from many types of warehouses/stores at the same time. Since customers demands the choice for varying shipping requests, the point(s) to which an order is destined in the supply chain can be numerous (Forrester Research, 2014). Spreading inventory and allowing order-fulfillment across channels to consolidate at a specific supply chain node lies in every logistic

chain's biggest interest, since the bottom line in a theoretical supply chain setup is always to try and consolidate at the absolute closest point to the customer. This supply chain landscape is not new, but thanks to the e-commerce revolution there is today a larger spectrum of actors that wish to operate with a logistically sound approach. These actors are smaller, less capital and labor intensive, and serve both businesses and consumers on a global scale. Taking into account the possibilities of new technology and a changing information system landscape, this has opened up for various new and old software vendors to redefine how systems may support these supply chains. Furthermore, according to the [ARC Advisory Group \(2014\)](#) study on WMS softwares the conclusion is that new logic is required in these multi-channel warehouses and systems to be able to manage cross channel order-fulfillment and in a proper way increase omni-channel sales and flexibility.

## 1.2 Problem formulation

The concept of omni-channel and order-fulfillment across channels developed from customers expectation and an yearning to "buy anywhere, fulfill anywhere" (see fig. 1.3). The "buy anywhere" has dictated most of the developments within the omni-channel domain, as its progress has been related to the growth in e-commerce and the customer interaction platform that is possible today. The "fulfill anywhere" has not had the same progress, since it relates to coordination of a company's resources to fulfill customer orders in any way that is desirable. The interaction platform provided to enterprises today may include cloud-based interfaces, which opens up an opportunity to actualize the increased flexibility that order-fulfillment across channels actually means. One of the main components or tools for enabling and managing this process is a WMS.

Considering the rapid changes in the retail environment, the growing expectations from customers on omni-channel fulfillment capabilities, and the increasing requirements and demands of solutions placed on out-dated warehouse management systems, this thesis will investigate how a WMS is actually affected by the transition to and its development towards an omni-channel environment.

WMS theory is greatly influenced by the vendors supplying these softwares. The literature mostly discuss all of the general functions and the considered more advanced features that will enable the WMS to facilitate omni-channel fulfillment. It does not however address the absolute critical underlying functionalities within the system architecture that will allow for all of those discussed WMS functions and feature to actually become operational. Based on this reason the thesis will also investigate what the basic functionality needs are in a WMS-structure and how these needs can be realized?

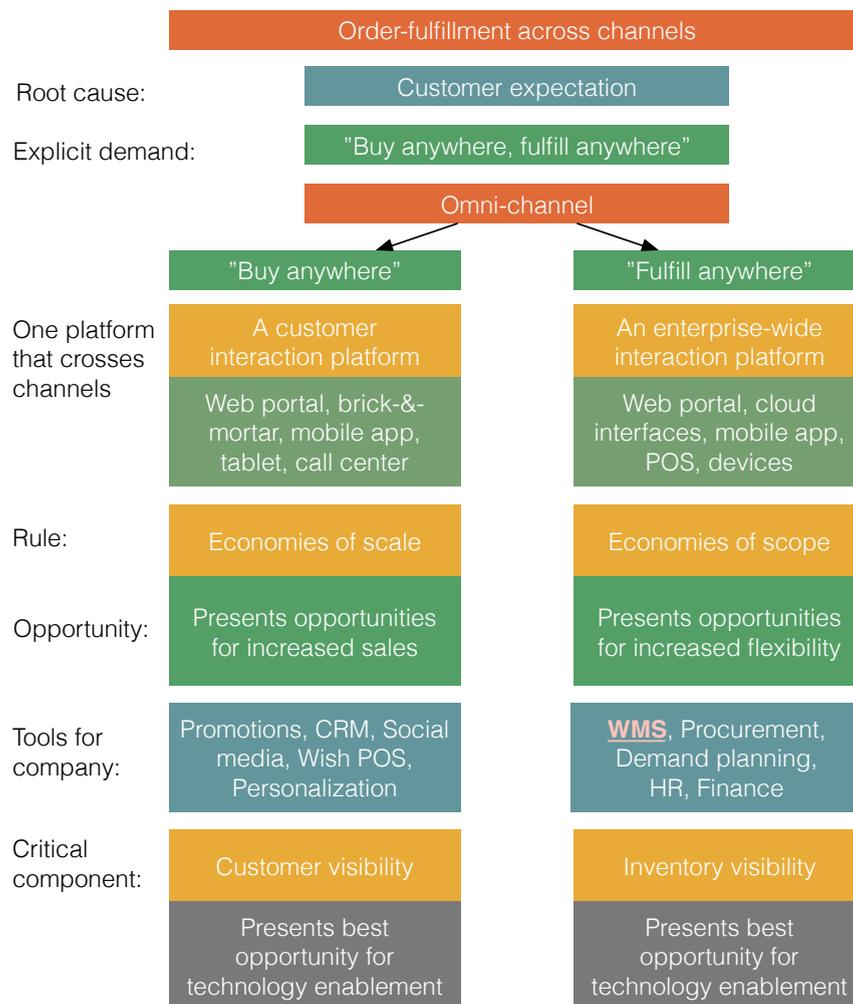


FIGURE 1.3: Relation between omni-channel components :: "Buy anywhere, fulfill anywhere"

### 1.3 Purpose and research questions

The purpose of this thesis is to investigate the implications on a WMS when developed towards retailers that operates in an omni-channel environment.

In order to fulfill this purpose the research will be conducted in collaboration with a partner company. This company has the desire to further develop their current ERP-solution offered to their customer by including an WMS-module that can sufficiently be implemented into omni-channel operations. Their customer base consists mainly of retailers working with or towards omni-channel fulfillment. By conducting research on these retailers and solving the fundamentals to the imaginative and proposed workings of functionalities from industry system development vendors, the authors hope to contribute to contemporary WMS, IS (Information System) and omni-channel retailing theory. By focusing on the results that the authors conclude, This thesis

could be as useful to a retailer that is investigating software vendors' offerings, as it is to a vendor that is developing this type of software.

The following questions will be researched and answered:

1. What functionalities should be considered in a WMS solution for efficient warehousing in an omni-channel environment, and
2. How can they be realized and implemented?

## **1.4 Perfect IT - A presentation of the collaborating partner company**

PerfectIT was founded in 1994 and is located in Saltsjöbaden, Stockholm, Sweden. The company is specialized in supporting multi-channel sales through contemporary web technology and coordinated business processes. This began with the company's purpose of addressing an increasing market need for web-based and integrated business systems, which lead to the creation of the software BeX (Business Extensions). BeX is a proprietary enterprise and retail system that is distributed as a cloud-based, SaaS-solution. Its architecture looks very much like the one in figure 1.2 and it also supports some orchestration of order-fulfillment across channels through rudimentary business logic functionalities. However, the system BeX lacks certain integrated warehousing capabilities and only supports fixed location storing. For its users to be able to compete in an omni-channel environment a WMS-module with the ability to handle these requirements need to be incorporated into the system. The channels supported through BeX are anything from in-store and online activities to retail stores and warehouse environments.

By fulfilling the purpose of the thesis and answering the research questions, the functionalities identified as requirements for omni-channel operations will be analysed and serve as the foundation for the creation of a requirements specification for the WMS-module that is to be implemented into BeX. Neither the method for development of the specification or the entire resulting product will be included in the thesis. A sample of the specification will however be included in the Appendix section of the thesis to exemplify the thesis project deliverable.

## **1.5 Delimitations**

The thesis will focus on distribution warehouses of retailers in the general merchandise segments, who also operate through multiple channels with one of them being e-commerce. The main focus will lie on the type of general merchandise that is fashion and apparel. The authors will

exclude 3PLs and any type of producer, i.e. contract and production warehouses. The thesis will focus on picker-to-parts and low-level order-picking systems, but it will nonetheless take automation and high-level picking into account so as to face and enable the technology through system provision. The focus will also be on the main flow-creating activities in a warehouse, i.e. receiving, storing, picking and shipping.

The mapping of the key functions in a WMS will not be done through RFI/RFPs (Request For Information/Request For Proposal) from any software vendors, since the authors are doing this project in collaboration with a company developing their own software and this would mean a conflict of interest. The information is provided by the public offering of other vendors as well as literature (books) on how these systems are usually implemented. This thesis do not only aim to examine the key functions for the phenomenon studied. Functionality of a WMS has been discussed thoroughly among researchers and industry pioneers. The authors therefore hope to identify which underlying features that matter the most by creating a pseudo-solution that solves the problems faced by typical actors. Actors that also wish to operate efficiently in the omni-channel domain. It will furthermore assume that the domain is on a cloud-based platforms since it is both an antecedent and provisioner of the cross-channel fulfillment concepts.

The thesis purpose is not about examining how omni-channel affects warehouse operations, since the way these operations look today they are affected by a lot more factors than what the omni-channel concept can cover. The focus is on what the warehouse management system of today and tomorrow needs. A system that will accommodate the expectations of its users and their typical warehouse operations that are best-of-breed today, no matter if these needs are new or have been existing long before multi-channel and e-commerce emerged. The authors do not claim the identified requirements to be a consequence of the emergence of omni-channel fulfillment, but rather as requirements of companies that work with omni-channel fulfillment programs.

## 1.6 Thesis outline

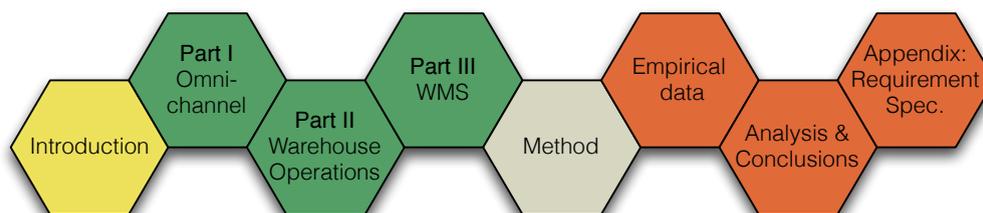


FIGURE 1.4: Main elements of the thesis

## Theoretical framework

After this introductory chapter the theoretical framework is introduced. This is divided into (1) omni-channel retailing, (2) warehouse operations, and (3) WMS (see figure 1.5). After presenting the basic concepts of retailing, e-commerce and multi-channel, a supply chain overview of the typical retailers involved in the omni-channel domain will be shown. This will be followed by a presentation of the different types of order-fulfillment programs that customers either expects or desires, as well as the barriers and opportunities with these fulfillment capabilities.

Then the perspective is moved towards the underlying theory in warehouse operations. Mainly because of what warehousing means fundamentally to omni-channel order-fulfillment, but also to introduce the concepts involved in WMS. It will address the main inbound and outbound flows, activities and underlying logistics “logics” that are carried out in a warehouse. The final part of the framework will be based on a mapping of WMS functionalities within the main processes of a warehouse and the benefits that they bring to overall logistics efficiency.

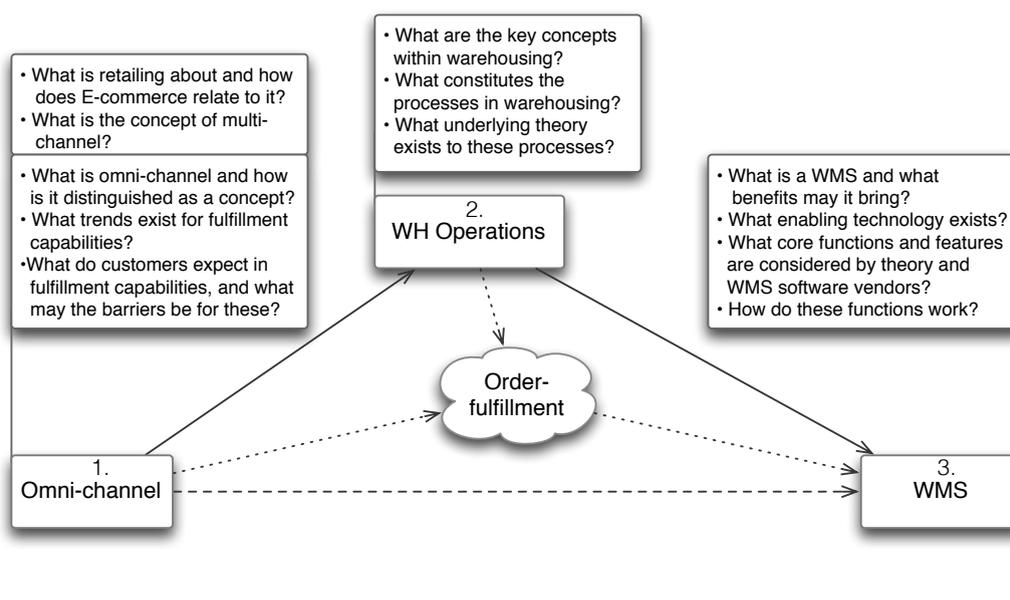


FIGURE 1.5: Elements of theoretical framework

## Methodology

After presenting the theoretical framework, there will be a motivation to the chosen research design, as well as the framework for the analysis. This framework will be a conceptual path that the authors will follow in order to analyze the collected data properly and so that valid and supportable conclusions can be drawn.

## **Empirical study**

After these parts the case study subjects are presented. The empirical study will follow a structure that resembles the top-down approach in the theoretical framework. The companies' supply chains and upstreams/downstreams flows will be discussed to present their overall characteristics and the omni-channel environment that they operate in. Then a more detailed description of the companies' warehouse operations will be presented and modelled. These will also include the user interactions with the BeX system. The modelling will serve as guidance and help when identifying what is to change with the system and what features are needed of it in order to create true omni-channel capabilities. Each case study will be concluded with an individual discussion to highlight their particular issues and opportunities with regards to the system and overall operations.

## **Analysis and discussion**

In the analysis the authors will address the cross-case considerations in view of issues and opportunities identified. The case study objects will be cross-analyzed to identify the patterns that exists between them in terms of their warehouse operations. This will also involve presenting the ideas that prevail for all cases and which ones that are likely to just be individual issues or solutions. This analysis will follow the outline of the identified core functions in the WMS part of the theoretical framework, so that discussions on functionality needs can be addressed separately. Then the authors will conduct a discussion regarding the functionality requirements that the identified issues and opportunities leads to. This will be followed by further discussion regarding the special considerations to the central and more fundamental ideas that were the outcome of the cross case analysis. These are compared against literature and emphasized, so as to show how the findings actually stand out from the typical research sentiment that the authors have seen. The concluding remarks will present how the research questions were answered and the implications that the findings have for theory. A summarizing epilogue on the findings and suggestions for future research topics and areas are also adressed.

## **Requirements specification**

The appendix chapter will show how the conclusion were converted into actual functions and used to construct an requirement specification. This will however only show a sample of the requirement specification delivered to the collaborating company. This will form an idea on what the authors have constructed out of the research study.

## Chapter 2

# Part I - Omni-channel retailing

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*This chapter will start by describing the characteristics of retailers and the industry. Since e-commerce is a main attribute this will then be explained. Lastly a large part will be devoted to explain what multi and omni-channel is, touching on main similarities and differences. Order-fulfillment programs, drivers behind the change, customers expectations and the barriers for successful omni-channel implementation will be discussed.*

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### 2.1 Retailing

Retailers do not have any manufacturing of their own and retailing involves buying merchandise or a service from an actual manufacturer, agent, importer, wholesaler or another retailer and then selling it to consumers for the consumer's own personal use (Zentes et al., 2007). The industry is changing and the emerging market will be marked by innovation, integration and responsiveness. Consumers are changing and therefore so will the industry (KPMG, 2009). MarketLine (2014) states that this consumer change is constituted mainly by an alteration in beliefs and needs but also in new demands and behaviour. The consumers willingness to wait to be satisfied or served has been greatly reduced, and they now expect instant product availability and gratification. Consumers will seek out the lowest possible product price in an increasingly transparent retailing market (Aubrey and Judge, 2012). Retailers must carefully monitor their online reputation and use social network sites to gather customer feedback as a way of forecasting demand and anticipating product and pricing priorities (KPMG, 2009).

A major concern for retailers are product availability. Fernie and Sparks (2009) defines the process as getting the right products to the right place at the right time. To ensure the availability

of product stock when it is needed the retailer have to manage both product movement and have a sufficient demand management in place. They need to calculate what is selling where and be able to react quickly and accordingly to changes in this demand (Zentes et al., 2007). Fernie and Sparks (2009) states that elements in the supply chain such as inventory control, storage facilities and product transportation are all interlinked. In the past it was commonplace that all these areas were functioning as isolated silos. These might have ensured optimality within each function, but were suboptimal in an holistic viewpoint (KPMG, 2009). Today the goal is to integrate these tasks and reduce all functional barriers.

### 2.1.1 Fashion / apparel

The apparel industry has always had to adapt to customers who demands the latest and newest designs while they are still in fashion (Abernathy, 1999). Some other recent emerging trends that affect the consumer expectations are swift, quick and free shipping and also free product returns. Companies have to be fast when accommodating for these changes or they lose market shares to other companies who are quicker at adapting (Diamond, 2006). Fashion apparel consists of all menswear, womenswear and childrenswear. The category includes accessories, shoes and in some cases hardware (Diamond, 2006). Fernie and Sparks (2009) have defined fashion products as typically exhibiting the following most prominent characteristics:

1. Short lifecycles: The product is often ephemeral, designed to follow current trends. Consequently the period in which the product is actually saleable is likely to be short and seasonal, usually around 8-12 weeks (Kawakatsu, 2010). When season change the inventory of certain products will have to be sold or the retailer will be forced to advertise the products at reduced costs (Krupnik, 2015).
2. High volatility: Demand for these products are rarely stable or linear. It may be influenced by social or other types of media.
3. Low predictability: Because of the volatility of demand it is difficult to forecast the total demand during a period. It is even harder to make week-by-week or item-by-item demand.
4. High impulse purchase: Many of the buying decisions for fashion and apparel products are made at the point of purchase. This means that the consumer will be stimulated to buy a product when confronted with it. This leads to the critical role of availability of items and particular colors and sizes.

Despite the short lifecycles, fashion and apparel products usually have a quite long ordering lead time, ranging between 3-9 months (Kawakatsu, 2010). For this reason the retailer will have to commit to a single order of seasonal items prior to the beginning of the season. Because of the

constantly changing and evolving trends in the fashion and apparel industry retailers constantly buy and sell new products which they have never had in stock before. This forces the retailers to make decisions regarding allocation, replenishment and assortment without any historical product data (Krupnik, 2015). The only way to predict demand will be to compare historically with similar products during the same seasons, which in many cases can be misleading due to past promotion campaigns, new product launches or product cannibalization (Krupnik, 2015). Fashion retailing are also quite unique in the aspect that one specific model of clothing can come in a wide variety of sizes and colors creating separate SKUs for each individual product.

### 2.1.2 E-commerce

Online retailing or e-commerce constitutes the selling products or merchandise through an online sales channel. The most common goods sold online are general merchandise (Biederman, 2013; MarketLine, 2014). With the expeditious expansion of the internet during the mid-1990's early predictions were made, that in a not too distant future all physical stores would be abandoned and consumers would use the internet for all of their needs and purchases. However, this hype far exceeded reality (Bond, 2015b; Lockton et al., 2013; Zwass, 1996).

The e-commerce market is continuously growing both for both the B2C and B2B sector (Richards, 2011; Schultz and Block, 2014). This growth helps alleviate the competition caused by the large number of online retailers and the low switching cost between different online retailers for consumers (MarketLine, 2014). The low switching cost has helped boost consumer power in this sector substantially which has made accuracy and on-time delivery of orders to essential components if the retailers are to retain loyalty from consumers (Richards, 2011).

Before the introduction of e-commerce the distribution centers received and shipped large volumes of product at the same time to fulfill store orders (Eskridge, 2013). E-commerce orders have a different profile from store orders. They entail an increased number and more frequent customer orders but at the same time they are decreased in order size (Mulcahy and Dieltz, 2003). The e-commerce order profile is most commonly 1.2 lines per order, with about 30% to 60% one-line orders (Cilt(UK), 2014b). E-commerce order-fulfillment has also led to an heightened importance of an accurate order entry, increased size of the piece mix and a reduced cycle time for order to delivery (Mulcahy and Dieltz, 2003).

This change in the structure from full-carton or full-pallet picks to individual-item picks places substantial demands on the warehouse pick system (Richards, 2011). The characteristics of picking and packing of low-cost items for e-commerce will utilize the same amount of labour and equipment as for high-cost items but the margin is going to be significantly different. Furthermore, as the e-commerce operation grows the increased amount of added product lines

will demand increased number of pick locations, and slow moving products may occupy valuable place in the warehouse (Richards, 2011).

E-commerce commonly experiences larger amounts of returned products than brick-and-mortar retailing. This can mainly be seen as a by-product of the sales channel, and the amount of returns can reach up to 40% of the outward volume. But many of these product can be replaced in the stock and resold after a quality control (Cilt(UK), 2014a; Napolitano, 2013; Richards, 2011). This high percentage of returns is especially common for fashion and apparel retailers, where it doesn't just occur by fault but to a great extent by customer choice.

Many distribution centers were not designed to accommodate such high levels of returns and in that case they will need to have highly functioning systems in place to deal with the replacements and returns in an efficient manner (Cilt(UK), 2014a). Vanelslander et al. (2013) recognizes two common ways for order-fulfillment for online retailing. These can contain minor or major variations. Either the retailer can function as a pure e-commerce player with only the online sales channel in operation, or the e-commerce section can be combined with brick-and-mortar stores. The last one is a common example of multi-channel retailing.

## 2.2 Multi-channel

Multi-channel retailing (see fig. 2.1) consists of the activities that involves selling different services, products and merchandise to consumers through more than one single channel of sale (Jie et al., 2010; Lewis et al., 2014). These channels are however usually functioning in isolation from one another (Cilt(UK), 2014b; Frazer and Stiehler, 2014; Strang, 2013). The expanded use of the multi-channel strategy for brick-and-mortar retailers has been facilitated by the emergence of the internet as a channel to sell products to the customer (Yan and Pei, 2012). In the same manner pure play e-commerce retailers added channels such as mobile phones and physical stores (Yan and Pei, 2012).

Clear key drivers for adding multi-channel capabilities for a retailer is to mainly increase sales but also to meet a rising customer demand (Lewis et al., 2014). Studies have shown that the multi-channel consumer spends on average 15-30 percent more than a consumer who only uses one single channel for their purchases (Hobkirk, 2013; Winter, 2012). The marketplace for brick-and-mortar stores are usually limited around its actual physical location. When adding additional channels, usually e-commerce, it become possible for retailers to take advantage of economies of scope and expand their market and reach new potential customers, without actually building new stores in other geographical locations (Jie et al., 2010). The retailer will also be able to provide the customer with a larger assortment of products and complement the existing product line offered in the store (Lewis et al., 2014).

The different channels of sales have their own positive and negative aspects. By utilizing a multi-channel approach it is possible to overcome deficiencies in the different channels. In a store a customer can use their senses to feel and see the merchandise before purchase, which will grant them instant gratification (Brynjolfsson et al., 2013; Lewis et al., 2014). The drawback of this is that they actually have to travel to the physical location of the store (which is only open at specific hours) to gain these benefits (Jie et al., 2010). An online channel offer the possibility to make purchases anywhere or anytime and also removes the time and cost needed for travel to and from a store location (Lewis et al., 2014).

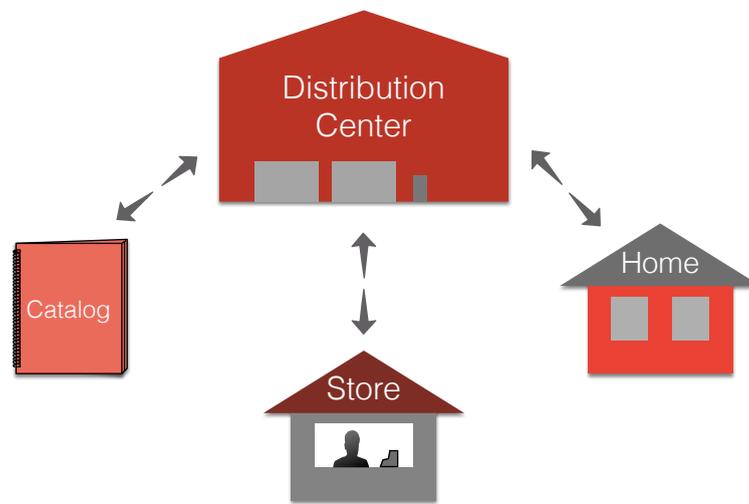


FIGURE 2.1: The Multi-channel approach, channels in isolation

If a retailer is offering a more unitized assortment of brands and products across the channels, customers can browse products in one of the channels for research purposes but do the actual purchase in another. This can also be used to promote sales between the channels (Lewis et al., 2014). The popularity of products can be examined throughout the channels and the highest selling products on an e-commerce channel could be the products chosen to occupy more valuable in-store display space (Jie et al., 2010). These were some examples of multi-channel integration but multi-channel retailing is still mainly considered to have different channels of sales functioning in isolation of each other (Cilt(UK), 2014b; Frazer and Stiehler, 2014; Strang, 2013). Different and/or separate orders are commonly fulfilled through different/separate supply chains. Replenishment of store inventories has commonly been managed from one DC, while the online order-fulfillment was managed from a different e-commerce DC or from a third party logistics provider (Strang, 2013). The customer could chose to shop in different channels but they functioned independently from one another. If a truly integrated approach was to be created across the entire retailer's supply chain, it could create a seamless consumer experience across all channels of sale. This multiple channel integration would then have evolved into an omni-channel environment (Lockton et al., 2013).

## 2.3 Omni-channel

The multiple channel shopping experience, with its channels functioning in isolation might no longer suffice for the demanding consumers of today and retailers will be forced to move their focus towards what is called Omni-channel retailing (Frazer and Stiehler, 2014). Omni-channel retailing refers to an “integrated shopper experience that merges the physical store with the information rich digital environment” (Frazer and Stiehler, 2014). Further Cao (2014) states that omni-channel is the strategy to assemble various channels into a single, interchangeable distribution system, promoting seamless transfer of orders between channels (see fig. 2.2).

To accomplish this the retailer will have to strive for full integration between all sales channels, remove all silos in the supply chain, and create a seamless experience. Altogether, this would erase the differences between online and offline and turn retailing into a showroom without walls (Brynjolfsson et al., 2013; Mansfield, 2014). Ideally, the customer should have the same purchase experience regardless of which channel it is currently using. It should also have the ability to move freely between channels, all within a single transaction (Piotrowicz and Cuthbertson, 2014; Wallace et al., 2004). The omni-channel approach targets integration of even more sales channels than before. (Verhoef et al., 2015). These added new sales channels are evolved from the introduction of new technologies such as smart mobile devices and related software (Piotrowicz and Cuthbertson, 2014). This presents the retailer with new possibilities for channel integration. New in-store technologies, such as virtual screens, virtual fitting rooms, and tablets, can easily connect the customer in an offline brick-and-mortar setting with the expanded assortment and possibilities of the retailer’s own online sales channel (Piotrowicz and Cuthbertson, 2014).

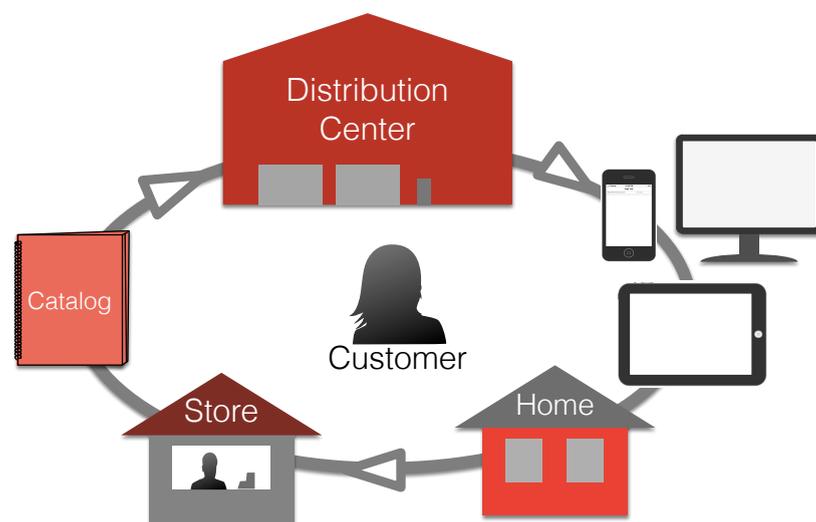


FIGURE 2.2: The Omni-channel approach, seamless channel integration

The retailers evolution to an omni-channel environment could be considered to be one of the main drivers behind the present growth of the retail industry (McCormick et al., 2014). One motivation for this evolution may be that there is a potential increase of sales and the development of an enhanced business model (Lewis et al., 2014). There may also be potential improvements in logistics efficiency from having a single view of stock and ability to cut total fulfillment costs, which are highly desirable effects of an omni-channel approach (Lockton et al., 2013). Another clear driver is the ability to meet customers expanding demands (Lewis et al., 2014).

According to Forrester Research (2014) the two most frequent reasons stated by retailers to adopt an omni-channel approach, was simply that the customers were expecting it and that the other competing retailers were already implementing it. Although there prevails a strong drive in the possibility of increased sales since the omni-channel shoppers are likely to spend 15-30 percent more in comparison to the multi-channel shoppers (Hobkirk, 2013; Winter, 2012). This sales growth originates from an ease of consumer access, better informed choices and enhanced customer services. The growth in the segment of online and offline retailing offers many opportunities but at the same time a number of pitfalls. In order to survive and succeed in an omni-channel environment retailers must adapt their supply chains, their order management and their order-fulfillment processes (Strang, 2013).

### 2.3.1 Fulfillment programs

Omni-channel fulfillment is increasingly becoming the norm for supply chains in recent years (Alexander, 2014b). For omni-channel adaptation the two most major order-fulfillment programs are (1) to allow customers to order online and then pick up the product in a store and (2) to allow customers to order in the store and have the product delivered to the customers home (Chatterjee, 2006). The first option will also include an expectation from the customer to be able to return or exchange the products they bought online in a store (Lang and Bressolles, 2013). The second option could entail that the desired product is shipped from another store or a DC if it is not available in the channel it was ordered from. According to Forrester Research (2014) these are also the two most highly prioritized fulfillment capabilities to implement by retailers, and store pick up is a key capability for retailers if they aim to compete with any of the pure play e-commerce retailers. Both of these options would allow consumers to switch between channels at various stages of the transaction process.

Another important order-fulfillment program for retailers to implement is the ability to turn brick-and-mortar stores into miniature fulfillment centres. This will enable the retailer to pick online orders from regular store shelves for separate dedicated delivery (Agatz et al., 2008). Shipping from stores will not be as cost efficient on a cost per item basis as shipping from the distribution center. Retailers will have to evaluate the need to improve and manage the in store

picking, packing, and shipping (Strang, 2013). A need to improve the distribution network might arise since there will be increased volumes of goods that will be pushed out to the stores, and orders need to be routed to stores for shipping. An implementation of this option could significantly reduce delivery time since shipping could occur from the store physically closest to the consumer (Napolitano, 2013; Strang, 2013). A disadvantage is the competition that could possibly arise between in store shoppers and online order pickers for the same products. This may lead to unexpected stock-outs and the need for substitutions in the online orders as well as frustrated store customers (Fernie and Sparks, 2009; Vanellander et al., 2013).

For retailers to achieve the omni-channel approach with an ability to fulfill customer demand from anywhere at any time, several fundamental processes might need to be developed or existing ones be changed. This could involve establishing processes that originally are not that typical for retailing operations. The systems supporting those processes might have to be redesigned as well (Strang, 2013). They would have to be able to ship from all available stocks, across all channels to anywhere at all times which would require a complete shared real time inventory visibility throughout all the different channels (Fortna, 2014). Shared inventory visibility is the first and most critical step toward omni-channel retailing (Strang, 2013). Furthermore, the altered or new systems will have to be able to support a new required level of complexity, precision and integration for order-fulfillment (Forrester Research, 2014).

It is important to recognize both the complexity in omni-channel fulfillment and the fact that cross-channel fulfillment is not a new phenomenon. The phenomenon is influenced by many factors, of which e-commerce and cloud computing are the biggest contributor to how cross-channel fulfillment can be done today. As seen in figure 2.3 is a traditional multi-channel supply chain with stores, one distribution center for the stores, as well as an e-commerce warehouse supplying the e-commerce channel. It has not been uncommon for the two DCs to supply cross-wise, which often rules out shared inventory and complex order-fulfillment with order consolidations, etc (McBeath, 2012). One factor has been the bottleneck created by poor system support. Order-fulfillment programs can be done manually, but rarely when supply chain flows scale up. In the example picture, there would be great logistics inefficiencies when an order includes an item that needs to be sent from another store or DC, especially when there are limitations to how the orders can be fulfilled. It is not uncommon that orders are ineffectively sent across a supply chain, despite a customer being located close to the merchant or the purchased goods itself.

As with the omni-channel example of a supply chain, the use of cloud-based system implementations may allow the seamless interaction and exchange between all types of supply chain nodes, including stores and the e-commerce channel (see fig. 2.4). These have a theoretical even capability of handling orders, given that they have some backroom space. All nodes get their

operative data from the same data sink and operate through the same interface, opening up for all kinds of theoretical cross-channel fulfillment programs.

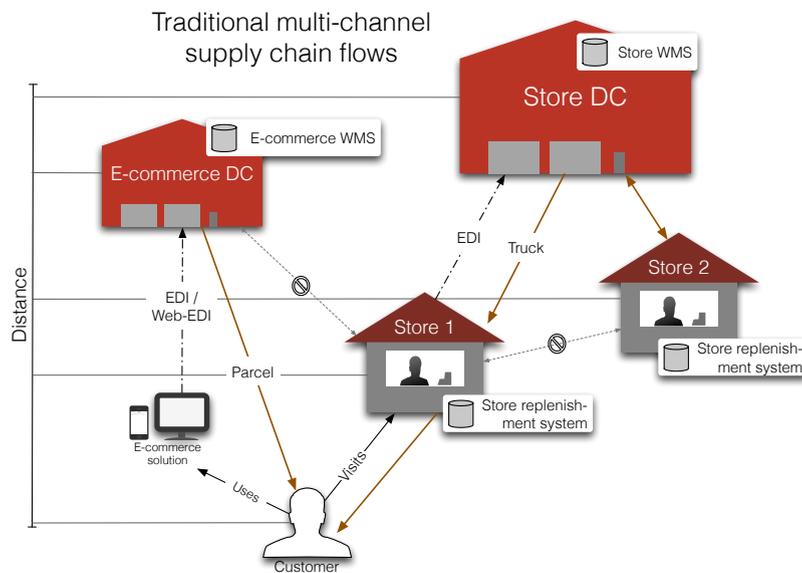


FIGURE 2.3: Traditional multi-channel supply chain flows

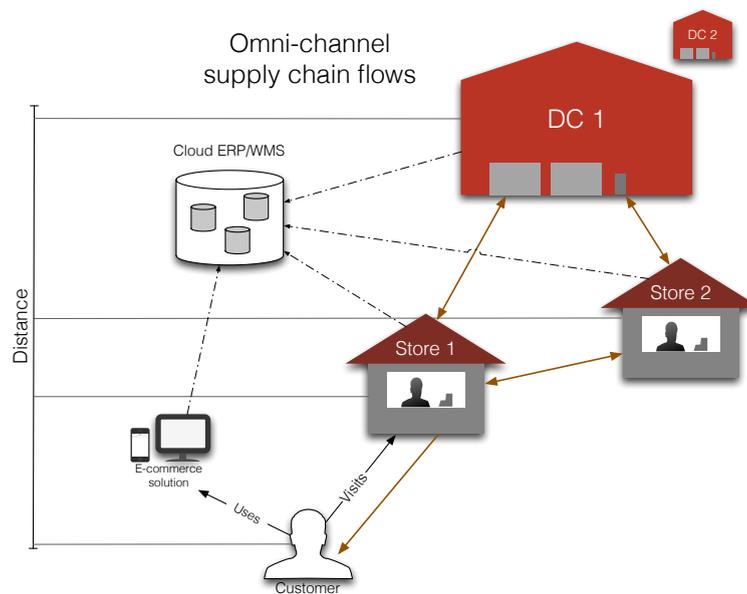


FIGURE 2.4: Today's omni-channel supply chain flows

In the e-commerce channel, the connection between the customer and the selling company is usually named the e-commerce solution. There are various implementations on how this is done, but figure 2.5 provides a guidance to how an external e-commerce platform works as a middle hand from the selling company and the customer. To sell products to customers, they will have to raise a query to the selling company of the existence of the item and requested quantity. If accepted by the merchant a query is sent to the customer's bank so that the e-commerce platform can assure the clearance of the order.

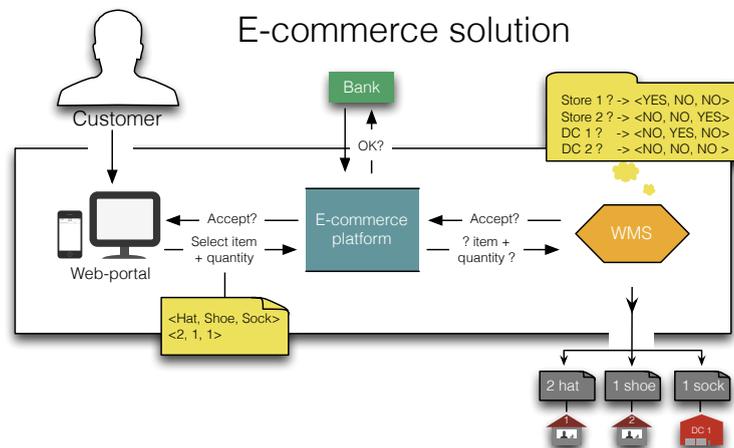


FIGURE 2.5: Inner workings of an e-commerce solution

To provide with an example that covers a cross-channel order-fulfillment in an omni-channel supply chain, figure 2.5 explains how one customer asks for two hats, one pair of shoes and one pair of socks. This consumer does not care where the products lie in the merchant's supply chain, and it does not care how the products come to it as long as it comes reasonably fast and convenient. It may choose to come to the closest store for pick-up or it may choose to get it sent home as parcel mail. Some order management functionalities together with inventory management functionalities accept the items of the order from three different warehouses. The two hats are in store 1, the shoes are in store 2, and the socks are in one of the two DCs that are in this country. Preferably, the shoes and the socks should be sent to store 1 for consolidation with the hats. This is because it is the closest point from which the packed order can be sent to the customer or picked up. Each warehouse goes through their usual order-fulfillment process (see fig. 2.6), i.e. distributing order-picking tasks to their workers, picking the items, packing and staging them, whereupon they are shipped with some truck service. The only thing unique to this cross-channel fulfillment is that two items are going to one destination to meet up and consolidate with other parts of the order, in this case the two hats that are in store 1. To take into account that this is happening in a store, the process of consolidating the three items to one place, where they can be packed, may happen in various ways and with various support from an information system. But done manually or not, the customer may now come to get

the collected order or it may be sent by some parcel delivery service to its home. This example emphasizes the particular importance of the role of a WMS in supply chains where it may serve a purpose of cross-channel fulfillment programs.

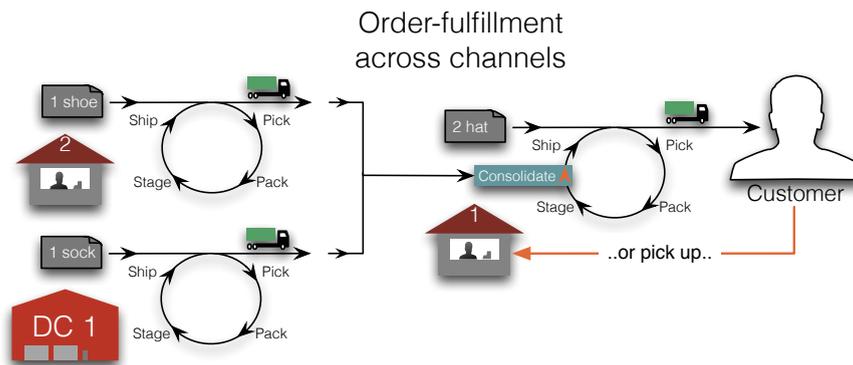


FIGURE 2.6: Example of order-fulfillment across channels

### 2.3.2 Customer expectations

Since one of the main drivers behind omni-channel fulfillment is to meet consumer demands, it is important for the retailer to be able to identify these demands (Frazer and Stiehler, 2014). As consumers get more exposed to services such as expeditious and free deliveries, order pick up in stores and in-store returns of online merchandise, their expectations are quickly changing (Forrester Research, 2014). A few years ago these services were commonly seen as the forefront of omni-channel customer service, but are today becoming conventional and highly expected. One of the main ideas with omni-channel fulfillment is to respond to customers orders as quickly as possible, since customers expect their products to be delivered swiftly and inexpensively to them (Blanchard, 2014).

In a study conducted in November 2013, Forrester Consulting did an in-depth survey with 256 different retailing companies, working with commerce in North America and Europe, and also with over 1500 consumers (Forrester Research, 2014). This study was designed to show the average omni-channel and multi-channel retailers priorities but also consumers expectations and demands on these retailers. The four most highly prioritized order-fulfillment capabilities that retailers were actively working to implement, and that consumers perceived to hold the highest value are listed below:

- Store pickup of online orders.
- Product purchase in-store then shipment out to customer from a distribution center or another store.

- Showing accurate in-store inventory online.
- Products purchase online and then shipping from store out to customer

The study showed that 71% of customers expect to be able to view in-store inventory on a retailer's website while 50% expect to be able to pick up products they buy online in a physical store. As many as 39% of customers were also hesitant to even visit a retailer's brick-and-mortar stores if not correct inventory information of the store was shown through the online sales channel (Forrester Research, 2014).

According to Blanchard (2014) one third of nearly 800 retailers and 3PL companies in a 2015 Third-Party Logistics Study felt they were nowhere close to developing omni-channel fulfillment capabilities. Even though the statistics show a clear trend in customer expectations, only around a third of these retailers had already operationalized the fundamental structural solutions, such as in-store pick-up, cross channel inventory visibility or store-based fulfillment (Forrester Research, 2014).

### 2.3.3 Barriers

Technology has been widely identified as the main barrier for multiple channel integration or omni-channel fulfillment. This lack of updated systems technology resulted in difficulties with achieving the expected synergy effects between the channels and many retailers faced significant issues (Lewis et al., 2014; Lin, 2012; Müller-Lankenau et al., 2005). Mainly because it involves challenging and complex alterations to the IT and logistics systems. When trying to implement omni-channel fulfillment programs such as buy online, collect in a store, and return the product in another channel, high demands were placed on the IT systems.

In the study conducted by Forrester Consulting in 2013 it was found that 44% of retailers that had implemented the ship from store fulfillment program struggled with the picking accuracy. Another 40% of the retailers had substantial difficulty integrating back-office technology across all their channels. They needed to have an accurate view of real-time inventory across stores and distribution centers which they were unable to implement (Forrester Research, 2014). Implementing order-fulfillment operations are troublesome due to the balance between picking, packing, shipping activities and with warehouse best practices (Alexander, 2014b).

To fully gain the benefits of adopting an omni-channel approach, significant investments will often have to be made to acquire new systems or upgrade outdated ones. The new systems will have to be able to execute functions for company-wide inventory visibility and inter-departmental logistics coordination, such as a distributed order management system (DOM), advanced point-of-sale system, or a complex inventory management system (Hobkirk, 2013;

Napolitano, 2013). For complex supply chains, a DOM system might be an essential component to achieve the “purchase from anywhere, ship to anywhere”, which is the fundamental building block of omni-channel. A DOM has the visibility of all the inventory in all the different stores and DCs, and the idea is that it can make a decision regarding where it is most cost efficiently to drop an order (Graves and Swartz JR., 2014; Napolitano, 2013). However, this kind of system module is expensive and sometimes superfluous, and used mainly by large enterprises with very complex supply chains.

Another critical requirement for an omni-channel retailer’s success lies in the planning and executing capabilities of a WMS or similar information management systems. More traditional WMS solutions were simply designed around only handling cases and pallets. Some of these older systems, ranging in age from ten to twenty years ago, lack the ability to support any type of less than case quantities or other multiple level item structures (Bond, 2015a). Now the challenges for a WMS lies in supporting the extremes in order sizes. The systems must be able to handle orders ranging from hundreds of items for any of the retailer’s stores, to only a few or even just one single item for the e-commerce businesses (Alexander, 2014a; Hobkirk, 2013; Napolitano, 2013).

The logic for the WMS has changed and doesn’t just include pick/pack/ship operations anymore. To include are modifications such as zone batch picking, multi-order picking, wave picking, priority processing, multi carton processing, pick-and-pass, put wall activities, shipping manifesting, and in-store order fulfillment activities (Napolitano, 2013). Furthermore, the requirements for inventory visibility has been the bottom line, where emphasis is put on a more granular and overarching visibility of the inventory and units in the supply chain’s warehouses (Terreri, 2009). This is what presents the best opportunity for technology enablement. A lighter version of a WMS could be implemented in the various brick-and-mortar stores to manage the back room area of a potential mini fulfillment center operation (Bond, 2015b). But lack of visibility may still be a problem, hence a growing trend suggests that retailers search for newer management systems that can handle this type of operations as well (Bond, 2015a).

## 2.4 Summary

Changes in consumer expectations are occurring in the retail industry. Consumers now expect instantly available products, short and inexpensive delivery times, and free returns. They also expect reverse logistics and expanded omni-channel order-fulfillment capabilities from their retailers. Some of the most highly expected fulfillment programs are online order pick-up and home deliveries from stores. To shorten the delivery times of orders many retailers are also investigating the possibility to turn their stores into miniature fulfillment centers. The heightened amount of consumer power and low switching cost between retailers makes fulfillment of these

Channels	Integration	Switch channels during transaction	Main drivers	Fulfillment options	Strengths	Weaknesses
Single channel	None	No	Simplicity	Single	Aligned	Limited assortment
Multi-channel	None / Siloed	No	Increased sales	One separate for each channel	Larger product assortment. Economies of scale	Prices and assortment might differ across channels Lower, varying service levels
Omni-channel	Full / Seamless	Yes	Meet demand Increased sales	Multiple by combining channels options	Unified brand Extensive assortment High uniform service levels	Technological barriers Costly and challenging to implement

TABLE 2.1: Single and Multi-channel compared to Omni-channel

demands crucial. Despite this a large amount of retailers have been experiencing issues when trying to implement these capabilities. These order fulfillment programs place high demands on having real-time inventory visibility and product traceability. Fashion products are difficult when predicting demand and they are highly volatile and have short life cycles. Retailers must now try and monitor online trends and activity to forecast product demand. By incorporating more channels, deficiencies in some can be overcome by the capacities of another.

Previously, parts of supply chains and different channels were functioning as silos. To adapt to an omni-channel environment the channels must be fully integrated. The barriers mainly consist of technology deficiencies. High expectations and demands are placed on outdated warehouse management systems. E-commerce distribution exhibits very different order profiles than traditional store fulfillment. A larger amount of orders with shorter order lines and a higher percentage of returns place new demands on the management of the warehouse operations in a DC. The warehouse management systems should also be implementable in stores to manage the mini fulfillment center operations. New systems logic must be developed for warehouse operations and the handling of the reverse logistics in the supply chain.

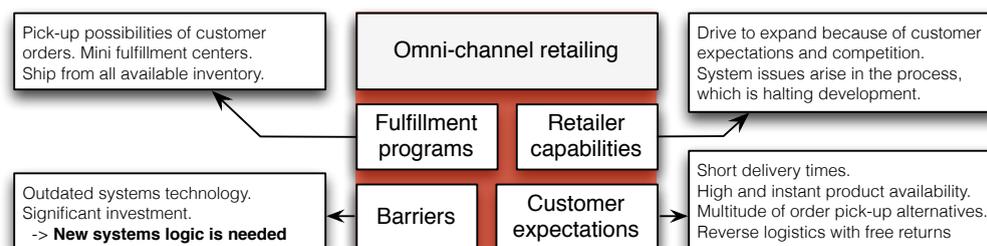


FIGURE 2.7: Important concepts of Part I - Omni-channel

## Chapter 3

# Part II - Warehouse operations

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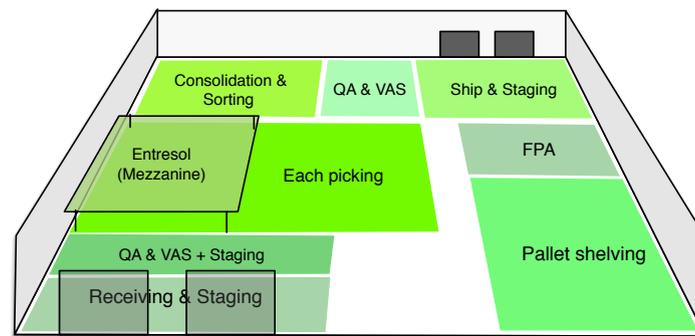
*This chapter will start with explaining some of the key topics surrounding warehouse operations. The reason is to create an understanding of how they connect on some level and also present the logical flow of the rest of the chapter. Each topic later on takes on an approach to explain the fundamental theory and logics around warehousing functionalities, which in extension are what warehouse management systems are built to manage to some extent. They also form the foundation for which the omni-channel paradigm is set on.*

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### 3.1 Key concepts related to warehouse operations

**Warehousing,** In short, warehousing is mainly about storing, reorganising and repackaging products (Bartholdi and Hackman, 2014). Furthermore, it is an essential component in the linkage of the supply chain's various chain partners (Lam et al., 2010). Major roles of warehousing include (1) buffering material flow, (2) consolidation of products, and (3) value-adding processes and customization (Goetschalckx et al., 2007).

**Warehouse flows and processes,** The most common perception of the processes behind the warehouse flows is a division based on *inbound* and *outbound* processes. Inbound processes are mainly receiving and put-away activities, whilst outbound processes basically consists of order-picking and shipping (Rouwenhorst et al., 2000). These activities are usually referred to as warehouse operations. The context of which warehouse operations are performed in a warehouse are called functional areas, which together make up a warehouse layout. Some of the most common ones are seen in fig. 3.1. The means for achieving material flow in a warehouse are the warehouse resources. Warehouse resources are anything from shelf storages, labor, material handling equipment and packing material.




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 FIGURE 3.1: Typical warehouse functional areas

**Warehouse management,** What ties warehouse operations and resources together is the organization of them. This is referred to as warehouse management (WHM) and includes all planning and control procedures that are used to efficiently fulfill customer orders with appropriate resources (see fig. 3.2). Traditionally, a warehouse manager performs these tasks, but today these are made with the help of a warehouse management system (WMS) (Lam et al., 2010). A warehouse management system can be part of many solutions. Its definition has been used ambiguously during its evolution. It is necessary to point out that an inventory-control or stock-control system is in fact not the same thing as a WMS. A WMS does have the main responsibility of inventory balance, as opposed to an ERP, which is responsible of the monetary balance of the stock. However, A WMS is also a system for warehouse management, i.e. managing resources and operations to achieve a more productive warehouse (Richards, 2011). The difference in contemporary softwares is to what extent the system executes and distributes tasks on its own, and how much control and coordination is required of the warehouse manager.

**Order-fulfillment,** Even though WHM is considered the umbrella term for the areas of interest within a warehouse, there is sometimes a need to express the operations in a business perspective rather than just a logistics perspective. *Order-fulfillment* is sometimes used to describe the warehouse operations in the context of customer orders (Mulcahy and Sydow, 2008). To generalize, order-fulfillment is the complete process from the point of sales (POS) to the delivery of requested products to the customer (see fig. 3.2). However, order-fulfillment actually involves more steps than just fulfilling orders. It is about having a supply network and process that supports meeting customer requests while also minimizing the total cost of delivery. As a consequence, order-fulfillment involves generating, filling, delivering and servicing customer orders (Croxtton, 2003). Mulcahy and Dieltz (2003) categorizes order-fulfillment operation activities as (1) Pre-order activities, (2) Order pick activities, and (3) Post-order activities. All common warehouse operations go under these labels, i.e. the piece or material handling flows. But the focus is shifted downstream and with the focal point at picking (fulfilling) orders.

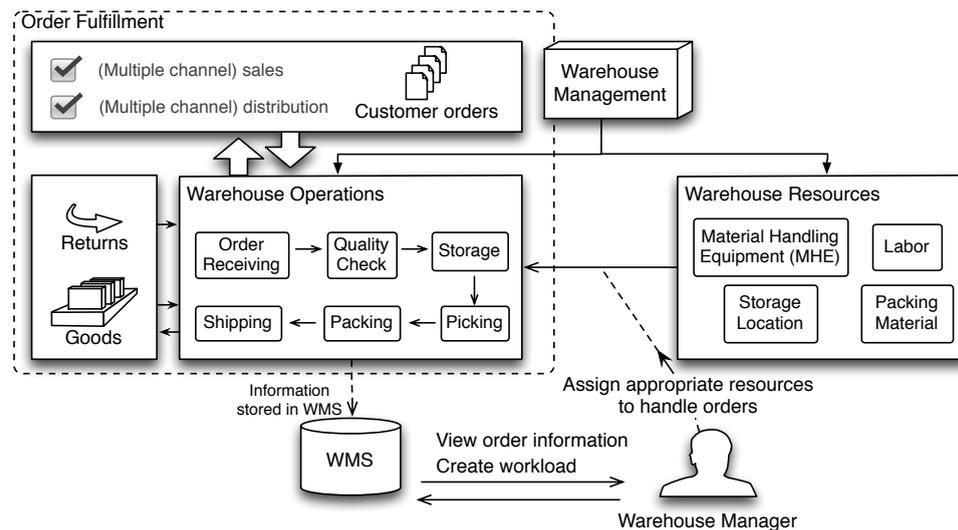


FIGURE 3.2: Meaning of warehouse management (Based on Lam et al., 2010)

## 3.2 Warehouse operations

The preconditions of and principles for storage differs depending on the type of warehouse, unit structure and how picking is done (Jonsson and Mattsson, 2011). The goal when designing a warehouse layout is to create as rational flows between any functional area as possible, while keeping a high utilization rate.

No matter the overall flow, it can be divided into more detailed functional flows. Figure 3.3 will guide the rest of the chapter, and it points at some main warehouse functions, i.e. activities or processes, that are carried out in the context of a few functional areas. As mentioned earlier, these functions are usually named receiving, put-away, order-picking, packing and shipping. (de Koster et al., 2007). However, it is common to expand packing into *order preparation/processing*. This includes activities such as accumulation, sortation, value added services (VAS), quality assurance (QA) and packing. Furthermore there are two special cases; (1) cross-docking is when the goods are only to be re-coordinated and sent back out from the warehouse, and (2) returns management, which has big implications on the industry studied (Richards, 2011).

### 3.2.1 Inbound

#### *Receiving*

The receiving function is the first process that an arriving item or collection of goods will encounter, i.e. an advance notification (Bartholdi and Hackman, 2014). These goods arrives from some mode of transport and from either a supplier or customer, i.e. returns. The products

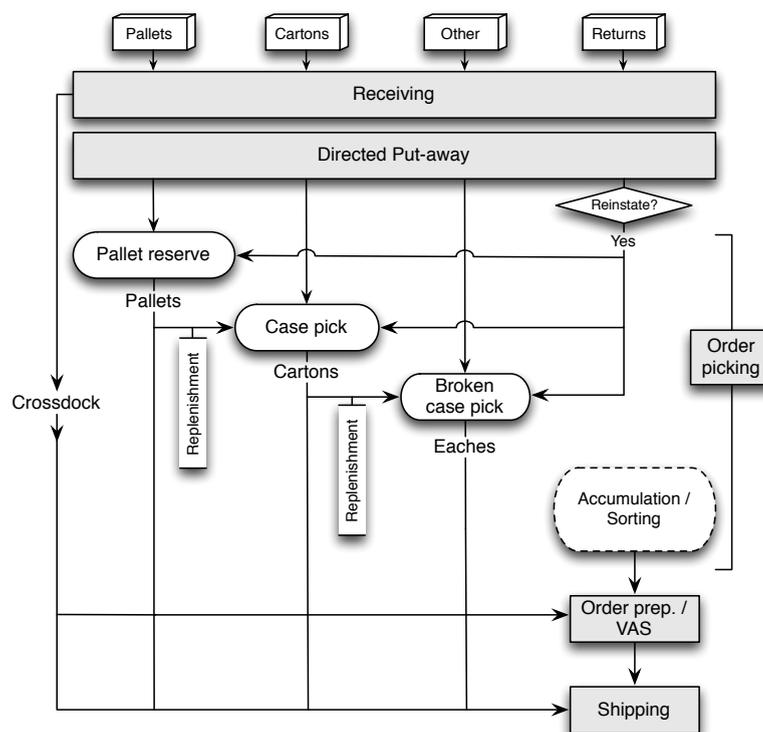


FIGURE 3.3: Unit flow model (Based on Bartholdi and Hackman, 2014)

need to go through some control activities to ensure that the right products are received, in the right quantity and of proper quality. It may include re-packing of goods into other storage modules (de Koster et al., 2007). Furthermore, waiting and transfer processes are important, as being able to hold goods in a middle-point before being handled in any next step is a necessity (Mulcahy and Sydow, 2008). In the receiving process there is an organizational policy called *assignment policy*, which usually relates to allocation of trucks to docks (Rouwenhorst et al., 2000). It may also relate to the allocation of staging areas or equipment that is to help the goods in the next step, which is the storage or put-away process (Goetschalckx et al., 2007).

### *Put-away*

Unless the goods are moving out from the warehouse again (Neslin et al., 2006), i.e. cross-docking, they go through a storage process. This, so that they can be put into storage locations before they can become picked to fulfill customer orders (de Koster et al., 2007). When designing a warehouse it is important to decide what *storage assignment principle* that is to be used. This concerns the withdrawal principle, for instance if the products should be picked according to FIFO or LIFO (Lumsden, 2006). Then there is the allocation of products, which can be done across a warehouse or within a storage system (Goetschalckx et al., 2007). Across warehouse storage usually refers to forward-reserve allocation, SKU department allocation or

zone allocation. The allocation of goods within a storage system (e.g. department or zone) is done according to some **storage (location) assignment policy** seen in table 3.1. If there is a system support for it, **slotting** is a popular function to put-away or re-store goods so that the pick-face is optimized and/or used storage positions have near 100% allocation rates. See Appendix B for more on these policies.

Dedicated storage policy	Random (floating) storage policy
Physical characteristics	Family grouping
Class based storage (strata)	Affinity/Correlated storage

TABLE 3.1: Storage assignment policies

### 3.2.2 Outbound

#### *Order-picking*

de Koster et al. (2007) defines the order-picking process as the process of obtaining a right amount of the right products for a set of customer orders. The usual distribution statistic in warehousing consists of around 60% order-picking, which is why most literature revolves around making this part of the flow more efficient (van den Berg and Zijm, 1999). In more detail, order-picking usually involves (Bartholdi and Hackman, 2014; de Koster et al., 2007):

1. Clustering and scheduling customer orders
2. Assigning stock on certain locations to order lines
3. Releasing orders to order pickers
4. Travel to the region of the storage location.
5. Routing according to some picking policy, local search, and pick articles
6. Sortation of picked orders into the individual customer orders
7. Passing of orders onto next step of the flow

Goetschalckx and Ashayeri (1989); Goetschalckx et al. (2007) developed an 8-dimensional model for which the complexity of order-picking systems can be decided upon (see fig. 3.4). It divides the internal factors that influence order-picking complexity into **system characteristics** and **order-picking organization**. The first is concerned about how complex the layout is and the control systems in use. The order-picking organization concerns the operational policies that decides how picking is performed. See Appendix B for more on each branch of this model.

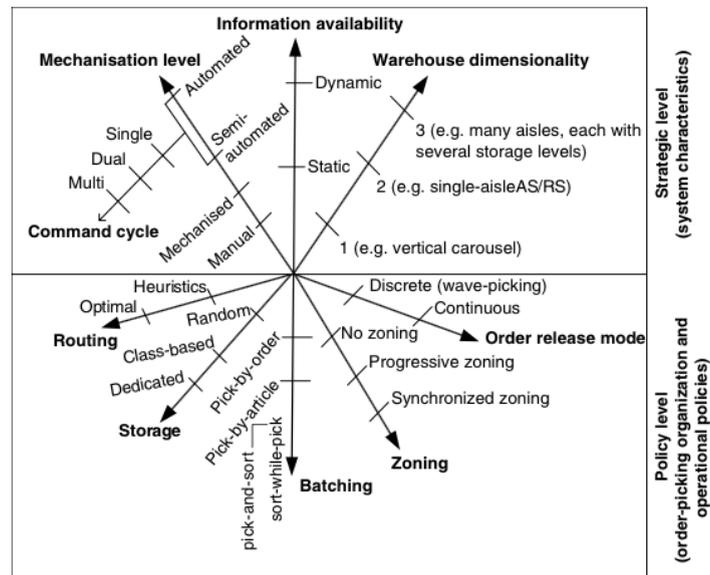


FIGURE 3.4: Complexity of order-picking systems (Goetschalckx, 2007)

### 3.3 Summary

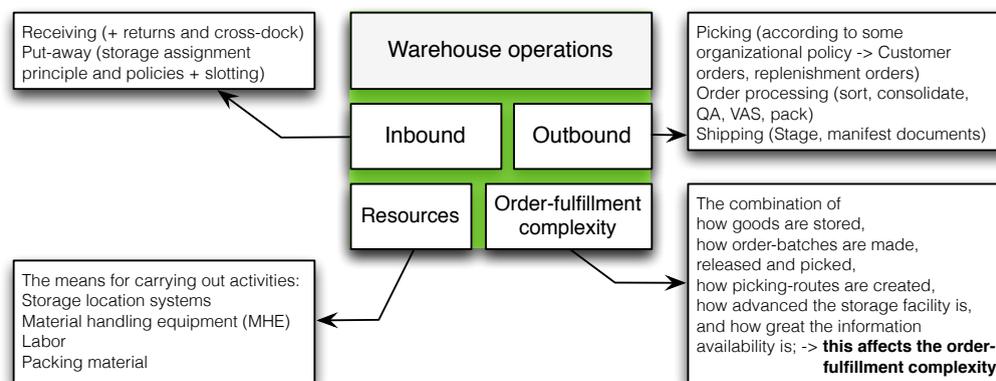


FIGURE 3.5: Important concepts of Part II - Warehouse operations

In this chapter the main inbound and outbound warehouse operations were run through. They were put into perspective in terms of both resources and concepts like warehouse management, order-fulfillment and warehouse management systems. With Goetschalckx's complexity model it is apparent that the elements of an order-picking system (the combination of how goods are stored; order-batches are made, released and picked; picking routes are created; level of complexity in storage facility; and the level of information availability), all of these affects the order-fulfillment complexity. This implicitly means that the greater the system support is, the more dynamic and capable a warehouse can be to all types of customer fulfillment demands.

## Chapter 4

# Part III - WMS

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*This chapter will address the potential benefits from utilization of a WMS and some important factors from a contemporary WMS. It will then explain what information exchanges that surrounds a WMS. Then a section is devoted to present a mapping of the different core functions of a typical WMS, their concepts and typical interaction processes.*

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### 4.1 Benefits with a WMS and important factors

#### Top 3 benefits of a WMS

**Increased inventory visibility, traceability and accuracy,** Whether the goods are entering, being transferred around, or exiting the warehouse, it is important to have accurate and timely inventory information to keep the operations on track and satisfy customers (Churcher, 2009). Increased visibility can lead to increased efficiencies in all processing activities (Partida, 2012). Through the use of license plating and real time interaction with the enterprise system with a barcode scanner, the quality of the information gets as high as it can. This allows for an unified view of inventory and traceability, so that the staff knows where things are and also where they should be/go. Furthermore, it enables tracing back to where, when and why something went wrong (Karolefski, 2009; Landy, 2009). In terms of customer service, the effects of increased visibility and accuracy are increased on-time deliveries, less expedited orders (Vjestica, 2012), and reduced reverse logistics (Partida, 2012; Richards, 2011). Having more visible inventory obviously reduces search, i.e. increased productivity, but by extension it is the foundation for having a well-stocked warehouse that will reduce capital tied up and enforce long-term efficiency (Partida, 2012).

**Improved throughput, space utilization and capacity,** By suggesting where goods best fit in the warehouse, the chance of maximizing the space utilization is greatly enhanced. Having total and updated visibility in the warehouse also helps take action that can improve space utilization ([Bartholdi and Hackman, 2014](#)). Furthermore, having the system coordinate the actions to execute, the complexity of warehousing is taken off the operators' shoulders. By allowing goods to flow more smoothly and swift through warehouse, the throughput is increased and hence warehousing capacity.

**Improved labor productivity,** By streamlining and automating warehouse processes, bottlenecks can be effectively reduced. By storing more efficiently with stratification and affinity analyses, allowing for automated information exchanges and directed tasks, reducing the number of handling steps needed in activities, getting rid of paper-based tasks, supporting running/perpetual cycle counting, having multiple order processing, productivity of all resources naturally increases ([Gill, 2007](#); [Richards, 2011](#)). Through visibility, data can also be collected for productivity monitoring and labor planning purposes.

## 4.2 Integration and interfacing with other systems

### Interfacing internally

According to [Mulcahy and Sydow \(2008\)](#), a WMS program has three major interacting information components that ultimately allows the WMS to execute product or order transactions.

**Host IT computer** - usually an ERP and it focuses on (1) external communications with suppliers and customers, (2) asset accounting so that inventory quantity matches sales figures, (3) financial data, like income and expenses, and (4) order handling, by working as a middle-hand to the WMS and customers.

**WMS program computer** - focuses on (1) inventory balance, (2) SKU data, and (3) product allocation from storage locations in order to complete orders. Information exchanged with Host computer is: (1) Pick orders or withdrawals from inventory balance, (2) Order manifests, (3) Inventory updates from receiving goods or returns, (4) Inventory quantity reorganization, inventory counts, inventory status, (5) Non-customer orders or other information affecting orders, and (6) Label creation.

**WH Computer or WCS** - Internally, the WMS can be seen as two units in terms of responsibility, where one keeps track of inventory data and one interprets it to suggest the best action to take with MHEs upon the given data. Some call this a WCS (Warehouse Control System), but in the most simple terms a WMS covers this concept entirely when seen as an execution system ([Richards, 2011](#)).

## Intercompany interfacing

For a supply chain to operate and be managed properly, its intrinsic systems need to be connected to each other. When they are separate it is vital to have them connected through some type of EDI (Electronic Data Interchange). EDI is defined as the inter-company interchange of business documents between computers. Common documents involve orders and invoices (Raney and Walter, 1992). To allow for successful communication there has to be some set of rules by which the documents can be interpreted and processed. Some of the most commonly used standards today are seen in table 4.1. EANCOM was first off in specialization against the retail industry, which later spun off to the UN/EDIFACT standard that is most commonplace today. It is rather complicated and needs people with a lot of knowledge in order to convert files into the correct format. RosettaNet is based on XML to allow for an e-business language. It has become very popular because of its structured semantics and ability to be run on any operating system. Another type of EDI is Web-EDI, which works through internet forms in browsers to collect information in a structured way (EDI Basics, 2015). It is easy to roll out and is especially advantageous when working with departments that for instance have low IT skills or works in different languages.

ANSI ASC x12	EANCOM	UN/EDIFACT	HIPAA	ODETTE
RosettaNet	SWIFT	Tradacoms	VDA	VICS

TABLE 4.1: EDI Standards

## Device and mechanics interfacing

When the systems that need to be interfaced relate to warehouse resources, it is common that it is dependent on **RF (Radio Frequency)**. This technology usually relates to handheld devices or mechanized equipment in the warehouse that transmits radio frequency signals when communicating with each other (Battini et al., 2015b). Within warehousing, picking performance has been the biggest driver of this development, but it has found applications within all major warehouse operations since the radio transmission enables real-time warehousing (Battini et al., 2015a; Vjestica, 2012). The handheld barcode scanner was one of the first adoptions, where barcodes could be placed on shelves or on the SKUs. Together with acoustic signals, these devices could also notify the user if the right item was scanned. Some devices have screens that resemble the use of a paper pick list. Some devices only tells the user what the next move is, e.g. Pick-by-voice (PBV) devices or pick-to-light systems. **Barcodes** themselves follow some set of standards, all of which have their unique applications. The common denominator is what they represent. At one hand it is the information they can contain about the content they are linked to, on the other it is the very fact that they are linked to some entity (Landy, 2009). This

is called license plating or using LPNs (License Plate Number). RFID is a mix of RF and the identification purposes that barcodes provide, and it has received greatest impact in receiving and shipping related activities (Friedman, 2009). RFID works through tags that are attached to entities in the same manner as with barcodes. Instead of having to read the information visually through scanning or visual interpretation, the RFID solutions use queries over radio frequency to accept transactions when entities are in the near proximity of each other.

### 4.3 Functions and features

As warehouse management systems have evolved, they have also extended what is considered as core and fundamental functionality (Cable, 2009). A literature review on WMS functions was mainly done through books (Bartholdi and Hackman, 2014; Manzini, 2012; Mulcahy and Sydow, 2008; Richards, 2011) and mapping of various WMS vendors, which ultimately led to figure 4.1. The vendors were chosen firstly according to the latest Gartner study on the leading WMS vendors globally, which divides the vendors in Leaders, Challengers, Visionaries, and Niche players (Klappich, 2014). From there, one suitable company from each square (except Niche players), was chosen; (1) JDA, (2) Logfire, and (3) HighJump. Next, two vendors were chosen based on their applicability in the e-commerce retailing industry and cloud-based technologies; (4) Dematic and (5) Foxfire. The following section will give a short run through of each function, what is typically included in them, and how a typical interaction process would look like.

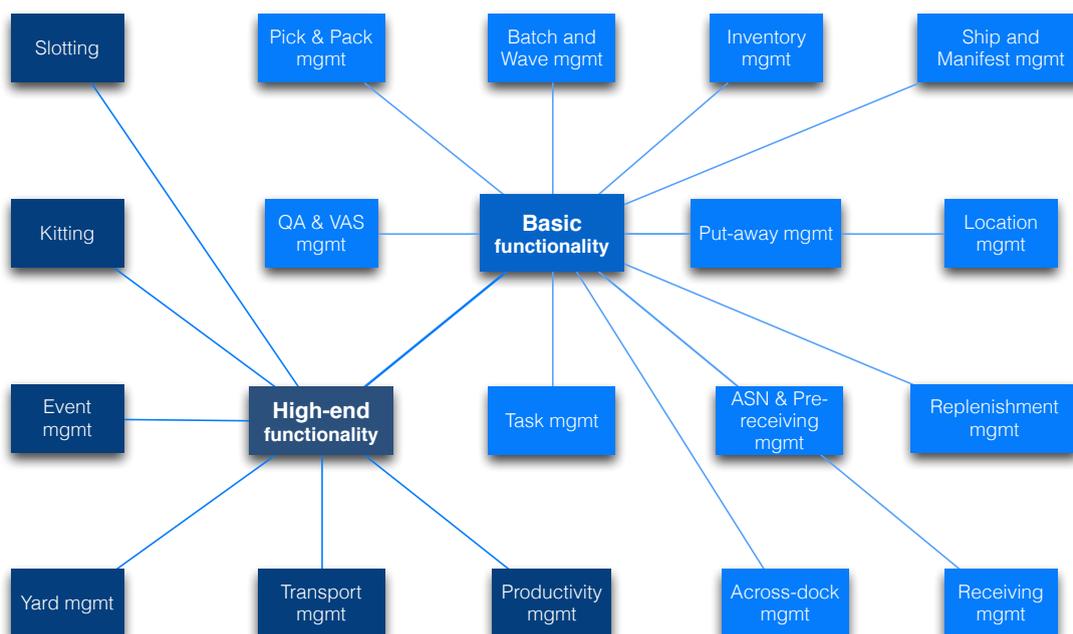


FIGURE 4.1: Mapped key functionalities in a WMS

### Inbound

#### ASN & Pre-receiving mgmt / Receiving mgmt (see fig. 4.2)

When a company wants to purchase something from a supplier, the supplier acknowledges this purchase with a (vendor delivery) purchase order (PO). With the use of ASN (Advanced Shipping Notice), a supplier can notify the one receiving the ordered goods as a pre-announcement of the shipment to come. It is also important for the receiver to know what order it is looking at when the goods are at the receiving dock. In printed form it is referred to as the tally sheet. It may contain information like what products are included in the shipment and in what quantity to be able to check what was actually sent and what was received. It may also have information like master carton quantities, pallet numbers and identification numbers. With appointment-scheduling functions, a WMS can use this information to plan ahead. More advanced functions, like yard management, can be used to efficiently coordinate trucks and dock doors.

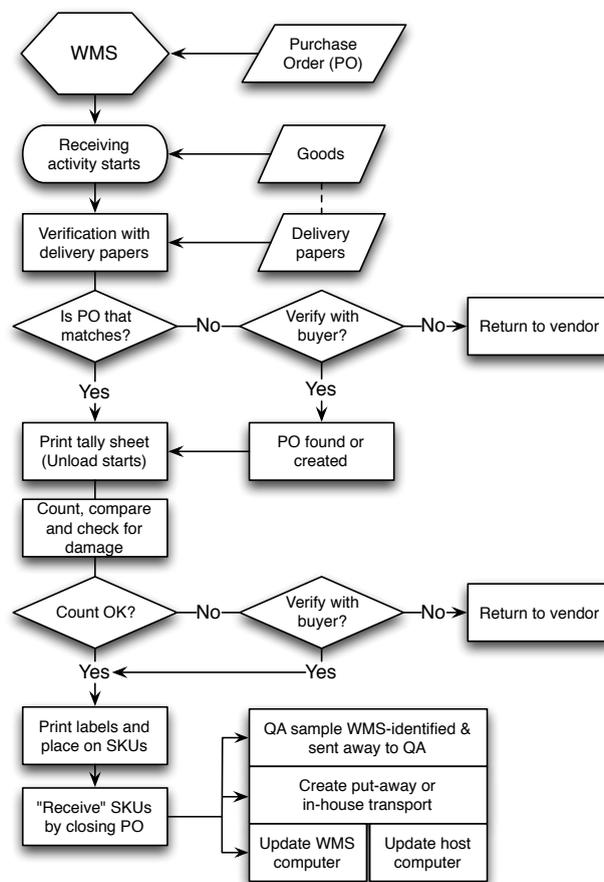


FIGURE 4.2: WMS interaction in the receiving process (based on Mulcahy, 2008)

Once the goods are unloaded, the WMS can assist with checking off the PO with scanning equipment, but only if the goods have barcodes or LPNs on them and with the right information. Otherwise, the quantity received is input manually. Value Added Services may be done in receiving to make sure the products are prepared for sales right away, be it a store-ready label or a special plastic bag wrapping. Usually a QA (Quality Assurance) process is made at this point to make sure that all the goods comply with policies, etc. This is something the WMS can help with by letting the staff go through steps in the system to assure that the intended quality parameters are fine. It may also give control over the sample and the releasing of the product for sales when the QA process is over.

In the final steps of the receiving process, the WMS may check off the order as *received*, which updates the inventory of the goods. According to predetermined rules, a WMS may assist with directing the goods to a staging area, reserve area, or maybe even to some area where it is processed for leaving the facility again, i.e. across-the-dock activities.

A little more tricky inbound flow is the reverse logistics flow, i.e. returns from customers (see fig. 4.3). This requires special handling since the item coming in need to be reinstated into the system in some way, and not always to the same status the item had when it was sold. It may be broken and overall not fit for sales again, but it still requires to be tracked in the system and have hold functions so that it is not available until it is ready. Sometimes there is a packing slip that can be scanned for easy access to the order ID. The operator then verifies the quantity and quality of the returned SKU and also acts upon the requests the customer may have. It may want the money back or swap to another product.

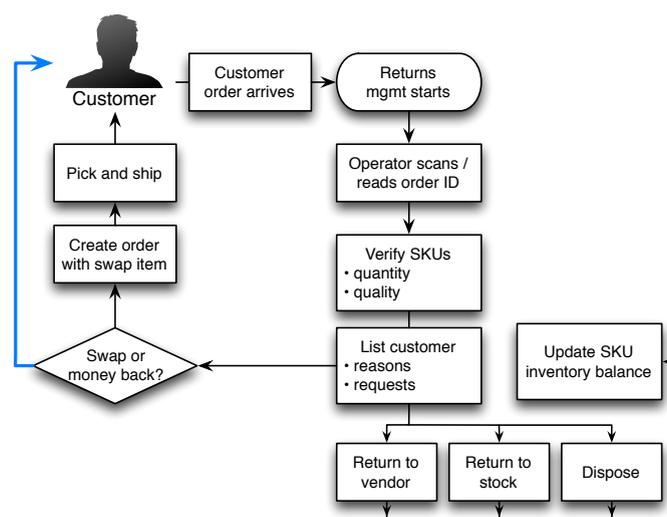


FIGURE 4.3: WMS interaction in the returns process (based on Mulcahy, 2008)

### **Across-the-dock management**

For a DC in the retailer industry, it may involve getting goods that are to be sent off to their stores by the time they arrive. This is referred to as cross-docking and flow-through processing. There is also the term put-to-store that relates to non-customer orders within the company (between warehouse and store). There is usually an order placed already by the head purchase department or a purchaser from the store recipient. Since it is usually an internal order between these units, the incoming goods have to be matched to this internal order in some way which a WMS can help with. The system may also support shipments that are mixed, e.g. one pallet has products that are requested by many stores. Then the goods are transported to some sorting concept, similar to the sorting processes in the picking process (See Pick and pack mgmt). After directed put-away by staff to stage area for exit, the system can assist through scanning and verifying that the goods are shipping off to the right location. This of course puts demand on that the company vendors meet the identification standards required (and agreed upon).

### **Put-away mgmt / Location mgmt (see fig. 4.4)**

In the similar manner that the WMS could direct goods to staging areas and back out to the shipping area, the system may assist in directing or suggesting where the products should go next and where the best lie in the warehouse storage systems. After the receiving process the goods are labelled, registered into the system, and lined up for in-house transport. When the operator arrives to put the goods away it may scan the goods to assure ownership and to update the status of the goods to *in-transit*. Not all systems require the operator to take the goods all the way to the end storage location. It may also be transferred onto a drop-point or aisle entrance for pickup by another operator or a mechanized/automated system. When the goods are placed onto their designated position, a scanning process can assure that the position and quantity placed there is updated into the WMS.

As mentioned in the previous chapter, there are a lot of factors that go into the selection of a suitable spot for a product. There are numerous philosophies as well as optimization techniques, all of which a WMS can help take into account. If the WMS is more advanced it might incorporate slotting functions as well. This takes into account the physical dimensions of the stock units and single items when trying to fit them to a storage location that is of optimal size. This kind of pick face optimization may work in two or three dimensions. While the latter is the most demanding function it is a lot more worthwhile today given the standard level of computing power. Literature on slotting mostly involves the use of heuristics from the AI domain (Artificial Intelligence), which don't always promise an optimal solution, but a feasible and search-space efficient solution. The slotting can be done continuously or as the part of a re-allocation task, which directs operators to move goods from less to *more* optimal locations.

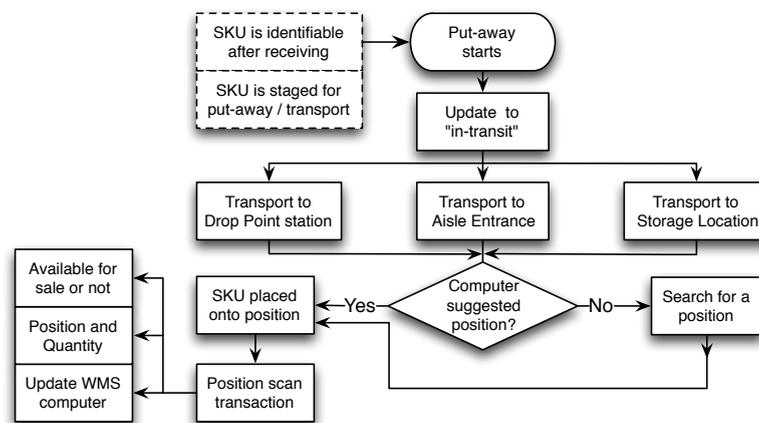


FIGURE 4.4: WMS interaction in the put-away process (based on Mulcahy, 2008)

## Task management

As an underlying function to previously mentioned function is the task management function. In a WMS this relates to the dispatch of assignments to the staff in order to achieve higher productivity. Instead of the staff having to go to the manager each time it is done with a task, new assignments can be passed via handheld devices. The tasks may take interleaving into account, so that workers do two tasks in one round. In some systems there are work order processing functions that can attach priorities to tasks so that they can be dispatched as the day go on. More advanced systems can create tasks that are distance and speed optimized, as well as create and dispatch these continuously. This requires a lot of information of the warehouse and is based on fairly advanced algorithms. These functions are sometimes collected in a system of their own, namely LMS (Labor Management System). Productivity management, i.e. monitoring, forecasting and scheduling of labor, are common functions, but they may be implemented in the WMS as well. Another advanced feature is event management, which can provide an overview of the operations and give alerts when events occur that match a certain pattern, e.g. trend breaks of demand of otherwise infrequent articles.

## Inventory management

The main idea with inventory management is to have a purchase plan that ensures that products are available when they are requested, without having too much or too little on average. This plan could be based on Just-in-Time theory, on forecasts and ultimately on EOQ theory (Economic Order Quantity) within the WMS. This function also relates to having inventory visibility functions. Furthermore, inventory management also involves cycle counting functions. The need for physical counting may vary, but the most common reason is accounting related

counts of inventory. In that case the entire inventory is counted. Sometimes there is a suspicion that a product has discrepancies in the balance count, of which a count for that specific product is then carried out. Modern WMS softwares support perpetual cycle counting, which is to allow for counting when stock units of an article run out. When it is run out it is an opportunity to check the count, since either the balance says there are zero left or more/less than zero.

In regards to the visibility functionality, inventory management in WMS software involves features like lot serial control, status/hold assignment, and the ability to tie stock units to barcodes and LPNs. Lot serial control is important where the products are characterized of a legal incentive to keep track of when things arrived and how long they have been lying in the warehouse.

## **Outbound**

### **Batch and wave management**

This core functionality apply to the generation of collections of orders that become tasks to one or many operators. When orders arrive into the system from the host system or external order platform they need to be dispatched as tasks according to some rules. The system can handle priorities or query-based aggregation of sets of orders that are suitable to be picked sequentially (waving) or in collections (batches). If the warehouse is a DC that distributes to a lot of different regions they may have trucks coming in periodically during the day and that are later dispatched to destined regions. Then it makes sense to also pick the customer orders in batch groups that have destinations in common. Other criteria are carrier restrictions, SKU characteristics, the storage principle used (e.g. FIFO), type of orders, and pick types/methods. There are a lot of strategies in batching, which a WMS enables through grouping/aggregating/clustering of orders according to desired criteria. More advanced WMS softwares enable automatic creation or suggestions of batches, where a consideration to total distance and speed puts the greatest demand of the solution.

### **Replenishment management (see fig. 4.5)**

Replenishment theory can be quite lengthy, but it is mostly because it can be done in so many ways and for so many different purposes. The most basic feature of replenishment setups is that an item has a dedicated position of the fast-pick area. Either the positions are based on assigning the same amount of space to all SKUs or they get a volume that is based on how often they are picked. In basic systems these levels are set and calculated manually, but it's possible to have calculations with both trivial and advanced algorithms provided by the system.

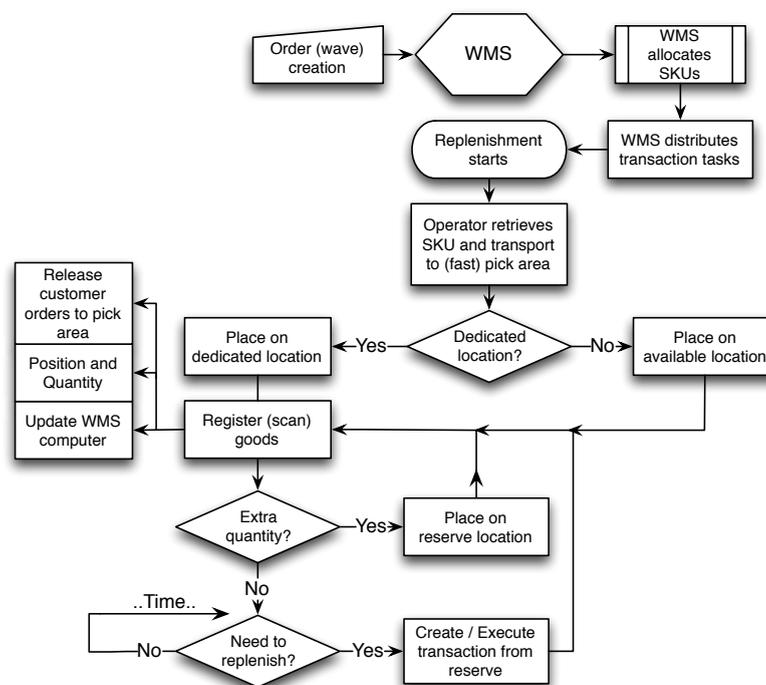


FIGURE 4.5: WMS interaction in the replenishment process (based on Mulcahy, 2008)

The system may also be anticipative, so that it looks ahead in the batches or waves that are to be or have been dispatched. If the amount to be picked exceeds the item available in these order collections, replenishment tasks can be dispatched in advance. This is usually done through a replenishment wave order that is distributed to operators. When carried out they transfer the items to the pick area and stores as much as they can on the pick location. The rest is put somewhere else but nearby as a local buffer, for instance on a shelf location above the designated pick area. The quantity is registered into the system, which releases the article for pick to orders. When the quantity exceeds zero or some defined level, a replenishment task is dispatched automatically. In more advanced systems and where the products picked differ a lot over time, it is common that the system allows random storage locations in the FPA. The product offering changes in front of the operators because new items are replenished to the pick area all the time. This kind of methods are often related to PBV and pick-to-light systems.

### Pick and pack management (see fig. 4.6)

Picking of orders have very different methods depending on equipment used, automation level, batching/waving strategy and what unit structure it concerns. Usually an operator or manager creates an order wave and/or batches, which is then released in the system and allocates the SKUs to be picked. If there are needs for replenishment this can be done in advance (see Replenishment mgmt). The WMS can help with directing the operators through RF devices to

pick according to some route that includes reserve area and/or pick areas, while minimizing the total distance travelled and traversed. The routing function is usually based on various index arrays, where the storage locations are ordered in a long list for each rack and aisle. According to [Bartholdi and Hackman \(2014\)](#) there is no WMS today that manages an explicit geometric model of the warehouse layout for true routing optimization, which also seems to be the case for the screened vendors.

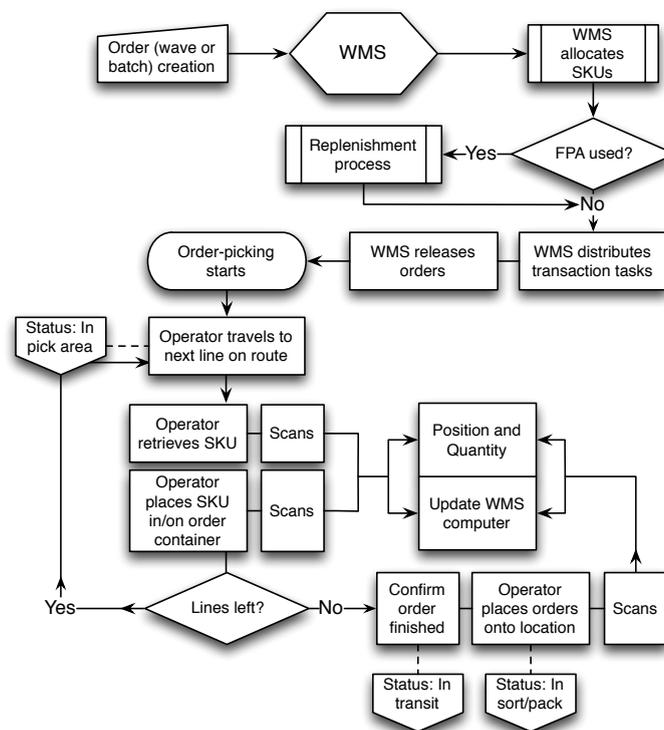


FIGURE 4.6: WMS interaction in the order-picking process (based on Mulcahy, 2008)

The scanning process can be used to make sure that the right item is picked and that it has been handled correctly in the next step. The WMS may suggest appropriate actions, such as the order-tote to put the items in, or the actions to take to sort or consolidate the goods picked so far (sort-while-pick). It all depends on the work image decided upon. The system may assist in tying stock units to order-totes on trays and also in putting statuses on the batch and its orders. This enables traceability since the progress of orders can be monitored.

When there is a need for sorting and consolidation after a pick there might be a put-to-light system or paper-based sorting (see fig. 4.7). Along with an order is usually a pack slip that can be used as this paper “pick-list” to fill each order with the items requested. Each order gets a compartment on a shelf that the items are put in. If it is a put-to-light system, the operator scans an arbitrary item and the system will highlight the compartment that needs that item.

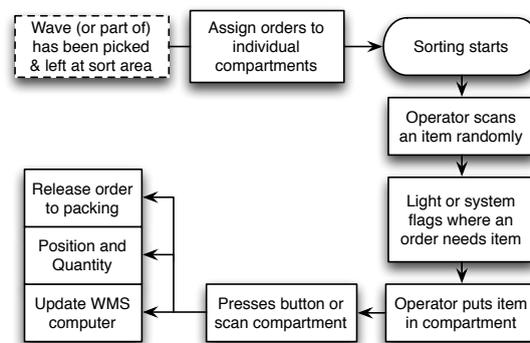


FIGURE 4.7: WMS interaction in the sorting process (based on Mulcahy, 2008)

Kitting is a function that is available in more advanced solutions. It enables the collection of units for building or assembling a product within the warehouse. This can be done in a *push* or *pull* manner, where the units are sometimes assembled to stock to accommodate future demand, or to order to accommodate current demand. It puts demand of the system in terms of item structures, since it needs to keep track of all the individual sub-items of one sellable product.

Lastly, there are some vendors that support in-store/darkstore picking and processing of e-commerce orders. Picking can not always work in the same way in the store as in a warehouse, where the staff is completely designated to warehousing tasks. It's highly desirable to be able to pick products in the store in an efficient way while not obstructing everyday store tasks.

## QA and VAS

Quality Assurance and Value Added Services are part of a term that is usually referred to as order preparation (see sec. B for similar explanation). Some see packing as part of the picking management process, but it's common that it relates here as well since they often occur in the same functional area of the warehouse. Once the orders have been picked, they might need to be sorted and consolidated, then packed and perhaps with a certain value adding sequence, and ultimately labelled for shipping. The QA process is usually a check activity between the items in the customer-order tote or box and the quantity listed on the packing slip. Packing procedures may also be put into the management system to help the operators pack efficiently and according to some value adding policy. System support also here applies to price tags and shipping labels.

## Shipping and manifest management

WMS softwares may support several activities in the shipping area as well. Manifest management relates to the document management in packing, but it more commonly fall under the shipping activity for the vendors studied. The most beneficial WMS feature in this process is staging and loading of goods with the help of RF devices. The WMS can direct the operators to sub-areas in the shipping area and make sure that the goods are set up in a sequence to match the outbound sequence. Ship confirmation can be done through RFID as well, so that when the goods pass the dock door, the ERP and the customer can be notified. More advanced solutions have a transport management functionality, which may take responsibility of coordinating and dispatching of goods for least travelled distance to the customers. This is sometimes handled through a system of its own called TMS (Transport Management System).

## 4.4 Summary

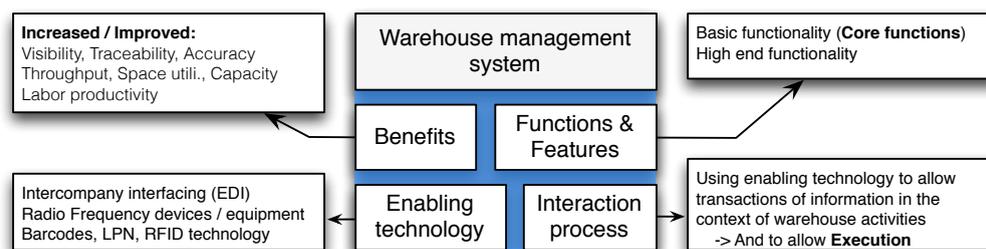


FIGURE 4.8: Important concepts of Part III - WMS

In this chapter the main benefits from the utilization of a WMS were presented, as well as the technology that enables these benefits to be realized. A solid introduction to the main core functionalities and some common features was made. It included detailed interaction processes for some of the core functionalities. This put the utilization of enabling technology and various resources in the context of warehouse activities, as well as data transactions of inventory and order information. With real-time collection of data the WMS may also execute processes in real-time, which emphasizes the *Execution* in W.M.S. as a supply chain execution software. Paramount to this collection of data is the equipment by which you gather it. However, of even greater importance is at what points you collect data, and also what it can tell you about what action that is needed to be taken to the object(s) that the data originates from or relates to. This does not just relate to the significance of knowing where things are in the supply chain, but also to understand the states that these are in so that one can deduce the actions that are needed to be taken upon object(s) to lead them onwards correctly.

# Chapter 5

## Methodology

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*This chapter will start with motivating the research paradigm, theoretical “lens”, approach and strategy chosen to fulfill the overall purpose stated in the previous chapter. Furthermore it will explicitly outline and motivate the design of the study, where the underlying theoretical framework and the conducting of the case study will be discussed. A presentation of the analysis framework will be made, so as to provide a pedagogical discussion to the reader on how the data will be analyzed. The chapter will end with bringing up critics around the quality of the study.*

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### 5.1 Introduction

Research methodology refers to a model for undertaking a research process in the context of a particular research paradigm so as to build theory (Saunders et al., 2009; Wahyuni, 2012). The first step of the process concerns the research philosophy, which refers to different philosophical paradigms and are important assumptions about the way to view the world (Saunders et al., 2009; Wahyuni, 2012). Hevner and Chatterjee (2010) defines a research paradigm as “..the set of activities that a research community considers appropriate to the production of knowledge in its research methods or techniques”. This makes it important to know where the discipline(s) involved may belong in a paradigmatic sense. The philosophy adopted in a research study will be influenced by physical considerations, like the purpose of the study, but the main influence will be the perceived relationship between knowledge and the way this is developed through research (Saunders et al., 2009). Furthermore, Creswell (2013) promotes the use of a theoretical “lens” in combination of the paradigm chosen, which may further guide the creation of knowledge within the research community and context.

It's apparent that one discipline employed in this thesis belong in the logistics research community. Mainly since logistics research is concerned with how all functions and activities in a logistics channel intersects with other elements and activities, as well as how they are managed (Lindskog, 2012). Another discipline employed belongs in the Information Systems (IS) research community. It is a unique discipline and it is mainly concerned with examining how IT intersects with human systems and organizations, as well as how they are managed (Hevner and Chatterjee, 2010). Seen in figure 5.1 are some of the main traits from philosophical paradigms and theoretical lenses in regards to the logistics and information systems (IS) disciplines (Gammelgaard, 2004; Hevner and Chatterjee, 2010; Kovács and Spens, 2007; Lindskog, 2012; Mentzer and Kahn, 1995; Saunders et al., 2009; Smith, 2006; Vaishnavi and Kuechler, 2004, 2015; Wahyuni, 2012). Together with the purpose and research questions of the thesis, this will guide the choice of theoretical lenses and philosophical view on theory building.

## 5.2 Research paradigms in logistics and IS

### Positivism

The main argument behind positivism is that the social world exists externally to the researcher, and that it's possible to discover, explain and measure causal relationships through objective and value-free observation (Saunders et al., 2009). The positivistic researcher will apply objective empirical studies in order to reach hypotheses and then finds the characteristics of the studied object, which should have been observed in similar cases and in theory (Gray, 2009)

### Interpretivism

Interpretivist researchers have the belief that social reality is constructed by social actors and the perceptions that these actors have of this reality. Since these perceptions are subjective, there is a possibility that this social reality changes or has multiple perspectives (Wahyuni, 2012). Since the view of that reality might change, interpretivists believe that there are no absolute truths and therefore no possibility to developed generalized laws. Instead the aim and focus is on understanding what should be appreciated for being interesting (Goldkuhl, 2012).

### Realism

Realism relates to scientific inquiry for knowledge, and to a general view that entities exist independently of what is being perceived. Furthermore they exist independently of any theories we may have about these entities (Maxwell, 2012). This also relates to allowing more than

<b>Theoretical lens</b>	Behavioral science	<b>Design science</b>		IS discipline
	Analytical approach	<b>Systems approach</b>		Logistics discipline
<b>Paradigm</b>	<b>Positivism</b>	<b>Realism</b>		<b>Interpretivism</b>
<b>Ontology</b> <i>View on nature of reality</i>	Objective, external A single reality Whole = sum of parts Knowable, probalistic Independent of social actors	Objectively accessible Multiple realities Whole ≠ sum of parts		Subjective Multiple realities Socially constructed Whole is only structures of meaning
		<b>(Realist) ::</b> Exists independently of knowledge of their existence World unchanging	<b>(Critical realist) ::</b> World always changing Interpreted through social conditioning	
<b>Epistemology</b> <i>View on acceptable knowledge</i>	Detached observer of truth, Only observable phenomena can provide credible data and facts. Focus on causality and law-like generalizations	Implicitly pragmatist Knowing through making Focus on explaining within a context Objectively constrained construction		Subjective meanings and social phenomena, Knowledge emerge from researcher-participant interaction
		<b>(Realist) ::</b> Can reach predictive power by studying observable empirical phenomena, Entities exist independently of investigation, Insufficient data means inaccuracies in sensations	<b>(Critical realist) ::</b> Underlying mechanisms cause observable phenomena, Can only be identified through practical and theoretical work of social sciences	
<b>Axiology</b> <i>View on values</i>	Value-free and etic, independent of data	Value-laden and etic, biased by world views		Value-bond and emic, not separated of data
<b>Methodology</b> <i>Preferred method behind process</i>	Observation Quantitative Statistical	Developmental Qualitative and/or Quantitative. Evaluate/Measure <b>utility</b> or artifactual impact on system		Participation Qualitative Grounded
<b>Empirical focus</b>	Truth: universal & beautiful, prediction generalized law	Control, Creation, Problem-solving, Improvement, Understanding, Design knowledge Holistic system knowledge		Understanding: Situated and description
<b>Type of knowledge</b>	Explanation	Constructive		Understanding
<b>Role of knowledge</b>	Truth Predictive capability	Pragmatic value Solves problems		Interesting
<b>Data analysis</b>	Description, hypothesis testing	Mapping, Modelling, Design of artifact		Interpretation
<b>Purpose from paradigm</b>	Determining cause-effect relations Reduce phenomena to simplest terms	Understand reason for phenomena as precursor to change		Understanding, sense-making, Contextual knowledge
	Arrive at universal principles	Arrive at theoretical propositions and/or application/invention		Manifesting varieties

FIGURE 5.1: Contents on some of the paradigms and theoretical lenses employed in logistics and IS research

one scientifically correct way of portraying and understanding reality (Maxwell, 2012), since values and facts are hard to disentangle because of the way they are intertwined (Hevner and Chatterjee, 2010). Scientific realism is usually the umbrella term for other tenets of philosophical realist paradigms (Hevner and Chatterjee, 2010), where critical realism is one of the most prominent tenets of realism within social sciences (Maxwell, 2012).

The main difference lies on the views on change. A critical realist believes that one can only understand and ultimately change some social world by identifying the inherent structures of that world, which in turn generates events and discourses as part of a natural order (Hevner and Chatterjee, 2010). A critical realist further believes that these structures are not spontaneously apparent, but can only be identified through practical and theoretical work (ibid). This entails either qualitative or quantitative methods (Wahyuni, 2012). A realist researcher is implicitly a pragmatist because the knowledge form is constructive (Goldkuhl, 2012), which is usually associated with (1) prescriptive (to give guidelines), (2) normative (to exhibit values), and (3) prospective knowledge (to suggest possibilities) (ibid).

### **Philosophical view employed**

Engineers, architects, and computer scientists are some of the most common schools that apply problem-solving paradigms, e.g. to work with technology, understand salient issues and constructing or improving some artifact (Hevner and Chatterjee, 2010; Höst et al., 2006). In regards to logistics, Saunders et al. (2009) argues that a critical realist stance is more in line with business and management research, since the purpose with these is often to understand reason(s) for phenomena as an antecedent to giving recommendations to change. This has been the case within the IS research community as well and have received more attention the last decade in relation to critical realism (Hevner and Chatterjee, 2010; Vaishnavi and Kuechler, 2004). Since the authors aim to understand the systems made up around omni-channel order-fulfillment and the issues related to information system support, and then use that as a precursor to improvement (suggest how this could be achieved) - this strongly suggests that a critical realist stance should be held for this study. The next sections will give insight into the theoretical lenses in the logistics and IS disciplines.

### **Theoretical lenses in the logistics discipline**

Theory and knowledge building in logistics research has mainly been done in relation to two theoretical lenses, *analytical approach* and *systems approach*, but recently *actors approach*, has been discussed as a strong and needed complement (Gammelgaard, 2004; Naslund, 2002). The *analytical approach* is based on positivistic traditions and seek explanations and to uncover causal relations/patterns, while the *actors approach* is based on sociological meta-theories and

draws its foundations from interpretivism. The *systems approach* (see fig. 5.2), however, is pragmatic in nature and seeks to understand and improve a logistics system in practice, underpinning its base in problem-solving (Gammelgaard, 2004). Kovács and Spens (2007) connects this lens with scientific realism, where the empirical focus has been on acquiring knowledge about concrete systems through mapping and modelling. In turn this helps with coming up with contextual recommendations to the elements, processes, structures or components that are to be handled in logistics management (ibid). This theoretical lens fits this thesis rather well, since the authors recognize mapping of the study object's supply chains and processes as a key to find the issues and opportunities in regards to information system support.

### **Theoretical lenses in the IS discipline**

In regards to IS research there has also been two favored theoretical lenses; behavioral science research and design science research (Hevner and Chatterjee, 2010). Within behavioral science research one usually seeks to find the truth through hypothesis proving/disproving. However, it is also common with interpretivist studies. The second, design science research (see fig. 5.2), is fundamentally a problem-solving paradigm, by which the end result is the production and evaluation of an artifact. The term artifact relates to an artificial thing that is constructed by humans, and can take the form of (1) *constructs*, the conceptual vocabulary or symbols of a problem/solution domain, (2) *methods*, the algorithms, practices or guidelines on how a task should be performed, (3) *models*, the abstractions and representations on how something should be, and (4) *instantiations*, the implemented and prototype systems (Hevner and Chatterjee, 2010; Vaishnavi and Kuechler, 2004). The underlying philosophy is critical realism (ibid), as IS design science research is not about attempting to develop concrete IT applications, but to develop meta-artifacts that are to help the concrete IT applications. This further motivates the use of a critical realist stance in this thesis as well as applying design science research. Mostly since the authors do not wish to include an entirely specified solution concept, nor do they wish to produce the actual artifact designed. Instead their aim is to prescriptively specify statements on how the warehouse management system can accomplish supporting necessary functions for omni-channel retailers.

	How all functions and activities in a logistics channel intersects with other elements and activities, and how they are managed	How IT intersects with organizations and human activity systems, and how they are technologically enabled
<b>Research discipline</b>	Logistics discipline	IS discipline
<b>Characteristics from lens</b>	Systems approach	Design science
<b>Goal from lens</b>	<b>Problem solving</b>	<b>Problem solving</b>
<b>Purpose from lens</b>	Seeks to understand a given part of the world, identify system parts, determine how the syst. should function	Seeks to develop practical knowledge for the design and realization of IS initiatives
<b>Outcome from lens</b>	Proposes situated organizational improvement and how the real-world system is to achieve	Proposes design theory or artifact shown to have utility and that satisfies given sets of functional requirements
<b>Theory type</b>	Models, recommendations, normative aspects, Knowledge about concrete systems	Design and action Says how to do something, gives explicit prescriptions for constructing an artifact

FIGURE 5.2: Theoretical approaches in logistics and IS research from the paradigm of realism

### 5.3 Research approach

The authors recognize that the word *approach* is used ambiguously, as it takes part in the names of all of the theoretical lenses from the logistics discipline. *Research approach* relates to the philosophical methods of reasoning (Saunders et al., 2009). Kovács and Spens (2007) presents a framework of research approaches and their application for building of theory within different research paradigms. There is the *deductive approach* which tests logically derived hypotheses in an empirical setting. This is mainly connected to positivism but also scientific realism. The opposite, *inductive approach*, uses empirical observations and arrive at emerging propositions on anything from subjective varieties (interpretivism) to relative generalizations (scientific realism). The abductive approach is similar to the inductive approach in its way to arrive at theoretical generalizations, but also includes a deductive phase through the actual application and/or testing of these hypotheses. The authors' ambition is to use systems modeling to inductively arrive at functional requirements for a WMS, that are to create some situated organizational improvement. Then the aim is to inductively map these requirements to theoretical propositions - described as design theories that a proposed system should accommodate, and presented in

terms of how they can solve and achieve the identified requirements. As the theories are not applied or tested this motivates further an inductive approach to theory building.

## 5.4 Research strategy

According to Yin (2003), choosing a suitable research strategy is the first step in deciding which set of methods to utilize in the collection and analysis of data in a research study. The most common research strategies are seen in table 5.1: experiment, survey, archival analysis, history and case study (ibid). Experimental research strategies focus on manipulating the behavior of phenomena directly and systematically. Archival analysis and historical strategy focus mainly on contributing to past events where a phenomena is no longer accessible and facts or physical artifacts are all that remains. A survey is usually used when large amounts of data are to be collected from a sizable population, which puts constraints on the depth of the study conducted since there will have to be restrictions on the number and complexity of survey questions (Saunders et al., 2009). The case study strategy facilitates more in-depth investigation of a contemporary phenomenon that can be observed in its natural context (Yin, 2003). A case study strategy usually uses multiple methods for data collection from a number of entities, but without any real control or manipulation of the phenomena (Meredith, 1998). Höst et al. (2006) states that the strategy should be chosen based on the type of research and goals with the study to be conducted. Further, Yin (2003) argues on three main factors affecting this choice: (1) the type and formulation of the research question, (2) the level of control required over the phenomena, and (3) the researcher’s access to contemporary or historical events.

Strategy	Form of research question	Requires control of behavioral events?	Focus on contemporary events?
<i>Experiment</i>	how, why?	Yes	Yes
<i>Survey</i>	who, what, where, how many, how much?	No	Yes
<i>Archival analysis</i>	who, what, where, how many, how much?	No	Yes/No
<i>History</i>	how, why?	No	No
<i>Case study</i>	how, why?	No	Yes

TABLE 5.1: Situations for different research strategies (Yin, 2003)

The research questions of this study are focused on first getting to “what” the issues and opportunities are, and then get to the “how” this can be solved. The first question is theory-based and sense-making, and the second is a design-based, problem solving question. Both of which represents two very critical classes of research questions within management disciplines (Hevner

and Chatterjee, 2010). The questions will be answered by in-depth observations of the phenomena in its contemporary and natural setting, without any need for controlling the behavioral events studied. Based on these factors a case study strategy was chosen. Gammelgaard (2004) strengthens this proposal by advocating case studies as the ideal method in systems analysis. Furthermore, case study is the primary and most common research design in IS (Johari, 2009).

## 5.5 Research design

### Units of analysis

Having to establish a unit of analysis stems from the the issue of defining what the actual *case* is. Without any proper proportions of what the study will include the researcher might feel the obligation to cover everything (Yin, 2003). A unit of analysis could be contained within the study of a specific individual but it might also be expanded into covering implementation programs or organizational change (ibid).

For this thesis the units of analysis will be the warehouse operations for the retailers chosen for the case studies. This is established in accordance with the purpose and the research questions, since the mapping and analysis of warehouse operations will help identify the functional requirements of a WMS used by omni-channel retailers. This may ultimately lead to conceptualizing design theories that will allow the realization of these requirements.

### Case study design

One of the most fundamental issues in the design of the case study strategy is the decision whether to include a single or multiple cases in the study (Wahyuni, 2012). Ellram (1996); Yin (2003) argues that the single case study method is suitable if that specific case represents a critical case when it comes to testing a well-formulated theory, of which one single case in particular might be best suited to meet all of the specified conditions to test the theory. Further, a single case study would be suitable if it represented some extreme/unique aspect of the phenomena (ibid). A limitation with the single case study is that it limits the generalizability of the conclusions, theories, and models developed in the study (Voss et al., 2002).

A study may contain more than one case, i.e. a multiple-case study is conducted. A case study research should ideally use this type of design and methods involving multi-site studies and multiple methods of data analysis (Wahyuni, 2012). The rationale behind the use of multiple-case study is enabling comparison among observed practices in relation to the subjects studied. The main purpose is to reach a more extensive apprehension of these practices (ibid), while either

predicting similar results among the subjects (literal replication) or find contrasting results that are to be expected (theoretical replication) (Ellram, 1996). Using this logic, cases selected that confirms emergent relationship will enhance the confidence in the relationship (Voss et al., 2002).

Yin (2003) presented the method shown in fig. 5.3 for conducting multiple-case studies along with using theoretical replication. Yin (2003) states that a multiple-case study has quite distinct advantages and disadvantages when placed in comparison with a single case study. The findings and the evidence gathered from a successful multiple case study is often regarded as more compelling, which leads to the entire study being considered as more robust (Herriott and Firestone, 1983; Yin, 2003). The contents of the cases are likely to differ in some way or to some extent. If the same conclusions can be drawn under these varying circumstances, the external generalizability of the finding will have been greatly expanded in comparison to using a single case. Multiple cases may however lessen the depth of the study but can augment validity and reduce observer bias (Voss et al., 2002).

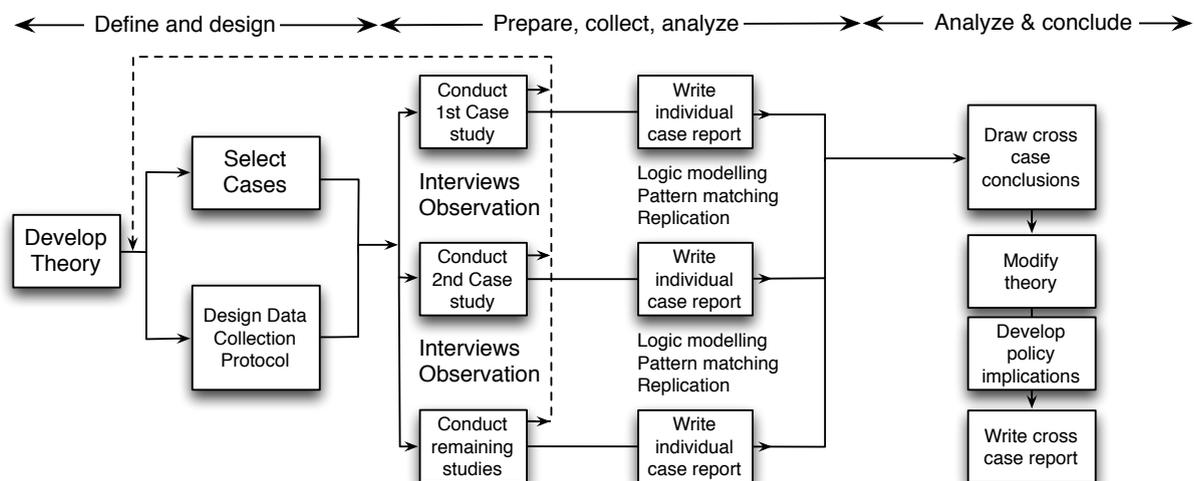


FIGURE 5.3: Method for multiple-case studies, as proposed by Yin (2003)

### Chosen case study design

The aim of this study is to investigate the implications on a WMS used by companies that operates in an omni-channel environment. This will require establishing similar patterns of underlying meta-requirements in warehouse operations for actors that are, or strive to be, active in an environment like this. The theory base established also suggests that the warehouse operations and the order fulfillment strategies may vary greatly between different retailers working in the e-commerce and multi-channel sector. These variations will have a significant impact on the requirements and demands on the development of a WMS. It was concluded that this thesis

would highly benefit from integrating a multiple case study design using a theoretical replication. This will facilitate the exposure of the diversity among processes but also the similarities in meta-requirements between the different warehouse operations. This will be cross-analyzed, after which the aim is to use this knowledge to develop theoretical propositions, i.e. design theories, on how these meta-requirements are to be achieved by a proposed WMS.

## 5.6 Develop theory

Developing a theoretical framework is seen as one of the most important steps in case research (Voss et al., 2002; Yin, 2003). The theoretical framework is the main conveyance to generalizing the results from the research study (Yin, 2003). The idea with the theoretical framework in qualitative research is to provide an explanation of the main things to be studied in either narrative or graphical form (Voss et al., 2002). Voss et al. (2002) also suggests that by extension, the construction of the framework forces careful thoughts about what to include in the study.

The theoretical framework in this thesis is founded on the main contents of warehouse operation theory, warehouse management system theory and omni-channel theory. The contents of the theoretical framework was mainly found in published books, scientific journals and articles subjected to peer reviews. EBSCOhost was used as a search engine and keywords such as *omni-channel*, *order-fulfillment*, *multi-channel integration*, *WMS*, *cloud-based*, *SaaS*, and *warehouse management/operations* were frequently used. Keywords such as these tied the evolution of the retailing environment together with warehouse operations and WMS.

Literature on warehouse operations has been around for many years, while literature on omni-channel retailing is a fairly new concept and a buzzword. Since buzzwords have a scientifically capricious way of evolving (Mjos et al., 2014), its meaning tend to differ. The authors experienced the subject to be discussed mainly in the views of the customers instead of the businesses carrying out the services it involves. With WMS, there was not an abundance of studies that conveyed the sought information. This is mainly because the interesting parts of such systems are hidden with the vendors that produce these, as mentioned in the introductory chapter. Therefore the authors decided to allow the WMS part in the theory to have more online sources, in order to cover what functions a typical WMS has. The authors have also resided in books on WMS softwares, since they are usually more in-depth than scientific articles.

## 5.7 Time horizon

It is of significant importance to decide on the time horizon of the study. The cases could either be *longitudinal* or *cross-sectional* according to (Saunders et al., 2009). Longitudinal cases

investigates how events develop over time. The same case(s) are studied at two or more points in time and the theory of interest might specify how conditions change over time (Yin, 2003), i.e. study cause and effect during a prolonged time period (Voss et al., 2002). Cross-sectional refers to a specific study of a phenomena at a specific time. This is more commonly utilized because the majority of research projects are under time constraint (Saunders et al., 2009). This thesis will apply an cross-sectional study since the thesis is subjected to time constraint and its findings is to represent a contemporary phenomena.

## 5.8 Case selection

A vital question for the design of the multiple case study will be the case selection or sampling of the cases to include in the study (Voss et al., 2002). Patton (1990) stresses the importance of selecting information rich cases whose study will illuminate the questions of the research. According to the replication logic, cases should be selected to either replicate previous cases, extend emergent theory, fulfill a preset theoretical category, or provide examples of polar types (Eisenhardt, 1989). Voss et al. (2002) stated that fewer cases could increase the depth of the study and the researchers decided that four case subjects would be optimal. This decision was based on the resources, time available to complete the study and the decision that four in-depth cases would implicate sufficient replications for an adequate level of certainty and generalizability for the findings. When given a limited number of cases to investigate it would make sense to select cases that can represent contrasting situations and polar types, in which the differences in the phenomena studied will be highlighted and apparent (Eisenhardt, 1989; Voss et al., 2002). It is also important to establish the factors and parameters that define the population of interest, which should be held constant across the selection procedure (Voss et al., 2002). Patton (1990) states that criterion sampling, in which cases are selected based on a predetermined criteria of importance, is an effective way of assuring the quality of the cases. Wood (1995) suggests a number of criteria that can be applied and used as a test of relevance (see fig. 5.4). Two criteria for the cases to be included in the study were selected (same figure).

*Active as an e-commerce retailer* was a fundamental criteria since having an online channel operational is a vital prerequisite for implementation of any type of omni-channel approach. The next criteria was for the retailer to actually *be actively working with or towards omni-channel order fulfillment capabilities*, since solely being an e-commerce retailer is not sufficient for the purpose of this study. Cases in different stages of an omni-channel transformation was selected to capture multiple aspects of the phenomena targeted for research. An omni-channel approach requires multiple channels of sale so the criteria entailed every case selected to have a minimum of one brick-and-mortar store as well as their e-commerce channel. A subsequent dimension chosen as a deciding factor was the size of the company. A larger company will have

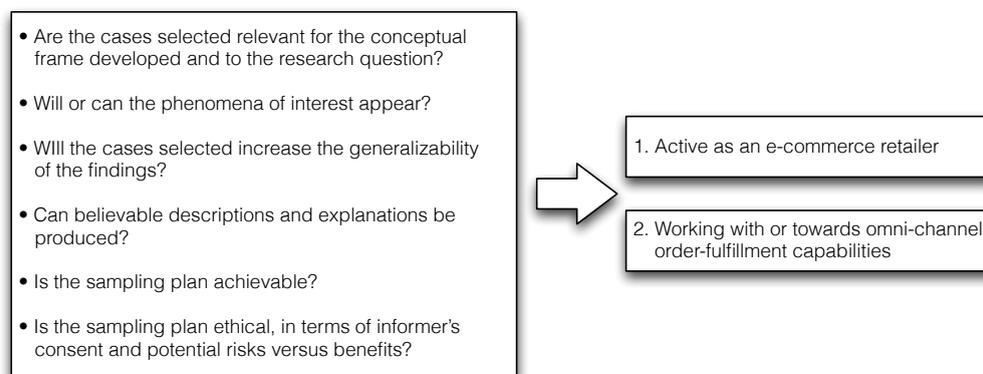


FIGURE 5.4: The criteria established for selecting study objects to include

a different set of requirements for their warehouse operations compared to a smaller retailer. The second dimension was the selection of products that the retailer offered for sale. Retailing consists of a wide variety of different types of products with widely differing characteristics. These differences could consist of variations in size, volume, stackability or frailty (e.g. garments on hangers (GOH) or skateboards).

A summary of the four cases selected with regards to the established selection criteria is presented in table 5.2. The cases selected consist of a majority of fashion and apparel retailers. This was done due to the vital part omni-channel capabilities play for retailers of fashion and clothing merchandise. The researchers do recognize the fact that there are numerous other types of goods sold which might have special handling or storing requirements. But the need to cover and isolate the fundamental requirements of the warehousing processes for merchandise in general in an omni-channel environment, obstructs the authors from covering every requirement of every type of merchandise in detail. They argue that the same basic principles apply to all types of merchandise and goods.

Size of company is defined as following. A yearly revenue over 600 MSEK constitutes a large size retailing company, between 100 and 600 MSEK is considered medium and below 100 MSEK constitutes small. Omni-channel capabilities are defined as high if it involves full channel integration and the complete adaption to an omni-channel environment. Medium is defined as the development of some fundamental increases in order-fulfilment capabilities and channel integration. This could involve online orders pick-up and returns in a store. Low constitutes retailers with only minor omni-channel adaption but with a focus on developing further capacities.

Company	Company A	Company B	Company C	Company D
<b>Company size</b> S:0-100, M:100-600, L:600-	Large	Medium	Small	Small
<b>Product characteristics</b>	<ul style="list-style-type: none"> <li>• Baby fashion</li> <li>• Bulky trolleys</li> <li>• GOH</li> </ul>	<ul style="list-style-type: none"> <li>• Fashion cloth</li> <li>• Various brands</li> <li>• GOH</li> </ul>	<ul style="list-style-type: none"> <li>• Streetwear</li> <li>• Boards / Bulky</li> <li>• GOH</li> </ul>	<ul style="list-style-type: none"> <li>• Skincare prod.</li> <li>• Small items</li> <li>• VAS</li> </ul>
<b>Price segment</b>	Upper/mid	Premium	Mid/premium	Upper/mid
<b>Markets</b>	Europe	Sweden	Global	Europe
<b>Distribution channels</b>	<ul style="list-style-type: none"> <li>• E-commerce</li> <li>• Flagship store</li> </ul>	<ul style="list-style-type: none"> <li>• E-commerce</li> <li>• Stores 2 in capital + 3 country</li> </ul>	<ul style="list-style-type: none"> <li>• E-commerce</li> <li>• Stores 3 units, 5 stores</li> </ul>	<ul style="list-style-type: none"> <li>• E-commerce</li> <li>• Flagship store</li> </ul>
<b>Omni-channel capabilities</b>	Medium	Medium	Low/Medium	Low/Medium

TABLE 5.2: Table with selected cases

## 5.9 Data collection protocol

The validity and reliability of data collected from case study is strengthened by a well-designed research protocol, i.e. a data collection protocol (Voss et al., 2002; Yin, 2003). Its core are the questions to be used in interviews and the subjects to be covered and the required data (Voss et al., 2002). Voss et al. (2002) suggests using the funnel model as the format of the research protocol, which starts widely with broad and open-ended questions or subjects, and ends with detailed and specific questions. According to Voss et al. (2002), case research within logistics is different from case research in the field of social science, since these researchers are more concerned about the processes and systems behind an entity. Handfield and Melnyk (1998) emphasises the need for logistics researchers to consider the effects derived from the industry, size of organization, manufacturing processes, and interorganizational aspects. Voss et al. (2002) advocates for logistics research studies to have extra attention to “processes and systems to be studied, the methods for studying these, and the operating data to be collected from them.”

The foundation for the research protocol was an adaption to the famous value chain model by Michael Porter (Porter, 1985 (Republished 1998)). It was complemented from theory around warehouse operations, ancillary supply chain activities, e-commerce retailing, as well as aspects from the concepts of multi, and omni-channel retailing (see fig. 5.5). It served as an initial framework to the elements involved in the thesis and where to establish the focus. The support activities outlined had more use for the authors in the start of the development of the theoretical framework, and less for the collection and analysis of data. This resulted in the finished protocol mainly being focused on primary activities. A top-down approach was used to cover the wider aspects of inbound and outbound (upstreams and downstreams) flows and the more detailed

processes of warehouse operations. In order to adhere to the research questions, the aspects of system integration and omni-channel considerations followed the process every step of the way.

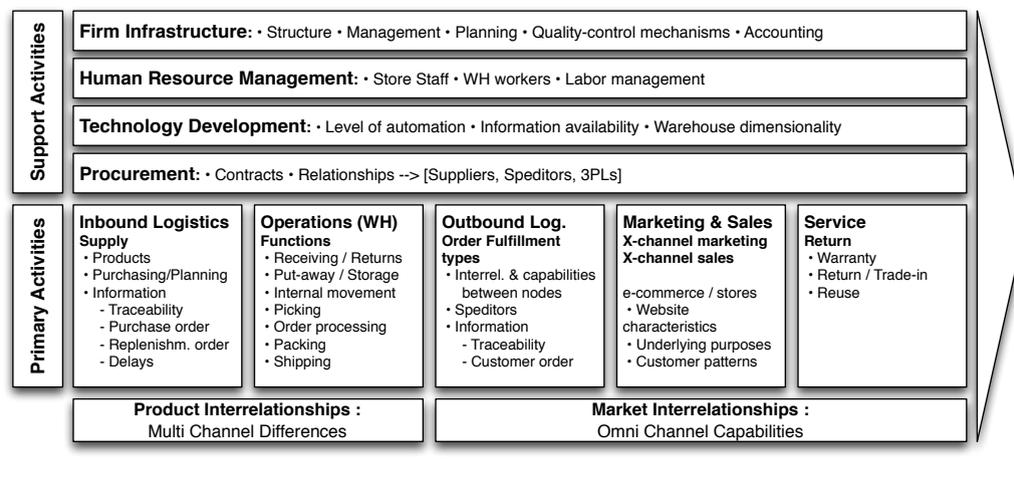


FIGURE 5.5: Porter value chain as foundation for research protocol

## 5.10 Conducting case studies

### Collecting empirical data

Research in the scientific realism paradigm promotes the use of either qualitative or quantitative approaches to data (Wahyuni, 2012). Creswell (2013) advocates the use of qualitative research when the situations is that quantitative measures and statistical analyses doesn't fit the problem. Further, interactions among people and systems are hard to capture using quantitative measures. This makes it evident that a qualitative approach to data is a much better fit in this study. In relation to the theoretical lenses, qualitative methods to approach a problem solution conceptually are advocated (Gammelgaard (2004)), as the understanding through researcher-participant interaction is instrumental for change (Goldkuhl, 2012).

**In-depth interviews,** In all of the four companies we had one or two semi-structured in-depth interviews. The purpose of these was to be able to map their supply chains and warehouse operations, and to bring forward critical types of products and orders. This top-down thinking resulted in two interviews at three of four of the companies. These were supply chain managers and warehouse managers. In one of the companies it was the same person that had these roles, which merged the interview material. After a pilot-study the authors agreed to focus the interviews towards primary activities within the companies, as the support activities were superfluous to the purpose of the study. This also lead to tighter and richer interviews, which could be done in two and one hours respectively. The "operations" interview was shorter since

it served as a first insight into their warehouse operations. Compressing the time spent here also lead to getting more time observing their actual warehouse operations, which was a straight continuation of this interview. Both of the authors participated in all of the interviews and responsibilities were divided in advance according to; one interview lead and one data collector. A tape recorder was used facilitate the transcribing of the intense data material. The companies were contacted a second time for secondary information that could contribute to the study, and a third time to validate the individual case reports.

**Observe warehouse operations,** The observation work had a focus on the inbound and out-bound flows of the warehouse operations. Unstructured interviews with the warehouse manager and warehouse staff was done to get an insight into the exact flow and processes, including interaction with the WMS. This also collected the participants meanings, which is advocated by (Creswell, 2013) in a qualitative case study like this. All of the main processes were observed in their natural context to provide all of the preconditions for performing their operations and the issues/opportunities that comes with them. The warehouse visit was complemented with a visit to the stores of those companies that had secluded store operations, which gave further insight into the extended warehouse operations that these stores represent.

## Writing individual case report

After each case study the material was transcribed and summarized as soon as possible, which is in line with the recommendations of (Creswell, 2013; Höst et al., 2006; Voss et al., 2002). The report had a set design that was according to the outline of the framework and case study design. The top-down thinking lead to a narrative approach that followed the steps in fig. 5.6.

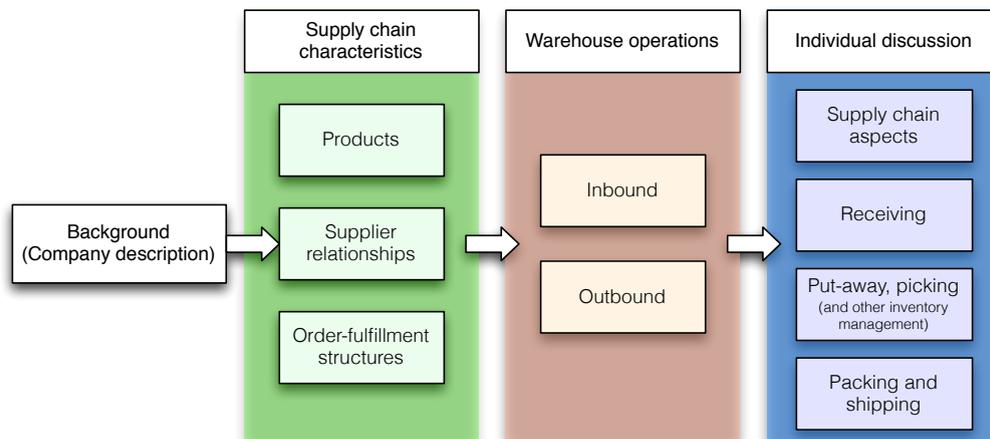


FIGURE 5.6: Steps involved in the case study reports

The supply chain characteristics explained some of the key elements in the companies' upstreams and downstreams flows. Then the warehouse operations were explained through process maps, which had a focus on the inbound and outbound flows of the warehouse. These were modelled through typical flow charts. Their meaning is shown by the fig. 5.7. The mapping was based on both a flow, and system integration perspective. The use of logic models is one way of addressing internal validity that is advocated by Yin (2003). The most essential parts of the inbound and outbound flows were modelled, but in some cases the complexity necessitated visualization of a specific part beyond these to facilitate understanding of the process. The format on the modeling resembles the ones in part III - WMS of the theoretical framework, so that differences and similarities in the process steps may become apparent more easily.

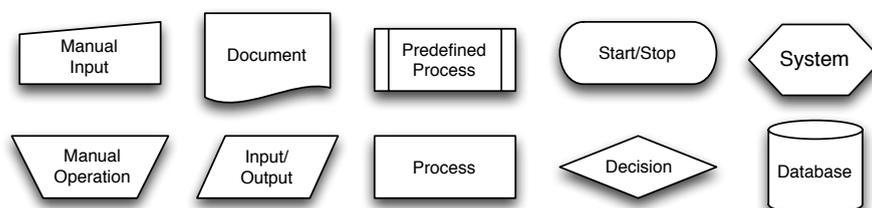


FIGURE 5.7: Symbols used in process modeling

## 5.11 Analysis of empirical data

“Analysing data is the heart of building theory from case studies” (Eisenhardt, 1989). Yin (2003) advocates the use of three general strategies for the analysis of single or multiple cases. The first and most preferred strategy uses theoretical propositions to guide the study to focus on the collection of specific data. The second strategy is to define and test rival explanations. The third consists of developing a framework that is descriptive to organize the case studies (ibid). Yin (2003) also suggests that suitable causal links can be analysed in case study research by using some technique of analysis, such as time-series analysis, pattern matching, logic models, explanation building or cross-case synthesis.

Pattern-matching logic is one of the most desirable techniques for case study analysis (Yin, 2003). These could be patterns of non-equivalent variables, patterns of rival explanation, and also simpler patterns. Simpler pattern matching is to identify a resulting outcome as a dependent variable and investigating why and how this occurred in the individual cases, i.e. independent variables (ibid). Yin (2003) also suggests the comparison of an empirically generalized pattern with a predicted pattern. This may further strengthen the internal validity of a case study. An important trait of a general analytic strategy is to identify all the important differences and relationships observed, so as to ensure the development of an explanation for different resulting outcomes that are theoretically significant (Wood, 1995; Yin, 2003).

**Individual case analysis,** Eisenhardt (1989) stresses the importance of within-case analysis, as large amounts of data serves the purpose of for a divide-and-conquer manner. It also enables patterns from each stand-alone entity to emerge before any empirical pattern generalization is forced upon the cases. According to Wood (1995), the analysis within cases will come to two levels of understanding, namely descriptive and explanatory. First to describe what and how is going on and secondly to describe why it is happening. Wood (1995) supports the use of displays in analysis to support analytic texts. This is sequential and interactive to strengthen relationships as the analysis progresses, which basically strengthens the use of process models.

**Cross-case analysis,** Connected to these individual case analyses, is the search for cross-case patterns (Eisenhardt, 1989; Yin, 2003). The idea with the cross-case analysis is to prevent ill-considered or false conclusions by confronting the data in different in multiple ways or angles (Eisenhardt, 1989; Wood, 1995). The aim is to look for general results or findings that are either common features or differing outcomes among the individual cases (Cohen et al., 2007). Eisenhardt (1989) suggests searching for patterns within cross-case studies by identifying constructs or categories from the literature, then to look for inter-group and within-group differences. In quantitative studies it is common to use tools like matrices for comparison of groups across dimensions (Wood, 1995), while in qualitative studies it's more common with tables.

## Analysis framework

The analysis framework is set up according to fig. 5.8. It was conducted in four steps. Each one has independent information that lays the foundation for the following section, while also answering the research questions along the way.

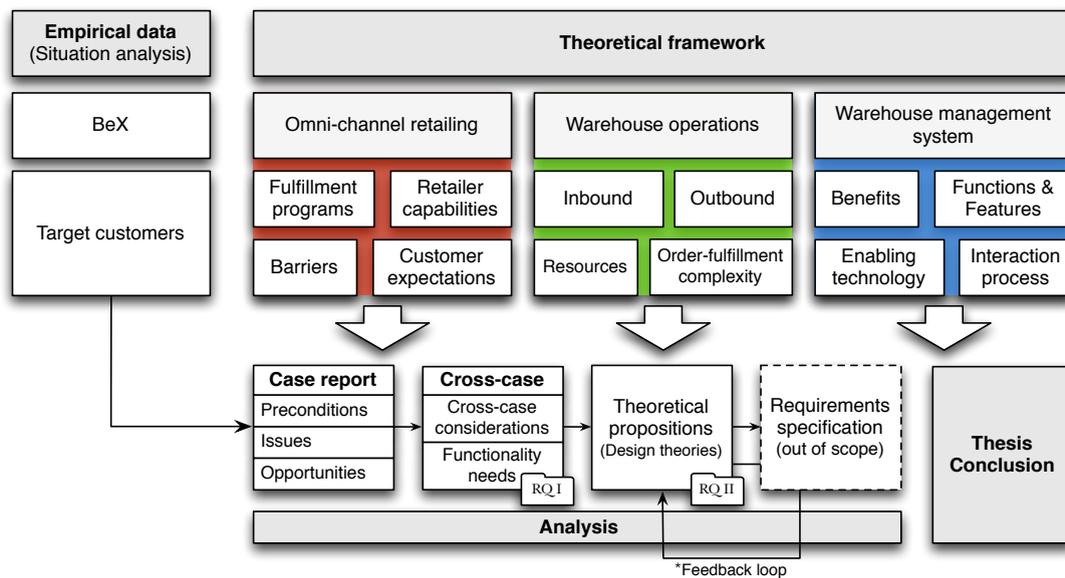


FIGURE 5.8: The analysis framework

**First**, the case study will provide a set of preconditions, issues and opportunities for each company, which are the result from the process modeling and summarized in the individual case reports.

**Secondly**, these opportunities and issues will be discussed in a cross-case analysis to express the patterns of problems and requirements among the companies' warehouse processes. This section will be followed by a discussion to identify how these patterns of requirements can be translated into actual functionalities in a potential WMS.

**Thirdly**, the previously held discussion will also lead to the development of a number of theoretical propositions, representing the underlying IT meta-artifacts on what the WMS software needs to accomplish and how that can be done. These design theories were integrated into the requirements specification, and then went through a feedback loop with an industry professional to evaluate their applicability and situated utility.

**Lastly**, a thesis conclusion will discuss the findings and how the research questions were answered, where it will take into account how proposed system features fit into an omni-channel

environment and enables efficient omni-channel fulfillment programs, as well as efficient warehousing. It will also explain what is the contribution to the research and will end with suggestions and considerations to future research.

## 5.12 Quality of the research design

For an empirical study there are four conditions of quality that needs to be addressed and maximized in the development of the case design and while conducting the study (Naslund, 2002; Yin, 2003). The conditions of quality might alter and the criteria of good research according to Naslund (2002); Voss et al. (2002); Yin (2003) are the following:

1. **Construct validity:** The extent to which we establish correct operational measures for the concepts being studied. If the construct as measured can be differentiated from other constructs.
2. **Internal validity:** This denotes the degree to which the findings in a correct and sufficient way map the phenomenon studied in the research. It also denotes when causal relationships can be defined entailing conditions that are shown to lead to other conditions.
3. **External validity:** This denotes the degree to which the findings can be generalized to other settings similar to the one that occurred in the study.
4. **Reliability:** Involves the extent to which the findings can be reproduced or replicated.

An empirical study can be subjected to a number of tests to evaluate these four criteria of quality. Yin (2003) has developed several tactics to address these while conducting case studies. It is important to in the beginning of the research process to establish the fact that these tactics should be applied throughout the entire empirical study process. The researchers of this study have utilized the tactics recommended by Yin (2003) to ensure a high level of validity. This process has been consistent throughout the design and execution phases of the case studies in this thesis.

**The construct validity criteria** was addressed by having the key informants from each individual case study validate the findings when the information had been compiled in an presentable manner. The thesis has also been peer reviewed by the supervisors of the research at Lund University. Information was also collected from multiple sources at each study location. In addition to the semi-structured interviews unstructured ones were held with numerous warehouse employees as well as store clerks in order to get multiple perspectives on the investigated scenarios.

Tests	Case study tactic	Phase of research in which tactic occurs
<b>Construct validity</b>	Use multiple sources of evidence Establish chain of evidence Have key informants review draft case study report	data collection data collection composition
<b>Internal validity</b>	Do pattern-matching Do explanation-building Address rival explanations Use logic models	data analysis data analysis data analysis data analysis
<b>External validity</b>	Use theory in single-case studies Use replication logic in multiple-case studies	research design research design
<b>Reliability</b>	Use case study protocol Develop case study database	data collection data collection

TABLE 5.3: Case study tactics and quality testing (Yin, 2003)

**The internal validity criteria** was addressed by doing a separate summaries of the cases.

These were then cross-case analysed to establish common patterns. The literature used in the theoretical framework was carefully selected from peer reviewed publications or respectable journals. Some information was gathered from vendors of WMS. They have an interest in presenting a subjective and somewhat glorified picture of the products they supply and this had to be taken into account. Therefore the material from these consisted mainly of the overarching categories that we recognized as some common denominator within a WMS structure.

**The external validity criteria** was addressed by using a replication logic in the multiple case study. Due to limited resources the number of cases selected for the study had to be limited. However to ensure a higher level of generalizability more case subject should have been included. Since an omni-channel integration plays a very important role and for retailers of fashion and apparel, the researchers might have been partly biased when selecting the cases. This was a conscious decision made in order to ensure that enough empirical data was gathered to answer the research questions.

**For the reliability criteria** a structured interview guide was constructed. The guide would ensure that the questions posed during the interviews would be consistent and that the method data collection at each case study location would be the same. Every single one of the semi-structured interviews was recorded so no information would be overseen. The only interviews not recorded were the unstructured ones with the warehouse workers and the employees at the stores. This lowers the level of reliability since this was conducted as a conversation and some information might have been missed when only taking notes. All the collected information and the manner in which it was collected is stored in a case study database. This database can be accessed and utilized if anyone would aspire to replicate the research.

## Chapter 6

# Empirical data

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*This chapter will first go through the key aspects to the BeX system, followed by a current situation analysis for each study object. The individual parts will consist of (1) descriptions of the companies and their supply chain characteristics, (2) process maps and descriptions of their inbound and outbound processes, and (3) an individual summary that will present issues and opportunities with respect to BeX and the main warehouse processes.*

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### 6.1 Perfect IT - BeX

Perfect IT - BeX is the system that is used uniformly across all the study objects. It is an ERP-system that spans all the way from financials and stock keeping to POS equipment in the stores. Online orders and payments go through the e-platform, Panagora EDGE. BeX makes sure the inventory levels are available to Panagora so that online transactions can go through, and BeX then receives orders into a centralized order system. This allows the website to focus on sales, and BeX to focus on conducting the order-fulfillment activities. All the retailers in the study utilizes both BeX as an ERP-system and Pangora Edge as an e-platform. Perfect IT has focused on bringing in electronic devices for POS equipment (cash register hooked to scanners) and picking devices (tablets and wireless mini scanners). This has been complemented with their own barcodes that can be used both as warehouse tagging and price tags for products in stores. The main differentiators in the system is (1) cloud-based browser interface that is available everywhere and easy to implement, (2) order-batching capabilities, and (3) Web2Store functionality, that allows the customers to integrate the inventory from all its warehouses/stores into the internet-available stock. The issue has been the lack of warehousing capabilities and location management, as well as a lack of system support for omni-channel capabilities.

## Order-batching

One of the key functions in BeX is the order-batching function. It is based on a filtration function, that allows for sifting through orders according to some set of criteria that fits the company at hand. With (1) the use of trolleys with up to 70 compartments, (2) an automatic designation of orders to those slots, and (3) a predefined routing, the customers have been able to pick efficiently and on a very satisfactory level.

## Web2Store

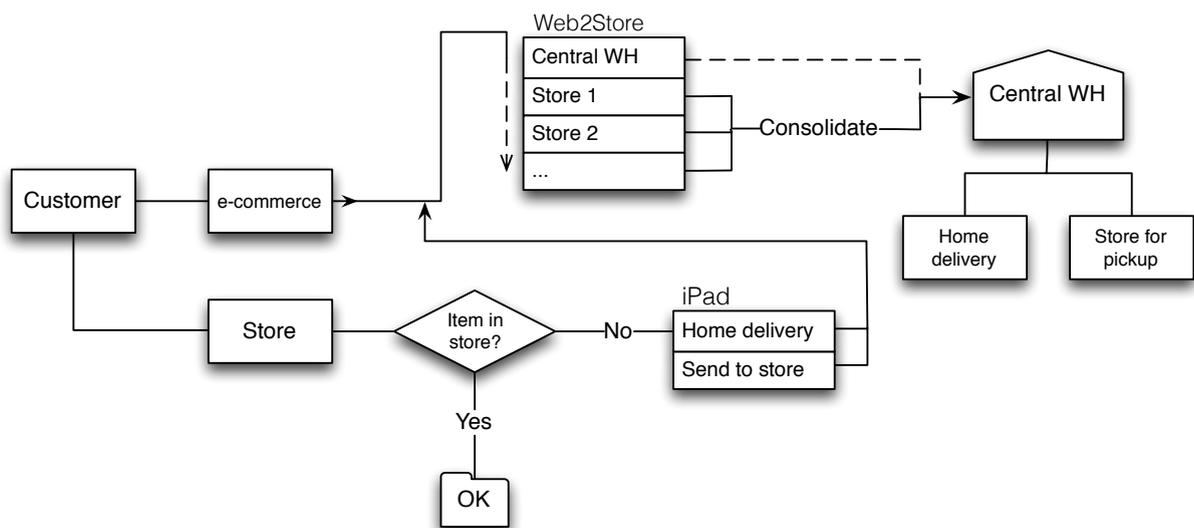


FIGURE 6.1: Web2Store function of BeX

This specific function works similar to a loop over the different storage locations. When the customer order is placed into BeX the function starts searching through the different inventory locations in a pre-established priority order. BeX start with comparing the article numbers of the ordered products with inventory presently located at the central warehouse. If no match can be made the loop starts over and begins comparing the products with the inventory of the next location on the priority scale. When the products are located, an internal purchase order is made and they are shipped to the central warehouse. Products are never transferred directly between different stores. Every product destined for e-commerce sales has to be shipped to the DC and registered as an inventory transfer. When an order contains multiple order-lines every location is checked in order to see if it has the capability to fill the entire order. If no such store or warehouse is located the wheel starts again and tries to combine products from different locations to complete the order.

## 6.2 Company A

### Background

Company A was founded in 2006, today it is one of Sweden's leading web shops within the children's apparel market, with more than 80.000 customers spread out across more than 50 countries. They have also expanded their focus from just children's apparel to include shoes, toys, baby carriages, child seats, maternity clothing, accessories, etc., for children between the ages of 0 and 10. Company A have one main warehouse for the distribution of the e-commerce orders.

They only have one physical brick and mortar store, a flagship store located in Stockholm, which is mostly used for offering the most popular products from the website and showing upcoming brands. Other than that they are solely an e-commerce retailer.

Company A is planning to become the leading children's store in Europe. As a means of reaching this goal they made a takeover of an Swedish industry competitor and they very recently acquired a British equivalent company. The Swedish company had their own brand and their own website which Company A decided to keep. Company A also has an in-house brand of their own mainly for B2B sales. Company A have in combination with these newly acquired companies a turnover of above 400 million Swedish Crowns and the web-shops have approximately 2 million visitors a month.

### Supply Chain Characteristics

#### *Products*

Company A has over 240 different brands available for sale on their website. This is excluding the ones that the newly acquired Swedish company contributes with

#### Significant products

1. Adult and baby clothing
2. Accessories and baby related merchandise
3. Baby Strollers

The clothes are divided into different standardized subcategories such as sweaters, overalls and shoes. Adult sizes occurs as well. A few of the brands stand for most of the sales in this group, but it is mostly seasonality and possibly campaigns that impacts what is frequent. Further, viral

news and blogs from the many “mother bloggers” in Sweden causes sudden surges in demand as well.

Company A also has a great deal of baby related merchandise. Product groups include everything from pacifiers and bags to baby toys and seats for car-use. These are important in a supply chain perspective because of the inherent variety in volume and demand of these products.

The last category is interesting because of their bulky nature and the fact that the strollers that they sell on the web-shop are kitted in the warehouse. The parts that constitutes a stroller consists of the frame, wheels and the central piece. These come in a variety of different colors, which is also the only customizable part for the customer.

### ***Supplier relationships***

Company A have a supplier base of about 500 different suppliers. The suppliers deliver from all different parts of the world. The purchase orders to the suppliers are usually placed 4-5 months in advance by the purchasing department. The exact delivery date of a purchase order is of today not specified by the suppliers. The most common delivery information provided is a delivery window established by the suppliers. During this window, which usually ranges between three to six weeks, the suppliers have agreed to deliver all the ordered articles. This could entail that an entire purchase order is delivered in multiple different shipments during this time period. The main way for the warehouse to estimate what amounts of product stock that is scheduled for delivery, is to calculate the actual value of the amount of product that has already arrived and compare it to the total purchase budget for the entire season. Company A tries to do labor planning, but the evaluation is only done after the goods has arrived. When the arrived goods are inspected the purchase department is informed, after which a priority list is sent back to the warehouse. This crudely decides the order of the put-away process.

A recent development has been to persuade the suppliers to comply with the notification standard that Company A would like to work with. They want the suppliers to set a delivery date (that they are expected to honour). It is also desired that suppliers send delivery requests in advance, both when the shipment is and isn't one time. Some suppliers have complied to this and started sending e-mails in advance according to the template, which then describes amount of items and date that these are to arrive.

### ***Order-fulfillment structure***

Company A operates on two levels of order-fulfillment. Primarily, purchase orders can be placed on their website. Secondly products can be purchased at their flagship store in Stockholm. Their e-commerce order can either be shipped directly to the customer's home address or picked up

at the store's location. The customers may also return their internet-bought products in the store or by regular freight.

The store inventory is kept separate from the e-commerce's and as mentioned earlier only mirrors a minor fragment of the article selection offered on the website. The web-shop gives no indication to which articles are exclusive for the website and which ones are available in the store. However, Company A's flagship store has implemented a computer which is connected to the web-shop and available to customers so they can view the entire product assortment offered. It is an important tool for customers and a source of additional sales. The purchase is completed online as regular and the product is shipped from the main warehouse either directly to the customer or to the store in Stockholm.

### **Warehouse operations**

The main distribution center operates with the fulfillment of all the company's e-commerce orders and orders for the flagship store in Stockholm. The store encompasses only minor storage capabilities and would not be able to function as a miniature fulfillment center in its present state. However, the DC acquired full control of their warehouse operations quite recently. These were previously contracted to a 3PL company, but there was a need for more flexibility so a consolidation was decided upon. The result has been enhanced time efficiencies and autonomy, but also a much bigger demand on the toolbox to handle their operations.

The warehouse consists of a single floor area occupied mostly with low-level single deep storage shelves, but also with regular pallet racks. The three different brands mentioned earlier are stored in separate zones. The average number of SKUs in the warehouse lie at about 56.000. In a near future this number will have risen to 100.000 different articles. This will put particular strain on the warehouse operations, which is already quite complex with its siloed multibrand solution.

***Inbound (see fig. 6.2)*****1. Goods arrive**

Products usually arrive in large pallet shipments. The average shipment size spans from 5 to 10 pallets, but can peak at 20-30. The actual products included in a shipment are randomly distributed in the boxes on the pallets, and the shipment may just be a part of a big PO. This is why Company A started scanning the products of incoming orders to tick each one off the purchase order as they are handled. This action registers them as arrived in BeX and kick-starts the label printing. They use the EAN code provided on the articles. This is most of the time (70-80%) already registered in the system together with supplier added information, otherwise it's done manually. The priority list mentioned earlier is sent to the warehouse after the goods are registered, which informs them of the order to store and photograph the products. The priority is set based on the level of importance for new collections to become available for sale.

**2. Photography process**

If the article is not a recurrent product a photo must be taken of the article before it can be made available for purchase on the website. This process can begin as soon as the products have been accounted for by the arrival station since no live models are used. A separate low-level shelf is designated for these products, along with paper sheets to keep track of the purchase order they belong to. When an item is finished in the photography process it needs to be consolidated with its remainder. Either goods are tied to a position or they are in limbo. But they can only be tied to one (1) position with the BeX system today, so the staff assumes that the rest is in the receiving area if the article is not tied to a position yet. If it is, the release of the product causes the balance of that product inventory to become +1 compared to what is actually available.

**3. Returns**

Returns arrive daily and are put at the returns area, which is basically a shelf alongside an office with staff devoted to returns management. Company A get returns of about 9-10% of the total shipped products. Returns arrive from all over the world, which causes problems when people write in their respective language on the returns document provided. This has the task to collect information about the reason behind the return and what request they may have. The returned product is checked by the staff and the information from the return document is entered manually into the system, whereupon a potential repayment process is started. The item is registered into the system right away if it is in acceptable condition for resale. The registering makes the item available for sales, which causes problems like in the photography process. The processed return items are placed in totes at the returns area until someone put them away, i.e. the stock balance may be incorrect for a while and the returned item may be invisible when pick lists are printed.

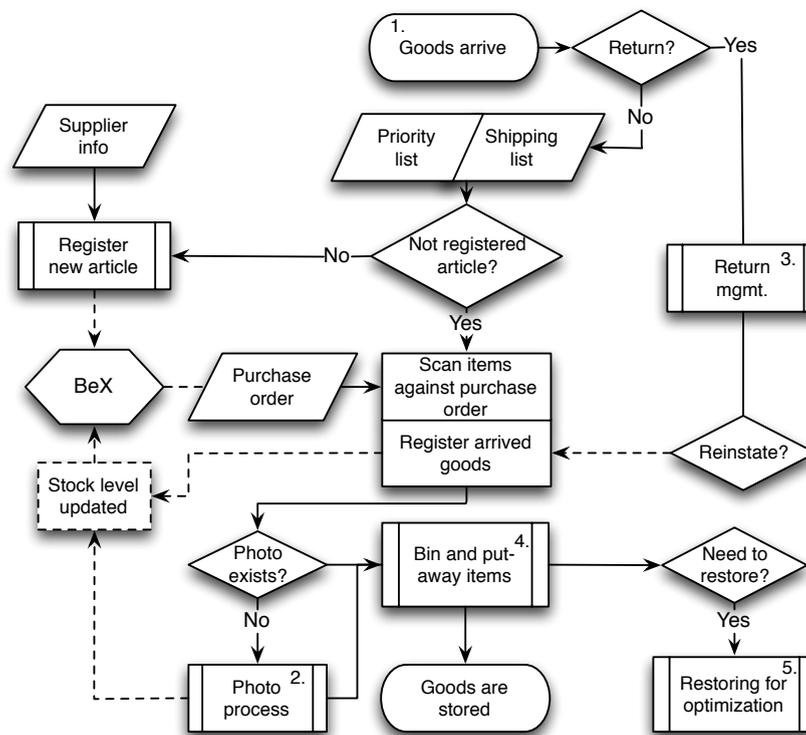


FIGURE 6.2: Inbound processes of Company A

#### 4. Bin and put-away items

Company A utilizes three different kinds of cardboard bins for their storing process. These are categorized into small, medium and large. Since BeX lacks dimensional data, the choice between the bins are done by manually estimation of the total volume of items to store. Arriving products are placed in these bins and the article number label is printed and placed onto the bin. An exception is if the article already exists in the warehouse at some location, which will cause the printed label to display the designated location. The operator will then try to fit the goods there instead. Since the system forgets where a product has been stored when the balance reaches zero there is a lot of bins in circulation. When boxes become empty the staff drags them outwards to indicate for others which ones that are empty and available for put-away.

In the put-away process the bins and products are placed on pallets or another means of transport. The workers will randomly choose an empty shelf or bin in the warehouse for storing. The smallest bins are mainly in a section of their own, but overall there is a mix in most racks and shelves. The put-away process is supported by a laptop and a scanner, so they do not need to use paper-based storing. Although it is an error-prone step since manual input into the system occurs when creating new locations. The racks are designed uniformly and they also try to keep the shelves uniform in regards to what bin type they are using at a certain shelf level (see fig.

6.3). When a shelf is chosen the information regarding the product’s storing point is entered into BeX. Because they try to increase the fill rate by storing several bins on top of each other, they need to create provisional positions in the system. These are named in a way that helps pickers know which bin in a vertical distance that they’re looking for. Although, a problem to this way of bin storing is the fact that the bins are not supported vertically by anything else than bins beneath them on the shelf level. If the bins are removed when empty the position of the boxes might shift and become incorrect (see fig. 6.4). That is why bins are never removed unless they can be replaced by a new bin.

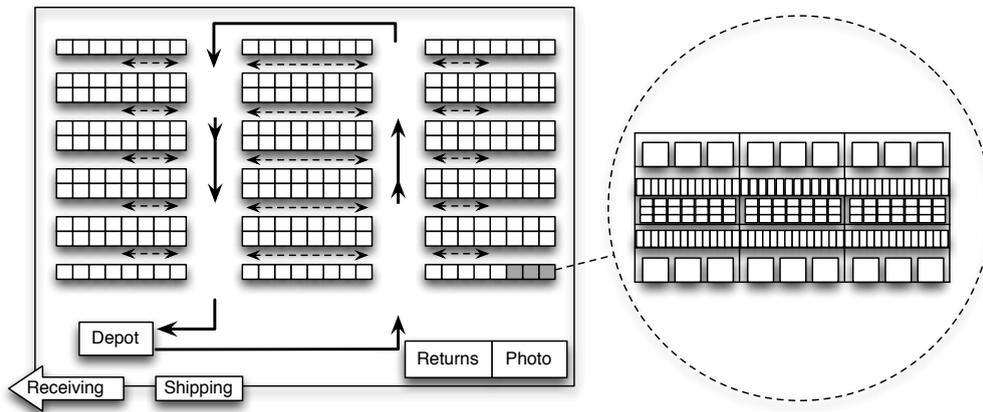


FIGURE 6.3: Generalized layout, shelving and pick pattern of the main shelf area Company A

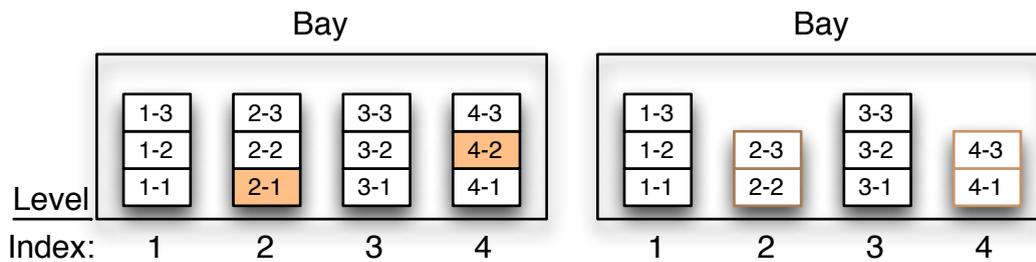


FIGURE 6.4: Bin storage problem at Company A

### 5. Restoring for optimization

If space needs to be made for peaks, a common move is to restock the articles that placed in bins that are too big. This is mainly manually judged by the number of items left, how much excess room in the bin exists, and whether or not a switch to a smaller bin is feasible. The problem with positions becoming erroneous apply for this activity as well, which makes it a quite time consuming process with a substantial risk for errors later on.

***Outbound (see fig. 6.5)*****1. Order is made**

Company A handles about 500 to 700 orders a day. Each order spans between 1-3 lines and the average lie at 2,85 lines per order, i.e. 1400-2000 products/day. They control orders arriving from the two other brands websites in a separate flow, but with a modified procedure. Orders arrive after payment via the e-commerce platform. Customers are warned if the inventory is low and the time to the next shipment, which is the warehouse shipping deadline.

**2. Batch-picking**

The DC works with batches of sizes up to 70 orders. They exclude items like baby trolleys and baby car seats, with which they later on make separate smaller batches. Every batch generates a picking list and also a shipping list for each order. Since a printed picking list holds 7 rows of articles per page, the pile created from the picking list becomes quite hefty. The picking is based on a pick-and-register manner where the staff picks what it finds and later on checks what was actually picked in the system. Besides this being a cumbersome process, it is an issue when the inventory balance is not precise. Customers risk ordering products that are no longer available, which is especially the case for baby trolleys that are kitted.

The order-picker follows the system based routing manually with their paper-based picking list, similar to the generalized figure 6.3. There exists some zoning by family grouping, e.g. shoes and the smallest bins, but generally the articles are evenly distributed. To their help they have a trolley with 70 order-slots and a basket to assist when traversing down the narrow aisles and picking products, while the trolleys are in the cross-aisles. When the picker returns with a filled basket the products are put in their respective order slot on the trolley. The picked quantity is noted on the pick-list for the registration in BeX later on.

**3. Packing**

After a batch-pick is finished the picker reaches the packing bench, i.e. the depot. The same person that picks also packs the orders. In an attempt to free trolleys for the use of other order-pickers, the routine is to unload the trolley's orders, pack them in plastic bags (or boxes for long distance parcels) and put them onto another shelf on wheels. This shelf is dedicated to the pack area. The orders that were incomplete are put in the lowest level of this shelf to separate them for a different handling process. One operator goes through the orders, registers them into BeX and labels them for shipping. The orders that were incomplete or erroneous are investigated to see if the missing items can be found somewhere, e.g. in the photo or return area. If an item still can't be found, this order is moved to a sort of interim batch list. This is used an under-the-desk type of collection in the system where the staff can circumvent a system-obstacle in BeX and put incomplete orders in a separate state.

The items of the orders that were fine are then moved to a separate shelf. Why there is a need to remove the erroneous is because order-batches can only be accounted for in one go when all of the orders are packed and ready for shipping, and this should not affect the other complete orders of the batch. Since the system is instructed to not withdraw the customer's money until the order is complete and accounted for, they need to get in touch with the customer to ask whether it wants the money back or change to a similar item with the same or lower value. This sometimes causes incomplete orders to lie in the separate shelf for a long time.

#### 4. Shipping

The orders that are registered and ready to be shipped are put onto pallets or into cages provided by the freight company. These are either Posten or UPS. Company A does not provide any particular service to handle sudden customer order regrets when the orders are in this stage. In BeX these orders are stated as shipped, while still being staged in shipping area in the wait for the carrier. Safety and traceability issues exist and becomes a problem when the freight company accidentally loses a package, since they have no automatic handover information.

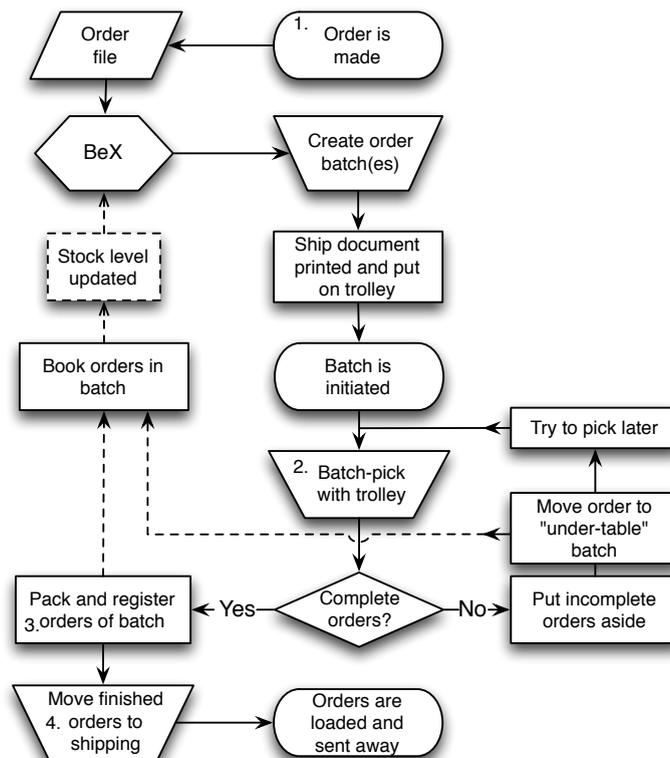


FIGURE 6.5: Outbound processes of Company A

## Observed issues and opportunities

### Supply chain aspects

We identify the possibility that Company A's store concept may expand into Europe. This would put pressure on the layout design of these to encompass any of the more advanced fulfillment capabilities and integration between channels. We also identify the need to have a structured back-storage that enables consolidation of orders. Packing is potentially not an issue here as it is about having the structure that makes sure that products finds the collection point of their orders. The first issue is to get past the siloed stores that causes inertia when transferring goods.

### Receiving

Company A has an emphasis on improvements on the receiving end. The system should support decision making in this area to increase the chance of having the right workforce and space available in time. Given that more of their suppliers start complying to their standards, there is a lot of room for a system to have the intended assisting functions. Knowing when, what and how much is going to arrive is the foundation for anything to work. To be able to make estimations out of this you either use templates or historical data. Having statistics on the time different steps have taken is more likely to give accurate estimates, but the basic use of templates may be equally sufficient.

Company A also had a cumbersome paper-based return documents that are sometimes written in a foreign language that needs an interpreter. The use of Web-EDI forms could allow for customized languages, so that the customers can input their requests trouble free and the system can automatically creates a scannable document.

BeX does not have any functions for using dimensions, except an information box indicating volume for an article. Company A can harness this dimensionality information from their suppliers. It would increase Company A's warehouse efficiency if a system could assist in deciding what demand for different types of bins lie ahead when shipments arrive. If the systems has a memory of what has been previously used it may also help as it can suggest appropriate use of bins. Furthermore, a system could theoretically calculate an expected outflow of products in terms of bins, i.e. the expected number of freed up space in a given time window.

### Put-away, picking and other inventory management

When optimizing the storage positions they switch bigger boxes to smaller if there are few enough items left of an article. They don't really know how full a bin is except when visiting

them in the aisle. It is obvious that this is a sort of rule-based inventory management. This could get support from a system if proper filtration functions exist to find out what the bins' fill rates are and where opportunities to rearrange lies. Then re-storage batches could be created the same way that pick-lists are made.

They need the traceability to know where split article collections are. Especially after a photo process when the stock balance is erroneous. Firstly, it would be favourable with a block function that can be put on the inventory that is stored while a photo is being taken. Secondly, a routing function that takes the processed items from the photo shelf into account. This could potentially be put either early or late in the route to make sure that it is emptied as the day progresses. A storage route could get the photographed items to the shelf they belong to or to the receiving area if that's the place that they are residing.

The problem with the kitting of baby trolleys is that it suffers from inventory balance related issues. When a baby trolley is sold, its constituent parts are not reserved. Pickers risk having a slight problem if they are not fast enough gathering all the items that are needed. Company A could circumvent these problems by actually selling the individual parts when a trolley is sold, but it would not be very efficient. Real system support would be more advantageous.

The picking activity is an interesting topic at Company A, mainly since they use bins to make the shelves more granular, but also because they would benefit from zoning according to family groups and stratification logic. The put-away and restocking difficulties creates a need for an indifferent view of the locations within a shelf. This could also make picking devices or PBV more desirable, which by extension removes their pile of order sheets. The use of barcodes and check digits could be used to efficiently tie goods to bins and positions, but also to the multi-order trolleys. However, this requires a need to track orders as well.

### **Packing and shipping**

Given their issues arising when orders are incomplete, a given solution to this is the ability to send incomplete orders and batches, as well has an ability to account individual orders. This goes hand-in-hand with abilities in consolidating orders, since it revolves around letting parts of orders traverse the supply chain. Orders should have the possibility to be checked off as they go, blocked for sales as they go, and not be hindered by a business process. If they need to stay until they are complete, it should at least be possible to integrate these in order-batches.

Due to the accounting characteristics of BeX, no particular information is kept after the point of registering the outgoing orders. Knowing when things leaves is important for traceability and safety. We identify the need for having some automated or facilitated dispatch procedure while also providing sufficient visibility into order's location statuses. Either scanning is used or RFID is a solution to know when goods are loaded onto vehicles and for triggering the registration.

## 6.3 Company B

### Background

Company B has its origin in an old Swedish clothing chain founded in the 1920's. In 2005 they opened a 1000 sq m brick and mortar store in a mall in Stockholm and three years later they opened up another one. In 2009 they got to expand the store area of their first store to 2700 sq m and thereby became the largest single multi-brand store in Scandinavia. In 2011 they launched their e-commerce site. They are in a very expansive phase. Since the website-launch then they have opened four more stores in Sweden. Their store concept is to offer a variety of different brands inside the store with each brand divided into its own section. The store sections is designed to represent its brands and the employees are usually working with the brands they are most familiar with.

The sales through the e-commerce channel is steadily increasing and social media is a backbone to their sales. Company B has a customer loyalty program in place which returns a percentage of a customer's total product purchases as credits to buy new products for. This allows Company B to keep data of what type of products are interesting for certain consumers. Company B believe in the role the cell phone and other portable devices can and will play for consumers, whereas their mind set can best be explained by omni-channel thinking. They have followed up recent pioneers in this segment and started offering p-commerce, which is QR-codes in commercials that directly connects customers with the product offered in the commercial without the need for entering the website to purchase it.

### Supply Chain Characteristics

#### *Products*

Company B offers around 118 different brands. These are mainly clothes but since they are in the fashion industry they have a variety of accessory items as well. In a Company B's store the products are divided according to the major brands. Some brands do sell better, but the major difference lies in type of product. They sell regular clothes like t-shirts, shirts, trousers, underwear and sweaters. They also sell suits, swimwear, outer garments, shoes and various other accessories. Some products are basic articles, of which they try to never get stock-outs.

#### Significant products

1. Accessories
2. Outer garments

3. Shoes and trousers
4. Dresses and shirts

The **accessories** they sell may be anything from napkins to wallets or bags. This product group excels in high volume and puts a very broad set of requirements on warehouse capabilities. **Outer garments**, e.g. jackets and coats, sell a lot. These also put extra demands on the supply chain because of their bulkiness and occasionally high value. **Shoes and trousers** have proved to become troublesome for completely different reasons, namely that they represent a large part of the return flow. **Dresses and shirts** are very frequent items. They differ mostly in their storing methods, since shirts usually come folded in a plastic bag and dresses are often on hangers. As any other set of clothes they can be difficult when it comes to retrieving the correct size, because they lie right next to each other and looks identical.

### *Supplier relationships*

Since Company B is a reseller of clothing they have very little influence over the product assortments offered by the suppliers. As mentioned, they have over a 100 different brands. Some of these brands have the one and same suppliers but most of them do not. Their business is characterized by seasonal high pressures. Every year is divided into two seasons. Each of these seasons is divided into three parts so an entire year amounts to six different collections - Pre / Main / High, and this times two. The highs are around Christmas and in the summer, while the mains are in the spring and autumn.

They order mixed brands or single brands, and at times only complementing orders. Collections will have to be decided and a purchase order will have to be placed to the suppliers at least six months in advance. The suppliers are the ones setting the terms and conditions for the deliveries. Some smaller collections can arrive all at once and larger collections can have their delivery times divided into multiple parts. A delivery window can actually be as long as three months before all the products included in a purchase order have been delivered. The smaller and complementing orders have lead-times at about 1-30 days.

### *Order-fulfillment structure*

Company B operates on two main order-fulfillment levels. The first option is for a customer to place their orders directly at the website. When an order is completed on the website the customer will receive the product directly at their home address or it will be sent to a pick-up point close to the customer. Company B are currently in the process of adding the possibility of delivery and pick-up in a store. This will allow the customer to actually look, feel and try

on a product before bringing it home, which is an important feature for premium products. The second option is the regular store purchase in any of the five stores. Company B are also launching a functionality in which they allow returns from any channel to be passed backwards in any channel as an omni-channel approach. A third dimension is tablets on the way of being incorporated in the stores with web-shop access. Then an item can be purchased online and either sent to the customers home or picked up immediately in the store if the item is available. To complete an transaction such as this, an e-commerce order, with a decrease in a stores inventory, the products location has to be moved manually in the system from the store to the central warehouse without actually ever sending the article. The customers can with this option use services such as invoice payment. A service that was previously exclusive for purchases through the web-shop.

### **Warehouse operations**

Company B does not have a warehouse solely dedicated for e-commerce fulfillment. The e-commerce channel mirrors the company's entire product selection. A small part of the inventory is available from the DC, but 95% is kept in the stores. The stock kept in the DC is mainly used for replenishment of the stores' inventories or fulfill e-commerce orders.

This gives an online customer the possibility to unknowingly order a product that is not available in the DC but must instead be shipped from its present location in one of the stores, to the DC and then out to the customer. This could entail that the product is sent from one store, to the central warehouse and then immediately out to another store for pick-up. To be able to fulfill this kind of order they use the Web2Store function in BeX.

A truck drives each day along a pre-destined static route and completes drop-offs and pick-ups of products at each of the different store locations and at the DC. The purpose is fulfillment of internal orders and completing inventory transfers. The truck starts its route by picking up all the inventory transfers from the DC out to the highest prioritized store, where it also picks up stock for e-commerce orders and returns. The DC supplies all the stores but the two-way distribution just mentioned only applies for some of them. The stores without the two-way distribution is not included in the Web2store function either

The stock that is heading out to the stores may not just be fulfilled from the DC's inventory as part of an ordinary internal order, but also as a cross-docking or put-to-store activity. When shipments arrive from suppliers the goods are pushed out to the stores according to a ratio-based division, which is decided by the purchase department based on store's demands and projected sales. The rest of a shipment remains in the DC.

***Inbound (see fig. 6.8)*****1. Goods arrival**

When goods arrive at the DC all the goods have to be checked and then registered into BeX. Incoming shipments vary in size and could contain everything from two boxes to ten pallets with boxes, or even 500 GOH (Garments on Hangers). The information regarding all the products contained in the incoming shipment should already have been received from the supplier and entered into BeX. This usually includes, color, color-code, size, purchase price and product category, but not any information on measurements or weight.

The product structure inside the boxes on the pallets are usually random and the same type of products could be scattered across all boxes and pallets. They start by marking the goods' shipping lists with the date they arrived, since they are aiming to utilize a FIFO principle. Then the purchase order will be printed and manually compared to the shipping lists. If the shipment is correct the articles are manually registered into the system, followed by the label printing. These also state the sales price of the products to facilitate the receiving and put-away process when at the store. After checking and registering all articles the entire purchase order is registered. Because of some purchase orders are delivered over a prolonged period of time they deduct what they receive in the shipment from the purchase order, similar to Company A's procedure, so that purchase orders are not closed until all of the goods have arrived.

**2. Store distribution**

When all the products are registered and labelled, they are divided according to which location they are to be transferred to. Every one of Company B's stores receives a predestined number of products from each new collection. Before sending the products off to the stores, an internal order is placed from the DC out to the stores. This registers the transfer and the inventory is moved to that specific stores inventory instead.

**3. Photography process**

All new articles will need to have their photo taken before being able to sell them online, similar to Company A's case. They have a queue with the garments put on hangers. The articles are already labelled for access in the system. When finished, the items need to be sent either to the DC shelves or be sent off to the stores. The photography process is done in the DC irrespectively to the store-distribution process. In other words, if a complete set of an article is to be distributed to the stores, one item is saved for the photography process. This item is sent to the store it was designated to after its photo has been taken and added to the article information in BeX. The item is just put aside at a trolley and gets a post-it note indicating what store it is intended to shipped off to. When the item is in this stage it is available for sales and is also registered as being in one of the stores.

#### 4. Put-away

The products that are to be saved in the DC will have to be put up on the shelves or hangers. These are made up of two zones beside each others, where one is a single type of low-level shelving and the other is a two level hanger rack for GOH. They also have separate women and men sections. One rack contains a number of brands and every section essentially consists of one brand, but because of the lack of space it is quite mixed. There are no internal placements within a brand since the storing is done randomly. They don't use any of the cartons that the products arrive in and they don't use any other container for storing either. What they do use is shelf dividers and hanger dividers, but not for the shoes. The brands separate placement is the only positioning that they use for the racks. For instance, a pair of shoes of one brand may lie across three levels of a shelf bay (see fig. 6.6). On each level you find the same shoe but in different colors. On each respective level you find a myriad of sizes. All of these items belongs to a master article number, while each unique article has its own article number. The master article number is used for easier locating. The picking obviously involves a lot of searching and they don't leverage any location system support. The shirt example is interesting because they consist of many sizes under one article number, so it is a quite error-prone step for the picker and the search goes on similar to searching for one size in a store.

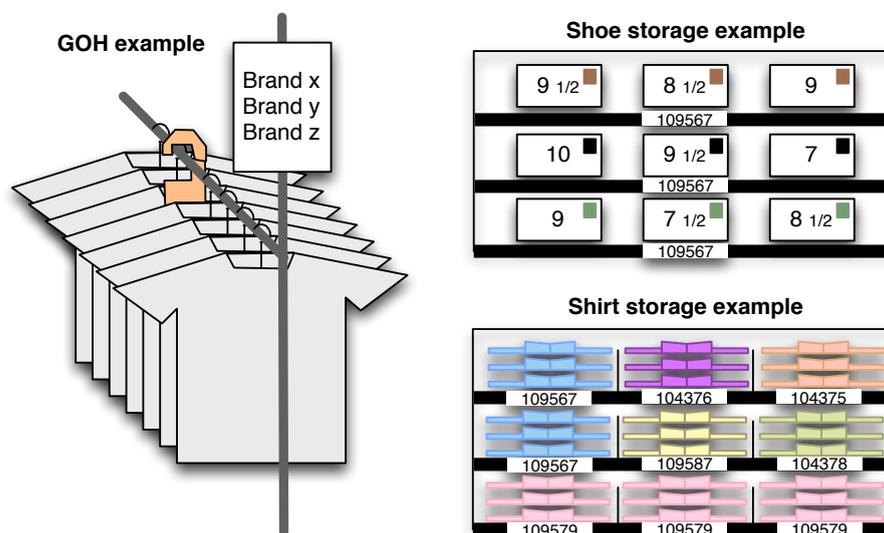


FIGURE 6.6: Example of storage of shoes, shirts and GOH at Company B

#### 5. Returns

The return flow is ultimately handled at the DC. Customers may do returns via mail or via the stores, from which the daily trucks pick up the customer returns (see fig. 6.7). An exception is if the store that received the product actually sells this article in its normal assortment. Then the item can be reinstated into the system and kept in that store. Otherwise, these returns

arrive to the DC in blue boxes from each store. All of them are quality checked and moved in the system to a virtual warehouse, which is not available for sale online. Instead it is a separate entity to allow returns be handled irrespectively to the ordinary flow.

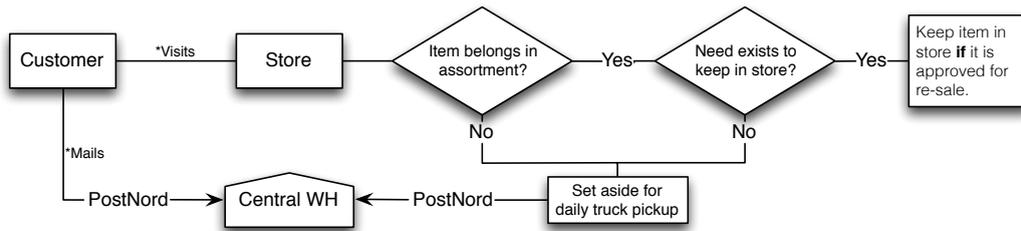


FIGURE 6.7: Returns process at Company B

Company B spends about an hour a day on returns. However, it does occur bottlenecks, e.g. after a campaign. Up to 10-15% returns is not uncommon. If the product is approved for resale they do an inventory transfer of the product to one of the stores that needs it. The transfer is made the morning after it has been sent, around the time of opening all of the stores.

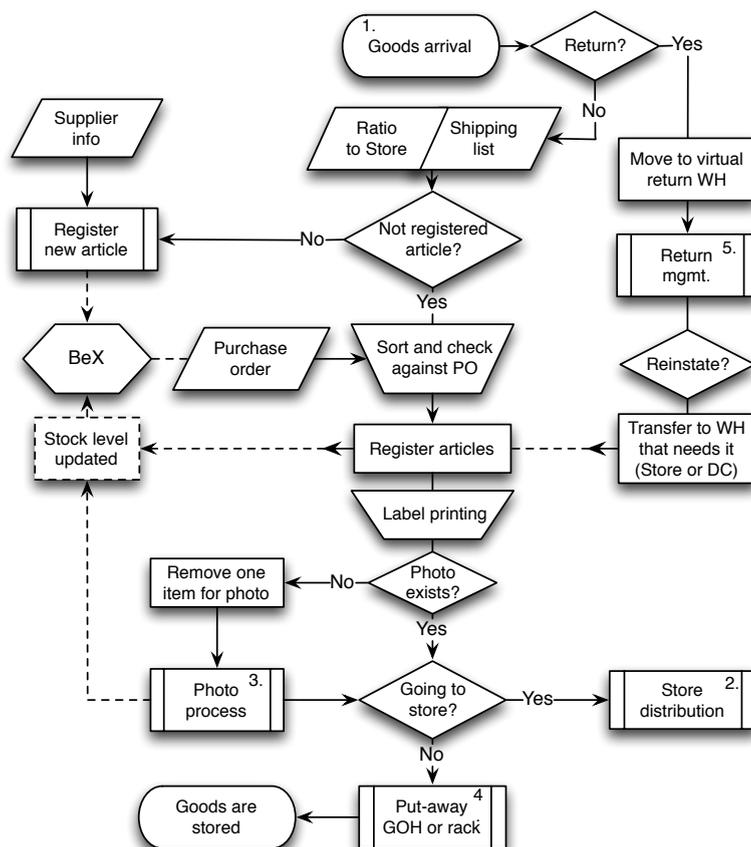


FIGURE 6.8: Inbound processes of Company B

***Outbound (see fig. 6.9)*****1a. Customer order is made / 1.b Store expresses demand**

At peak times, which typically occurs on Mondays, Company B might pick and ship about 600 products from their warehouse. These 600 products are mainly store replenishment necessary after the weekend. Otherwise it averages at 50-60 orders. Each order has on average 2 lines. Either a customer places an order online or a store expresses that they need some set of products. The DC has solved this by having separate picker-teams, where one handles customer orders and one internal orders to stores. For customer orders there is a second aspect when the Web2Store captures items from stores, after which items arrive in blue totes from the stores.

The internal orders for stores may sometimes be set up from an e-mailed purchase list or auspice of the purchase department. Customer orders arrive into BeX after payment has been completed via the web-platform. Since stores also have in-house sales there is a possibility that an item gets sold while a ready-to-purchase customer is having it in its hand. The store customer will get the product and the e-commerce customer need to go through the customer service department and either get its money back or switch to a new product.

**2. Picking process**

Internal orders from the store that are sent as replenishment of specific products are picked separately in an order-by-order manner. The e-commerce orders that are going directly to customers are picked in smaller batches. They use trolleys for multiple orders, which are the same ones that are at Company A's warehouse. The picking procedure is based on following a paper pick-list. The storage policy makes the paper invaluable since they need to look for a lot of parameters on this paper in order to pick the right item. The racks and hangers have paper notes on the end of an aisle indicating what brands the aisle contains, which apart from some location dividers is also the only thing that structures the storage. They don't have any location numbering, only article numbers and the BeX labels that are attached to each item. Once the right brand and article number is reached they need to look for color and then size (refer to example in fig. 6.6).

For those e-commerce orders coming in from stores, the staff manually keeps track of the items' arrivals. A store clerk puts ordered items in totes that are shipped off to the DC and creates an internal transfer order in BeX at the same time. Since there is a daily route the items will arrive during the opening the next day. Back in the DC a picker will in the next day go to the arrived totes and check for the items they're looking for. The internal order is then lift off and the inventory has officially been moved to the DC. The staff also manually checks the correctness of an order consolidation, if that is the case with the order. The products are put aside and a match is made with the help of a delivery note that contains a picture of the product and order

number. When an order is finally done it is registered in BeX, which reduces the inventory of the DC.

As with the internal orders out to stores, the DC has one trolley for each store as a collection point for these products. When shipment time is due, what has been collected so far is scanned to an internal order in BeX for each store and staged for shipping to the stores. The goods are considered moved when the internal order is registered back-office by the receiving store, hence products may still be purchased while being transferred.

### 3. Packing and shipping

When customer orders have been picked and/or collected from other stores, they go through a packing routine. There are instructions on the wall to aid the staff with packing. They try to pack as optimized as possible since they lose a lot of money due to the excess air in the boxes. The company pays the freight carrier for volume-weight, which is why they work towards quitting the use of cardboard when packing and using re-sealable plastic bags. The orders are registered in BeX by manually checking each order off and the order-batch that they're in, which triggers label printing. The package is put in a cage-roller provided by the freight carrier, which is picked up at the end of the day. They have two types of freight methods, MyPack or Varubrev. They use Varubrev more often since it is especially targeted on light products with a value up to 1500 SEK. However, Varubrev is not possible to track along the way.

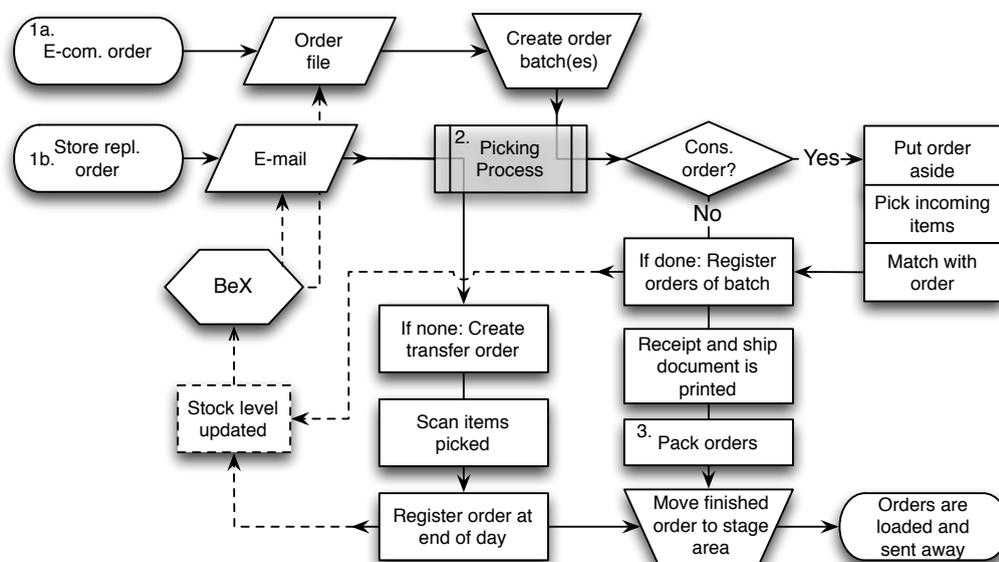


FIGURE 6.9: Outbound processes of Company B

## Observed issues and opportunities

**Supply chain aspects** We identify the possibility that more order-fulfillment capabilities of their stores are to be implemented. Big focus lie on a seamless pick-up-point and return management, which has been difficult when done crosswise. We see that order consolidation capabilities that are more sophisticated than today need to be put in action. This would open up for advanced order fulfillment even in a store. Another important aspect, identified at Company A as well, is the visibility and transparency of orders and items for both customers and staff. Knowing where items and orders are, and whether or not things are sellable, is vital for customer service. Store clerks found it difficult to make accurate decisions, which indicated a lack of helpful information from the system. For instance, filtering for decision making was cumbersome. If the stores are to work as mini fulfillment centers and support sales no matter where things are in the supply chain, proper system support need to be put in place.

**Receiving** Company B have a tricky work image to handle the distribution of a purchase order to its stores. Today they operate according to a ratio-based thinking, where each store has a designated share of a given product. It takes a lot of effort to get this right since the staff needs to remember how many of an article that they have sent off to a store. This gets even more complex when an ordered article may arrive in multiple shipments. The easiest improvement for them today would be to have a system made template that shows how much that is supposed to be sent out to the stores. There are ways of solving this, but the one that becomes most apparent is the ability to systematically check off internal orders from stores in the very same way that customer orders or purchase orders are done. Stores should be able to do internal orders that represents general demand or a purchase order. This should also be possible from the purchase department. In that way, when a big purchase order has been made, there is already internal orders tied to this purchase order and to whom the goods ordered are designated. For a system to know which store a product should go, if it is designated to multiple stores, it is suggested to have a rule-based decision. Company B use a sort of rule decision today, which emphasizes the applicability. The stores could be divided into a prioritization list, e.g. an item related to an internal order for one store is filled before other stores, in the case that there are others requesting this item as well.

**Put-away, picking and other inventory management** If an article during picking is the last of its stock and that article is on its way to be shipped to a store, pickers have to search quite a lot before finding that item. The system does not know that it is there, and it doesn't transfer system-wise until the end of the day but still states it is located in the DC. If the transfer between stores results in items shifting locations to "in-transit" or "in-staging-area", a lot of problems would be solved. It is reasonable that these goods are still sellable, so by preparing a

shipment to a store, only the location of the goods shift inside the warehouse. When the item has been shipped it will say “in-transit” and you will know where it is headed. Then the order can be sent to the store for fulfillment back to the DC, for instance. It should also apply to pick-up orders, that should be easy to find when shipped off and not be available for purchase. The block for purchase applies in particular to the stores, since there is a possibility that an item gets sold while a store customer is approaching the counter. The system should be able to reserve inventory both in the front area and the backroom of the store. Customers could be warned when inventory is low and lies only in the front area. This requires a system that can keep stock units apart in common store areas, as well as have a status system in place.

The only thing that structures the warehouse is the storing according to brand and the lack of location numbering. It forced workers to visit an aisle and look if the brand of the product they are looking for exists in that aisle. By using location numbering, barcodes on shelves, scanners, and the BeX labels on garments, the workflow could be made more efficient and error-proof. It would still be possible to have many sizes of one article number in one stock units location, but a scan of the label on garments could assure that the very right item was chosen. Regarding the put-away and optimization of space utilization, there is also room for improvements. There is a lot of space on many of the storage locations when an article is small and it only exists a couple of that item. They get too much room for their actual consumption. A binning system like Company A’s, or an easily adjustable rack in the system that can accommodate any adjustment would be recommended.

**Packing and shipping** The above mentioned issues apply in this area as well in regards of the traceability of the downstream flow. They need to know where things are in between the handling points within a warehouse and when in between warehouses. The packing does not necessarily need as much attention given that they want to move into a larger use of plastic bags, which also applies if starting to use stores as mini-fulfillment centers. It is more important to know when and where parts of consolidation orders arrive, and what is needed from an operator or store clerk to bring these items together.

## 6.4 Company C

### Background

Company C is a fashion and apparel retailer founded in 2003 in Sweden. They started out as primarily an e-commerce pure player and was in 2007 the fastest growing online retailer in Sweden. They have developed a strong niche in the streetwear segment, which after heavy expansion of the assortment has led to spin-off's in niched product segments. In 2006 they evolved into a multi-channel retailer when they launched two brick and mortar stores in Stockholm. Today Company C operates a total of five brick-and-mortar stores, each store with their its own niche and product assortment.

Following a few expansive years and as a result of a capital investment in 2013, they could acquire an competing e-commerce retailer leading in the alpine/water sports segment. In May 2014 they acquired another e-commerce retailer (Web-shop 2), which functions as a regular web-shop for customers located in Sweden and Norway but otherwise as a shop-in-shop on their original website. The different web-shops use the same administration interface and their inventory are stored in, and orders are picked from, the same distribution centre. Last year Company C had a turnover of nearly 78 million Swedish Crowns. 90 percent of the sales were through the e-commerce channel. Most of these sales were made abroad, spread out across more than 70 countries. To complement the differentiation they have in the stores, Company C's website has been designed with three separate sections which mirrors the product segments it offers in its layout design. The company is aiming for a stronger position in Europe and to push the turnover from 100 million to 500 million Swedish Crowns.

### Supply Chain Characteristics

#### *Products*

Company C offer around 220 different brands on their website and Web-shop 2's selection consists of 180 different brands. In this case many of the brands overlap between the two websites.

#### Significant products

1. Sneakers
2. Clothes
3. Hardware

The sneaker category is divided into different brands. All shoes and sneakers sold are received, stored and shipped in shoeboxes. The boxes differ in colour and design between the brands but are somewhat similar in size and volume. All the shoeboxes of one specific brand is identical between the different models. The only way to tell them apart is by their labels.

Clothes are divided into regular subcategories consisting of t-shirts, tops, shirts, jackets, pants, head-wear and accessories. The main part of the clothes are kept folded, covered with thin plastic and only some of the jackets, also protected by plastic, were kept as garments on hangers. Most of the head-wear posses fragile aspect and are at the risk of receiving crush damage if wrongfully stored, picked or shipped. The accessories consist of a broad spectrum of products. These include common products such as belts, glasses and scarfs but also toys, books, alarm clocks and various other merchandise.

Hardware consist of snowboard skateboard and surfboard related products. Apart from the actual boards this subcategory is also made up of snowboard boots and bindings, and different grips, wheels and trucks for the skateboards. The websites offers the possibility to personalize and manually design your own combinations of hardware. In an handling point of view, hardware is the most challenging in regards to both storing and returns.

### ***Supplier relationships***

Company C has a wide variety of suppliers with the majority of them located in Europe, Asia and USA. The different brands usually have their own supplier. This is the case for the bigger brands while smaller ones could have the one and same supplier. The product collections for a full year is divided into four different parts directly based on seasons. Each season required a new collection of clothes and purchase orders are usually placed 4 or 5 months in advance of its arrival. Purchase managers at Company C study previous product data and sales history to determine the new purchase order sizes. Since retailers of apparel is often divided into tiers by the suppliers the amount of products that Company C are allowed to order might also be limited by these suppliers. If a specific product runs out of stock, they have the possibility to perform a supplementary purchase order of that article if the specific supplier does not decline their order. When the new products arrives they usually come in large bulk shipments. A bottleneck has been experienced to be the sheer amount of products arriving at the same time with each of these larger shipments.

### ***Order-fulfillment structure***

Company C have the main distribution centre for their e-commerce in Stockholm, Sweden. The focus of this warehouse is to fulfill online orders. Company C has both their own and Web-shop 2's product stocks in this warehouse but they are kept in separate locations for fulfillment of individual orders from the different web-shops.

Company C's different brick and mortar stores receives their own shipments of products directly to the stores from the suppliers. They took the decision not mirror the brick and mortar stores different inventory on their websites based on the increased level of complexity that this would involve for the supply chain. This means that the only product available for purchase in the web-shops is the inventory located at the DC. If however a store lacks a product or a size of an product in their own inventory, and that article is available at the DC, all the different store has the possibility to transfer that product to their location from the DC for customer pick up. If a store lacks an item which is available at a different store but not in the DC there is no possibility to transfer that item between stores. It is possible for a customer to order a product in the web-shop and then collect their order in a physical store. Products transferred to stores but not sold will either be sent back to the DC or kept in the store depending on that stores current assortment. Customers can also return their products purchased online in all physical stores.

The next planned step is to integrate the two different website stocks kept in the DC so the company can choose which products should be available at which web-shop. Company C are also planning to start integrate their multiple sale channels by offering customers the ability to order from the website using tablets directly in a physical store.

### **Warehouse operations**

Company C recently acquired their present distribution centre from another company working with e-commerce. The warehouse had a pre-designed layout already and few changes were made. It consists of mainly low-level shelves and a small area with storage locations especially for the large and bulky surfboards. The shelf racks closest to the packing and shipping area are reserved and designed for shoes and sneakers, otherwise the warehouse's shelves are uniform. They have no current data stored on the different dimensions of the shelves. The warehouse is divided into two different levels. The first and largest ground floor level contains all of Company C's stock while the mezzanine level contains all of Web-shop 2's.

*Inbound (see fig. 6.10)***1. Goods arrive**

Larger shipments of new incoming goods arriving to the warehouse is always pre-announced from the suppliers by e-mail. They arrive on pallets and are placed in temporary storage spaces on the floor in the receiving area in the warehouse. Here the products are on hold and divided into boxes until they can be unpacked, labelled and placed on shelves.

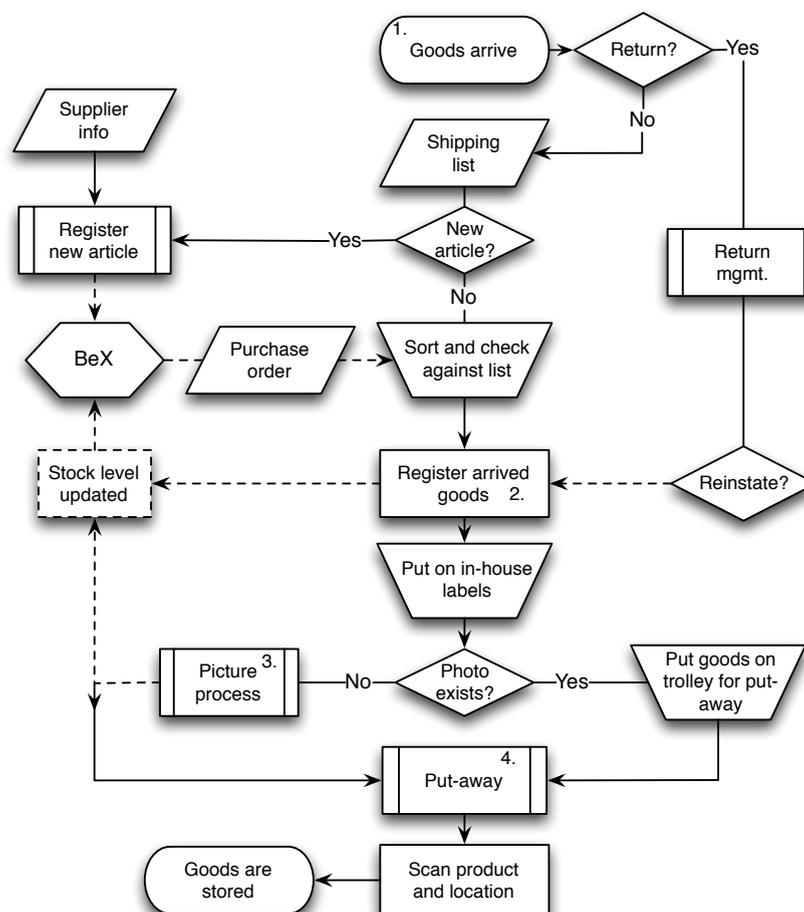


FIGURE 6.10: Inbound processes of Company C

One full time employee register the orders and the new articles in BeX before they arrive to the warehouse and also create a purchase order for the shipment. This employee also saves information in the BeX system regarding certain aspects of the articles such as brand, colour and size. Every article ordered must then be manually found in the shipment and compared to the purchase order. This procedure has proven to be arduous and a bottleneck in the receiving area. Now all the article labels are printed from BeX and placed on the products. When the labels are printed the articles are removed from the purchase order.

### **3. Photography process**

Some articles are re-occurring products with previously stored data as well as a photo connected to them. BeX has no way of telling the user if the product information may already previously been entered which makes double entries unavoidable. If the article lacks a picture one will have to be taken before the product can become available on their websites. The photography process is time consuming since it involves live models wearing the apparels as demonstration. To prevent the articles scheduled for photography to appear in stock before completion, an internal order is made which reserves the products. The products can be placed on shelves in this stage but the available stock will not increase before the internal order is removed.

### **4. Returns**

Delivery trucks arrived each day to the warehouse for collection of orders placed online for store pick-up but also for delivery of both store and e-commerce returns from the post office. Each package is opened and the product is inspected. If found in an acceptable condition, the order number from the return document is entered into BeX. The correct item is chosen from the order list and an e-mail is sent to the customer support division with the corresponding article number and reason for customer refund. As soon as customer service receive and process the refund request the article will be registered in BeX and the stock value will increase. Since the article is not back in its original location it should not yet be available for resale on the websites and an internal order reserving the product is created. This will decrease the stock value and as soon as the article is ready to be replaced on its location in the warehouse the internal order will be removed.

### **5. Put-away**

Company C use a stationary scanner connected to a computer for efficient put-away. To initiate the put-away process, a worker places the articles destined for put-away on a transport trolley and brings a table with the scanner computer on. Unless the products are of the faster moving kind that they keep in a special location near the packing area, these are transported to an arbitrary location in the warehouse. The location numbering is indexed all the way from floor, rack and bay to level and index. Each index on a shelf's level have a barcode, which they can scan and tie to articles in BeX.

BeX does not allow an article to be spread out over multiple storage locations and the goal is to keep one specific article on the same shelf. They lack location dividers on the shelves and they do not utilize any buffer locations. So articles may well take up more than one shelf if they are bulky or numerous.

Clothes usually arrive in convenient boxes that are occasionally used as bins. Accessories and other smaller items occur in lesser volumes per article which usually take up one location and

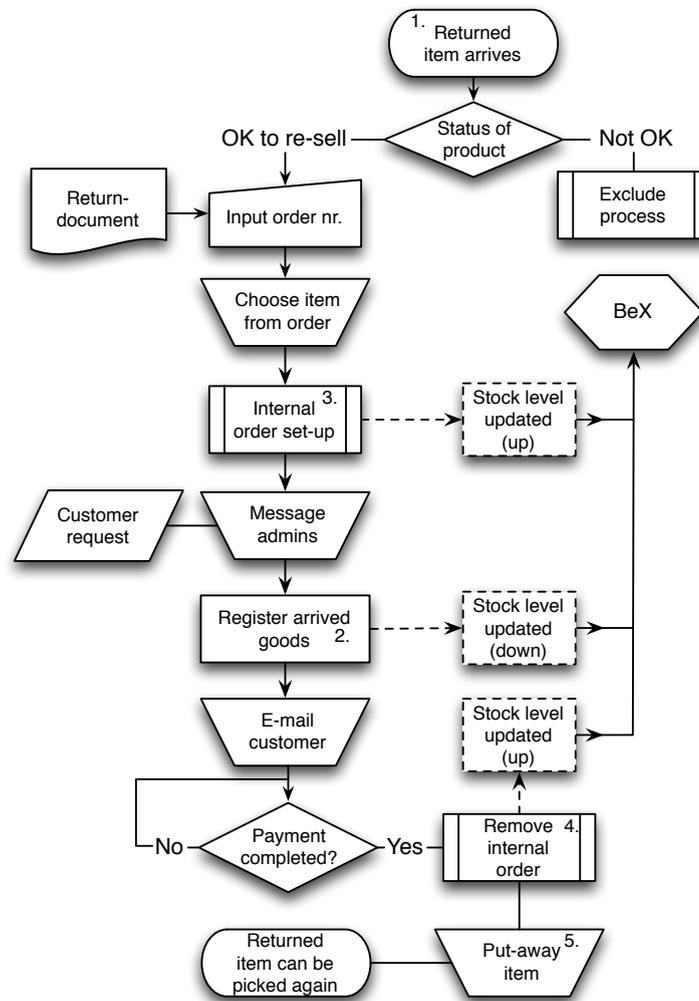


FIGURE 6.11: Returns management at Company C

are not stored in any bins. Head-wear sell in high volumes and they also places specific demands on the way they are handled or stored to avoid damage.

The mezzanine stores a lot of skateboards and skating equipment. Equipment are either just parts or articles sold in packages. The skateboards take up two rack stands, since they are too long for the depth of a shelf. Picking is therefore only done from one side. Each board type takes up one location on the width and is stacked just a few boards high, which leaves a lot of empty space above and possibilities for fill rate improvements.

***Outbound (see fig. 6.13)*****1. Order is made**

A customer may order from either Web-shops 2's or Company C's inventory depending on the web-shop used. These two mirror each other to a quite large extent but is kept in different locations in the warehouse. The order file arrives to BeX after payment is cleared with the web platform.

**2. Create order batch(es)**

The warehouse works with batches of sizes up to 20 orders, which is less than half the size of Company A's order batches since many of Company C's products take up more space. Either order-batches are prepared in advance or workers can initiate one when the need arises. They filter the selection of waiting orders to construct batches that match the trolley that they are using, as well as to make sure you get a route that is reasonable. No batch has orders across the two levels of the warehouse. The mezzanine floor has its own staff and operations.

**3. Pick according to batch**

The printed batch will result in a pick-list. The pick-list has numbers beside each order-line indicating in what field on the trolley to put the orders. As guidance the pickers have a picture, brand, description/color/size of product, and the article number. The article number is also divided into a master part and the individual item's number, similar to Company B. The picker walks with the trolley along aisles and since they are trained to look a few lines ahead in the pick-list they can occasionally put the trolley aside in a cross-aisle to pick multiple adjacent orders.

Because of the storing policy in the system and the warehouse, problems arise when picking an article that is surrounded by similar items or when an item is spread out over several storage locations on a shelf or even on multiple shelves. Shoeboxes of the same brand looks identical and consists of several different sizes and can be both numerous and bulky. An item on a pick list could potentially have been pushed aside by other products and be located quite far from the actual position given by the pick-list.

Given the example in the fig. 6.12, the red and green shoes may have been lying on this shelf for a while. All of the red ones are stored on the leftmost location. The green may be stored in the second one from the left, but could have been shifted to the right to make room for the red one at some point in time. The brown one may have been put-away last and is registered on the rightmost position. Since there is not many left of the green one, the brown is spread out on top of the green one. According to the system, the third position from the left is empty. A few picks later a red one has been picked, the two green ones and three brown ones. According

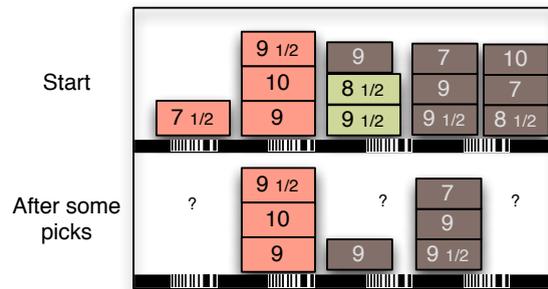


FIGURE 6.12: Shelf storage problem at Company C

to the looks of it there should be two available storage locations (leftmost and rightmost). The system will suggest the same but it will believe that it is the two positions in the middle that are available. This will create confusion in the picking process.

#### 4. Pack orders

When all items on the list are picked, the order-picker will head back to the pack area and register the batch in BeX. This reduces the inventory balance. Usually it is the same person that picked the batch that is packing the orders as well. With the registering, a receipt and freight slip is printed for each order. The worker double checks the orders and packs all of the items into a suitable sized box. Then they're put directly into cages provided by the freight carriers and moved to the loading dock for pick-up.

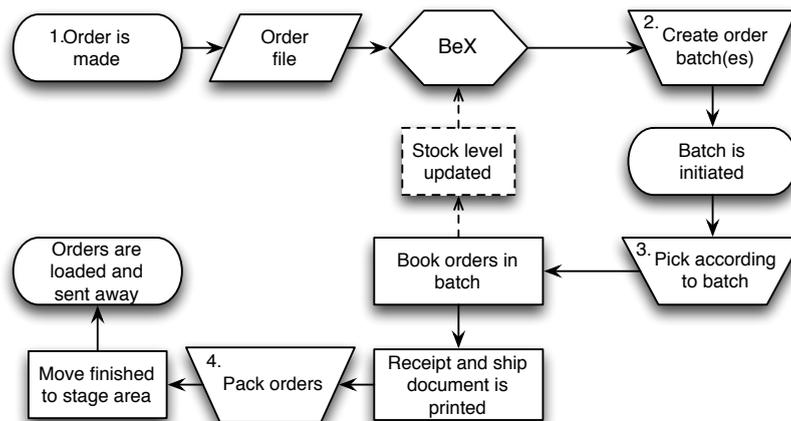


FIGURE 6.13: Outbound processes of Company C

## Observed issues and opportunities

### Supply chain aspects

We see that the boundaries between the Web-shop 2's inventory and the Company C inventory are to be diminished. Both the mezzanine and the ground floor have poor fill rates and there is room for improvements if the two were to be shared. The stores work on a small scale and since they all have differentiated inventories they are not that valuable to each other in terms of inventory sharing. Expanding order-fulfillment capabilities into having orders be fulfilled by many stores is therefore just not that interesting. However, they have progressed into having a modern return handling. Store clerks also believe that they can create additional sales through a seamless return handling. If this concept is to be realized to its fullest extent, the handling of returns needs to be more efficient. This is especially true if Company C are to grow as projected, which will definitely put a strain on the returns management.

### Receiving

The way that Company C uses BeX in receiving creates a need to register an entire purchase order at the same time. This forces the staff to sometimes divide an incoming shipment's order into smaller purchase orders, by creating new provisional ones post-arrival. This makes their receiving easier, since otherwise they would have to sort every article from the entire shipment, which may in fact be spread out over several pallets. It's worthy to note that other companies could progress a purchase order over time, but Company C used other measures to get around this. What they need is a system that can scan and register parts of a shipment while you systematically work through it, combined with the ability to put processed goods into different states. They could then just receive, scan and put-away goods as they arrive, without worrying about internal orders. It is also time consuming to put labels on every single product. Company B needed the labels for the store business, but that is not the case here.

We identify the same need for making the returns management more efficient for Company C as with Company A. Cumbersome papers came in with the item but required a lot of unnecessary manual steps, which could be solved by Web-EDI and the use of barcodes for maneuvering the "cause and request" flow. Returned items were locked and lying on trolleys until they were accounted for and the requested action had been taken by the customer service. The inventory balance faced a high risk to be incorrect, so these items should be either automatically returned to the warehouse among the rest of its likes, or the trolleys could just be temporary locations and the system could support blocking and clearing returned items. Locations could also for instance be included in the pick or put-away route.

## Put-away, picking and other inventory management

We identify the need to have a more proactive preparation for the put-away process. Not just because of the labeling, but also because of goods sticking around for too long in anticipation of the photo process, as well as a lack of direction in the storing process. The system should allow for goods to split and let items take detours for a certain value adding process, while the rest of the goods are stored. The inventory balance should not be affected and the system should allow for notification regarding what the next steps are for both parts of the goods.

They have quite a few recurring products that are also frequent items. They already have something that could be considered an FPA today. We identify the need to be able to store product by affinity, class and/or group. In the case of Company C, they have more focus on different types of products rather than brand, contrary the case with Company B. It would be a powerful concept to be able to (1) have support for zoning types of products, while (2) still being able to investigate best affinity or class storage for items within a type, and (3) to assign these to locations both in a horizontal manner and vertical. The concept also needs to be extended to the routing, since they have some need to make sure that different types of products are picked in the order that is implied by the chosen set of storage assignment policies.

A third aspect is the newer items, that may very well be prone for quick sales. Sometimes the purchase department expects this, but the warehouse doesn't harness it. If the system is storing based on a pick-frequency table, there should be an ability to override this table and insert new items at an index where one thinks is appropriate. It may be according to a sales projection. So the system does not store according to the fresh pick-data, but a modified version which would be controlled by the purchase department. In that way, items that are to be frequent can be stored conveniently already from the start.

The information could be harnessed in receiving as well, since this shipment could get a higher prioritization based on the classes that the articles belong to. If they know what classes that incoming items belong to and they also have class-based zones, then they could potentially designate trolleys for put-away use in a certain zone. So if you receive an item that is a class A item and you have a trolley ready to be loaded for put-away in that zone, then you may just load it onto that trolley directly.

The picking process is quite simple but effective at this current stage. They have a strategic batching and a logical routing. However, their toolbox needs to be expanded. If they know the zones and the characteristics of different products they could do batches that would result in more efficient pick routes. Their pickers were quite effective at the moment as a result of experience. They set their pick-trolley aside and gathered products from a multitude of product locations they knew by heart. But they could potentially save a lot of distance walked if the routing was more (1) scalable, (2) fit the diverse layout better, and (3) support the use of

recommended dwell points for the trolley. The latter could decrease the risk of bottlenecks being created by inconvenient placements of trolleys. A system-based support to indicate where to put each item when they get back to the trolley could save time in local search, reduction of cumbersome paper sheets, and a more error-proof flow. This creates the need to tie orders to the physical locations of a trolley. Today they are given numbers to which slots to put items. If scanning equipment is to be introduced the slots need barcodes and the orders have to be tied to these. It would work in the similar way as a put-to-light system, which after the scanning of a retrieved item tells which slot needs an item like this. Leveraging the trolley as a load carrier that represents some set of states for all items that are put on it.

Because of their mezzanine, they could potentially benefit from being able to distribute a batch to multiple pickers. So instead of having to save the deviating orders to a batch of its own, the orders that span multiple floors or other tricky variants can be picked by two or more workers. This of course puts demand on sorting capabilities, the ability to consolidate orders within the warehouse, and a highly customizable way of storing and routing. Because of their highly differing SKU characteristics, they would benefit to zone by family and sort according to characteristics like weight or fragility. Further, a stratification of products could highly decrease the total distance walked, as well as ergonomical considerations.

### **Packing and shipping**

Usually it is the same person that picked the order that is packing the order as well. We identify the need to pass this task to someone else seamlessly. A worker that wants to continue on its order would need to change its current role to be able to pick the order and pack it. Since Company C do not register batches until they are at the pack station, there is always a risk for goods to be sold even though it is stocked-out, similar to Company A and Company B. There should be an ability to (1) put reservations on items when they have been scanned, (2) save locations or logical places that the items reside in after they have been picked, while also (3) decreasing the available goods that is visible to other operators that are picking. The workers would then know at all points where in the process a product were.

## 6.5 Company D

### Background

Company D was founded in 2011 and is a web-based retailer of skincare and make-up products. The company's main goal is to be able to offer the customer the best products on the market with a guaranteed availability and guidance along the way. Company D has been awarded with the "E-commerce of the year" due to its aesthetically pleasing web-design but also for its highly functioning product choice guidance concept.

The retailer is mainly web-based but have established a clinic for skin-care. It is a location where customers can book appointments to try the products and receive guidance counseling on skin-care treatments. Company D has a wide line of skincare products for both men and women and all products are stored in and shipped from their 330m<sup>2</sup> warehouse. This warehouse is also in connection to their office. Their marketing concept is having various offers on popular products and a very high focus on quality. Their strength is their ability to offer known brands for reasonable prices with short delivery times.

Company D has just as Company B invested in the mobile based business segment of e-commerce. With QR-codes included on flyers and other printed advertisements the customers will be able to quickly access the web-shop and buy the advertised products.

### Supply Chain Characteristics

#### *Products*

Company D handles about 40 brands and 5000 articles of skin care products. There are three main categories and a few sub-categories (seen in table 6.1). The staff is required to have experience and knowledge of the products from the industry, which is why most of them are certified skin therapists. Since one of the main ideas of Company D's business is providing professional advice based on customer's skin profiles and purchases, it puts even greater demands on the staffs ability to know the products.

#### *Supplier relationships*

Company D has today about 20 suppliers, most of whom are Swedish agents for larger foreign brands. There is also one in England and one in Holland. Company D has been around since 2011 and some suppliers have been partners with them since their start while others have joined afterwards. When ordering from suppliers the lead-time averages at 3-5 days. The lead-time

<b>Main categories</b>	Facial products Make-up products Body products
<b>Sub-categories</b>	Serum Cleanser Day cream / night cream Skin types (sensitive, dry, blemished, etc.) Kits (bundling) and gifts Eyes and lips

TABLE 6.1: Main and sub-categories of Company D's products

from abroad suppliers may go up to 10 days, but these are typically larger and infrequent orders. Usually the ordering for future campaigns is done some time in advance. Sometimes they do reservations with suppliers a quarter of a year in advance. Since their suppliers sit on most of the stock, which covers about 6 months of inventory, Company D does not need to procure any large collections either. Instead they work more on a daily basis with purchasing. To manage and plan the purchasing they use demand statistics across the products of a brand. This is to identify the type of products that should have more emphasis put on them. The ambition is to always have all products available to achieve fast delivery to customers. Currently they have a level of finished goods that lasts about 1-2 months. To counter the risk of having stock-outs, they make estimations for all products up to about 30 days back. The risk of stock-outs is not analyzed with respect to potential costs, but rather from a quality point of view.

They use the purchasing and demand planning functions in BeX, but no automatic economic order quantity calculations. Instead this is done manually. The main reason is that they are dependent on campaigns and similar, so they need to stay on top of things. The product offering they have today is manageable in that sense, but it is unsure what the coming years of growth will demand out of their capabilities. The products are very trend sensitive and market factors control a lot. However, Company D tries to control this by using blogs, campaigns and newsletters. Peak season occurs during the autumn and around Christmas.

### ***Order-fulfillment structure***

Company D has one warehouse. Here all merchandise arrives and leaves according to an order-to-stock strategy following a customer order on the website. The warehouse is connected as an extension to the office mainly because of the dynamic capability to distribute staff as needed. This has been especially helpful at times of larger campaigns and peaks. The customers order their products at the website, which is connected to BeX. They work with a lot of customer service via the website. There the customers can make skin tests and study skin guides, just to get the full store experience. Freight is the main option and is of no cost for the customer.

There are two freight company options; Posten and Schenker, both of which picks up one time a day. Customer pick-up at the warehouse is rare, since it is then usually to try products in their clinic and get skin-care advice.

A powerful tool of Company D is the use of their newsletters. It works as a great complement to their website to put any of their current campaigns in the spot-light. The campaign structure is made up of two campaign windows that are two weeks long. They run from the 1<sup>st</sup> to the 14<sup>th</sup>, and the 15<sup>th</sup> to the 30<sup>th</sup> of a month. There are usually 10-15 active campaigns per campaign window. Furthermore, there is a special offer campaign every weekend, for which they do a so-called weekend pick. The heaviest days are Sundays and Mondays, while the mildest one is interestingly a Saturday. They can get all kinds of order statistics from customers. Directed marketing is of interest but is not in place in neither newsletters nor picks to order from previous customers.

### **Warehouse operations**

Their shelving system consists of only man-size shelves with about 6 levels and sparse depth. As mentioned earlier, there are about 5000 articles across 40 brands. These have a collected value at about 8.5-9M SEK. Given their turnover, they have a fairly quick turnover rate. The articles are small sized, and most are contained in their primary packages. Since skin-care products are semi-perishable (best before date is from time of opening), there is a need to use the FIFO storage principle.

Company D's emphasis on customer service stands out in comparison with the other study objects. Especially in terms of VAS activities and allowing customers to make changes to their orders. The pack and order preparation area corresponds to about 30% of the storage area. It is unclear what will happen if there are any larger growths to the turnover. Their edge is their use of expertise in fulfilling orders, and growth would test the warehousing capabilities as well as ability to grow organically.

***Inbound (see fig. 6.14)*****1. Goods arrive**

The first step is when goods arrive, which is either from suppliers or customers, i.e. returns. They only have about 1% returns, which results in about 3-5 returned shipments coming in daily. When this happens, the products come with any of the two freight companies. Returns are handled separately in an administrative office, where they are assessed for potential reinstatement to the warehouse. Customers always get full refund for returns, so this is a process that is always undergone. The staff working with returns management devote about 4 hours a day for handling the returns that come in.

For regular goods coming from suppliers, the average shipment size spans from just 3-4 boxes to 2 whole pallets with boxes. At peak times 5 pallets are common. The boxes contain varying numbers of articles. Each carton in this box contains anything from 10 to 50 eaches and may have more than one article number in them.

If there are new article coming with the shipment, an Excel file containing its information has usually already been sent to them in advance. This has the main information, e.g. article number, EAN, purchase price, supplier number, etc. Extra information that is useful to Company D is added in BeX. They have their own convenient article number structure when they create new ones in BeX. The first 3 numbers indicates what brand the article is of. The next number indicates its main category. The rest of the numbers give sub-categories and stepwise other information they need.

The boxes are unpacked into their eaches and primary packages. The unstandardized cartons is one reason why scanning is not used in receiving. Not all boxes coming in have standardized labels either. Today all of the goods are sorted and checked manually against the purchase order in BeX and the shipping list. If all is OK the arrived goods are registered in BeX at this point. The goods are then ready to be put-away.

**2. Put-away at respective brand's shelf**

All products are sorted according to what brand they are. This is for convenience reasons, since it facilitates the work for the pickers. They are not put in any containers or master cartons either, so the pick face is pretty much like a store front with a lot of primary packages facing outwards. They rely on EAN codes on product eaches and also the in-house labels from BeX that they have put on the shelves. They do not have any location numbering so these labels represent the location for each article, and hence resembles dedicated storage (apart from the system not knowing where the product is stored in the warehouse). This is very much like Company B's situation. The FIFO principle is important for Company D, and to work by this

they simply put the incoming products in the back of their respective shelf. If the shelf is full, the rests can be put as a reserve on top of the rack.

Brands that are requested frequently are closer to the packing area. However, there may very well be slow movers within a popular brands shelf section. There may also be several variants of an article, e.g. many variants of a specific lipstick. Because of the gains in easier location of the right variant for a customer with the organisation they have today, there is not much incentive to break this structure.

If a customer buy a product from one brand, it will get samples and gifts according to what type of product is ordered and what brand it belongs to. So basically there are (1) regular products, and then there are (2) sample products and (3) gift products. These are usually stored very close to the packing area, The sample products are the only ones that BeX do not have any balance of as a stock.

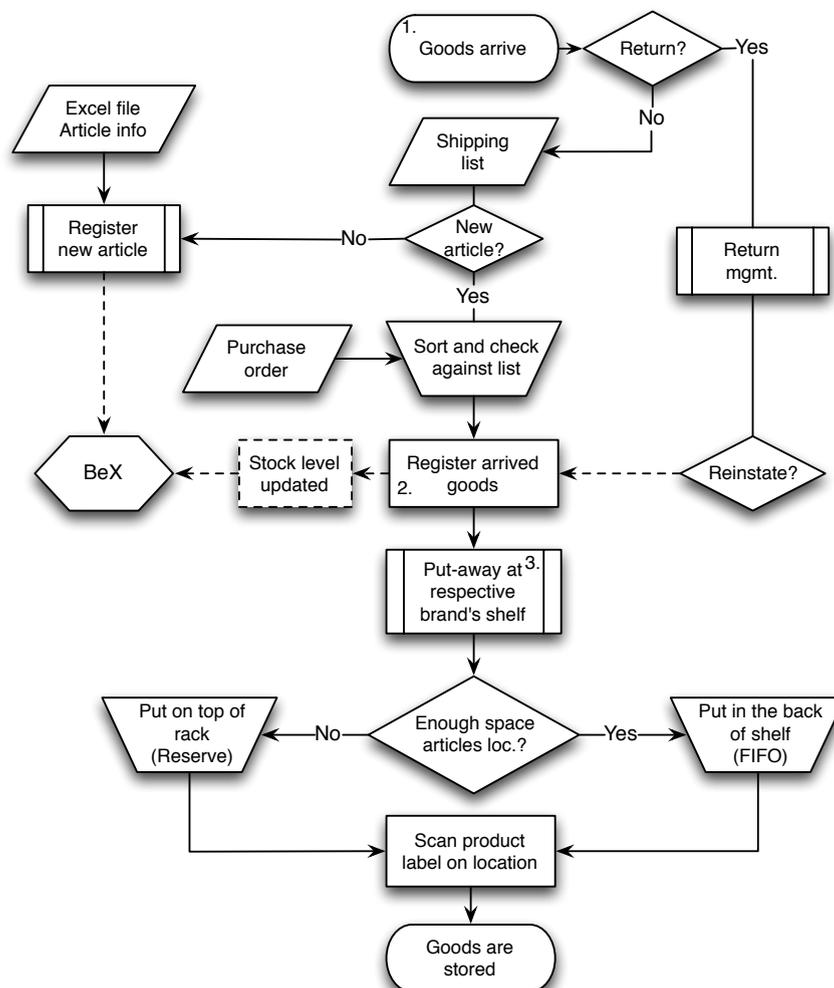


FIGURE 6.14: Inbound processes of Company D

## Outbound (see fig. 6.16)

### 1. Order is made

Company D receives and sends 500-1000 orders per day. Since they are mainly an e-commerce business only the warehouse flow is quite trivial. What makes it a bit more complex is their VAS to increase the quality that the customer will perceive and experience.

As mentioned earlier, customers make their order on the website, from which the e-commerce platform communicates with BeX. Customers may pick deals that involve free gifts. They may also accept getting samples and other gifts. Samples are not included in the pick list, but the gift they were promised is.

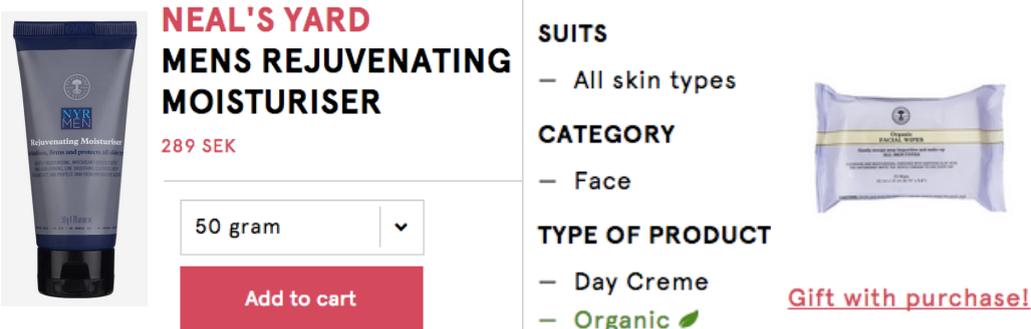
### 2. Order-pick is initiated

When a order-picker decides to commence a specific order, the order first gets registered in BeX. This reduces the balance of the products in the order and also prints a receipt, i.e. a shipping list. The receipt is what the order-picker follows when picking the order. The reason is just convenience. When they will go over to using scanning and handheld equipment they will switch to picking lists from BeX.

Orders are picked in an order-by-order manner. Mainly since batch picking would most likely make the VAS aspect of the order more difficult.

### 3. Value added services

By picking specific orders they can use their expertise better when actively matching the customer with samples and gifts. As stated earlier, this is a kind of directed marketing. For instance, if you bought facial cream, the order-picker might think it would be appropriate to complement the order with a cleanser or eye cream. Then a sample of this is added to the pickers basket on the go. This is a very important detail in Company D's revenue model.



**NEAL'S YARD**  
**MENS REJUVENATING**  
**MOISTURISER**  
 289 SEK

50 gram

Add to cart

**SUITS**  
 – All skin types

**CATEGORY**  
 – Face

**TYPE OF PRODUCT**  
 – Day Creme  
 – Organic

Gift with purchase!

FIGURE 6.15: Example of offer with a gift at Company D's webpage

Another important part of this quality thinking is the adding of gifts and packing of the order. The customer gets a myriad of extra things added to the ordered products, apart from the customer specific gifts and samples just mentioned above. Company D has a firm belief that this ensemble gives a shopping experience you would probably struggle to get anywhere else.

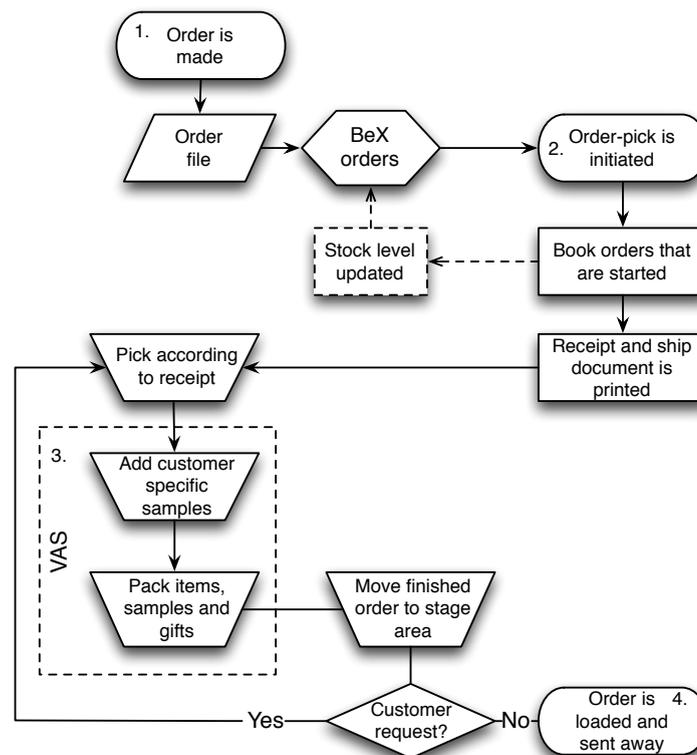


FIGURE 6.16: Outbound processes of Company D

#### 4. Shipping

Since the registering of the order is already done before picking it, there is no need for system interaction at this point. When the worker is finished with packing and freight labeling the order, the package is moved to a small staging area. This is not at the shipping dock, but instead just by the pack area. This is to easily change any order, e.g. upon request from a customer. The freight companies come by in the afternoon and pick up the pile of packages, which are then sent off for a 1-3 day lead-time before getting to the customer.

## **Observed issues and opportunities**

### **Supply chain aspects**

We identify a less likely expansion into more warehouses or store due to their close connection to customers with their high product expertise. However, the popularity of their services may very well lead to an expansion into a new warehouse due to an increased demand. Since it might be hard to find the right expertise for warehouse operators it would be superior to have a system that can lower the threshold of what constitutes as a qualified worker. A lot that goes in an order-pick is the skin care expertise, which is input knowledge that a system might not have. But it could remember and track which combination of products that have been picked previously. Association rule finding and affinity analysis could facilitate the VAS activities. By letting the system learn, from actions or manual input, what product combinations that generates a certain sample, pickers could be given tips and guidance that lessen the need for previous knowledge.

The dilemma with a system set up such as this is that the free samples included with every purchase are not accounted for in the system nor are they connected to any type of order. This complicates matter for association finding in the system and manual input of sample and product combinations will have to be necessary. This could be done by including the different samples into the system and then adding combination as the ongoing order are processed and packed.

### **Receiving**

Since they have a preference of working with the FIFO principle, it would be advantageous with a lot management system. Either these are created at the supplier or it can be tied to the shipment and purchase order as they were received. The specific criteria used to create the different lot batches would most effectively be to divided them according to arrival time to the warehouse or by expiration date of the product.

They have staff that spend a fair amount of time per day with handling returns even with their current low amount of returns. If the amount were to increase this structure would become unsustainable and system facilitation would be required.

### **Put-away, picking and other inventory management**

Since storage based on brand has proven to be quite an effective strategy for Company D so far they are highly likely to continue using that set up. However alteration and improvements

could be made. By dividing products according to pick frequency and dividing the rack in zones a golden rule system could be created. High frequency picks should be placed in the middle and most easily accessible shelves and lower frequency picks should be placed at the top or in the lower parts of the shelves.

A problem with storage divided according to brands was, as also experienced at Company C with shoeboxes, that packaging of the products within the same brand was quite uniform. Different products only expressed few variations in terms of size, colour and branding, and when stored together they could create confusion. An inexperienced picker had to closely examine the entire article number for each pick to avoid errors.

Their strong focus on value adding makes an interesting factor to the system, which could leverage the CRM part of the system and customers' purchase data. For instance decide things like what they need (as discussed in *Supply chain aspects*), or have an event-based feature that can send directed mails to customers when their products are likely to have run out. Since skin care products are consumables they usually only lasts for a set amount of time if used regularly. The consumption time will highly likely vary among customers depending upon their individual usage and type of product. If types of products were also categorized in the system based on average consumption time the process of contacting customer at the point where their product supply is starting to diminish will likely be more effective. Customer feedback can then be used to alter the product type consumption time. Alternatively the customer contact point can be based of product expiration dates if a lot management system is in place.

### **Packing and shipping**

Company D offers a number of kits on their website. These kit consist of packages of different product that should constitute all the essentials products needed for different types of beauty and skincare. As in the case of Company A, when selling kits of products the only way to guarantee that all the product included in a kit is available for purchase is to implement a kitting function in the system. By adding master items and their responding sub-items all product included in the kit will be reserved from purchase and the kit order can be fulfilled.

Company D pre-packs their kits which will make all the products in the kit unavailable for individual sale. If the pre-packed kits are sold out the inventory balance will read zero even if the corresponding products are available in stock.

## Chapter 7

# Cross Case Analysis

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*This chapter will be a cross-case report based on the case studies. It will use the mapped core functionalities in a WMS from the theoretical framework to find and analyze patterns in the warehouse operations and WMS utilization of the study group. Each cross case analysis section will be precluded by a summary table of key data collected during the empirical study. The cross case analysis will be conducted with the ambition to confirm theory and to elicit the requirement patterns in the case subjects warehouse operations*

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### 7.1 Cross case considerations

This cross case analysis will identify and address patterns in the demands and needs for the study subjects and the reflections are based on a perspective of identified fulfillment and omni-channel capabilities. The analysis will be structured around identified WMS key core functionalities in section 4.3. The authors have chosen to exclude Task management and Inventory Management as individual sections of analysis. This is based on the fact that both these WMS core functionalities are partly integrated into other functions or contain areas that are irrelevant or obsolete in an analysis perspective. Task management involves making process activities into tasks that can be distributed to operators which is not relevant for this thesis. Inventory Management mainly incorporates functions that handles cycle counting, demand planning and visibility of products. Cycle counting was an area without identified issues and no relevance in an omni-channel perspective. Demand planning was functioning sufficiently at the case subject and was deemed hard to systematize due to the products volatile demand and low rate of reoccurring articles in the warehouse. Product visibility is thoroughly covered by other core areas included.

TABLE 7.1: Fulfillment capabilities + Core functions :: Receiving mgmt, Across-dock-mgmt

Core function	BeX Support	Company A	Company B	Company C	Company D
Fulfillment capab.	E-platform integration Web2Store PuP through WH transfer Cross-channel returns*	Website Little backroom space and lack of organization Flagship store PuP Showrooms the inventory Returns only store sold	Website Reserve issues PuP in one of stores Stockholm + country stores Cross-return project in one store	Website Stores don't share inventory WH Next day PuP in one store Differentiated stores Returns via respective stores	Website Store in connection with WH Mainly freight only Showrooms and give advice Last minute changes & unconditional returns
Receiving mgmt	Article mgmt Returns mgmt PO receive progressively Receive w. scanning	Scanning against PO Articles spread across boxes PO spread across shipments Tries to plan labor Tries to prioritize among shipments Difficult document mgmt in returns Lack of visibility from returns Lack of visibility from received shipments Appointment problems	Manual comparison of PO Articles spread across boxes PO spread across shipments Saves rest from cross-dock and/or new articles Tries to work with FIFO Uses virtual WH for returns handling Transfers items back to stores after returns process Little visibility from processed returns	Manual comparison of PO, makes smaller temp. POs Articles spread across boxes PO spread across shipments Stages in wait for photo and/or labeling Time-cons. return mgmt w. many manual steps No visibility in return Returns may be stuck in return but stored at other loc.	Manual comparison of PO Articles spread across boxes Time-consuming return mgmt
Across-dock mgmt	Internal order setup Scanning onto internal order	Sells goods to/from store Siloed store	Distribute to stores by ratio Collects what's requested through orders or email Scans onto internal order Internal order trigger after workday Visib. and traceability issues	Stores served by suppliers Can serve stores with smaller exchanges	No cross-dock

## 1. Fulfillment capabilities

The fulfillment capabilities differ between the companies, mainly because of their supply chain structure. They all have the typical order profile of smaller orders and a need to batch orders, as suggested in (Fortna, 2014). Company B is the only retailer that has both multiple stores and website with shared inventory. This is made possible with the BeX Web2Store functionality as well as a overview visibility of the stock balance across inventory locations. However, the inventory has not been more granular than that, causing errors in various situations. Company C have differentiated stores instead with their own inventory. However, both of these companies have similar returns capabilities. Company C have pick up as well as returns in their stores. Although, they promote the regular freight service for returns. Company B distinguishes themselves with a new project which supports cross-channel returns through stores. This is considered one of the main traits in the omni-channel paradigm (McBeath, 2012). Company A's flagship store is rather siloed because of the separate financial structures of the store and the warehouse, which is a critical hindrance from conducting more advanced fulfillment operations (McBeath, 2012). Their returns handling concerns store sold products only.

Company D, with its connected store, has more focus on the showroom aspect in order to contribute with their expertise. It also goes in line with the omni-channel theory for typical e-tailers that decides to enter store channels on a showroom basis (Lockton et al., 2013). Overall they have a big focus on customer service, which is recognized in their dynamic and flexible VAS and unconditional returns. The showroom aspect applies for Company A as well, where they offer selected products from the website combined with computer stations for easy web-shop access at the store. Company C is investigating to utilize the same aspect, while Company B are already doing it with mixed success. They use tablets in the store, which are more prone for theft than stationary computers. However, one concern in the fulfillment of products that reside in one of the stores is the reservation related issues. An item may be sold to an e-commerce customer and to an in-store customer simultaneously. The inventory visibility has many different facets depending on fulfillment capability, but one of the main issues for these study objects are evidently a lack of visibility in stock units (due to the lack of floating location storing), which has been identified as a key factor in the literature (Churcher, 2009; Napolitano, 2013; Partida, 2012). A lack of traceability for orders was also identified which will lead to issues when conducting order consolidation in stores and warehouses. If orders are to be fulfilled from multiple shared inventories, order consolidation will have to be facilitated.

## 2. Receiving management

Company A distinguished itself among the others in terms of planning and appointment scheduling. This was to be expected because of their size, since they operate under several brands and

house a fairly complex warehouse. The matching pattern was the difficulty in getting suppliers to comply with appointment standards created by the retailers. Company A pioneered among them by having a template that is getting accustomed by some of their suppliers. This allows them to narrow the delivery window and establish a higher certainty of what is to be delivered. With simple historic statistics and flat rates on receiving, a crude labor planning could be done. The other companies could leverage their dynamic workforce capabilities of still having quite small warehouses. However, the problem for all companies was estimating the utilization rate and having appropriate tools for efficient handling of sudden surges of inbound flows, that are common with this type of retailing supply chain (Ferne and Sparks, 2009).

Despite a provision of certain receiving functionalities from BeX, there were quite differing patterns in the use of scanning and shipping lists. Mainly the check of a purchase order was done manually against each cartons shipping list. It was only Company A that had started utilizing a stationary scanner to receive goods in the system. With this they could also check off parts of shipments as they go, which has been a key feature to be able to handle the large inflow of pallets. This very feature was also utilized differently with the other companies, where Company C made temporary purchase orders to allow for receiving the goods that has been received at a given time. The common denominator across the companies was getting shipments from one purchase order over longer periods, which in the case of Company C caused a lot of issues in making sure the right items are received and in the right quantity.

For Company C it was important to use staging as a means to keep track of what has been received, labelled and have had their photos taken. The goods staged did not have any particular position tied to them. Mainly because of the lack of ability to have many stock units of an article in the system. This caused a lack of traceability and visibility, which for the same reasons was identified in the other companies as well. When items were to head to the returns department or for a photography process, it affected the correctness of the inventory balance for the rest of an article, as well as caused a severe lack of visibility and traceability. Not until the goods had been registered on some shelf they were traceable, so the receiving areas consisted of a lot of paper-based document handling. Company B solved this problem by using the ability to create multiple warehouses in the cloud-based system. One warehouse was simply used as a returns warehouse, to which the returns were transferred once they arrived. This made sure that these items could be processed without affecting the other items in the stock of that article, and was also not available for sale to customers. This resembled putting block for sale on the reserve items and having a separate stock unit, as supported by best practice WMS (Richards, 2011). However, the problem was still visibility because of the siloed inventory, and it was also rather cumbersome to make the transfers between the warehouses.

Overall, the returns handling was rather time-consuming in all of the study objects. This has been identified as a critical factor when the company is growing since it is hard to scale this

activity (Cole, 2012; McBeath, 2012). The interaction steps with the system were plenty and very manual in their nature, i.e. a lot of copying and pasting. Time was not the only aspect. The unstandardised process of handling the returns, the lack of instructions, the poor communication between customer and the retailer, were issues identified with all of the study objects. There was a clear and outspoken need to allow the returns documentation to be handled more efficiently, which is in line with Cole (2012) that emphasises the need for guidance of customers and operators through a returns process.

### 3. Across-the-dock management

BeX have support for setting up different kinds of internal orders depending on the customer needs. This function is quite influenced by the accounting aspect of the ERP system and resembles more of a financial transfer than a stock transfer. Due to the study objects' differing supply chains, cross-docking related activities were mainly observed with Company B. They used the central warehouse as a DC and had an active flow to and from the stores. Company B used mainly a "push"-based retail distribution, where incoming shipments from suppliers were distributed right after goods receiving. This is also identified as a trend among these multi-channel actors, as they can allow the DC to be less complex by offloading space consuming goods on to warehouse nodes in their supply chain (Napolitano, 2013). Company B creates a ratio by which a purchase order should be distributed to their stores. This process mainly consists of manual labor and is not an exact process. They use scanning to add sorted products to the tally that is to be shipped away to stores. This is both prone for errors and have shown to lack visibility and traceability. As identified in section 4.3, these put-to-store or cross-dock activities usually follow some internal order that is matched with the incoming goods. However, this is not supported as of today.

As for the other companies, Company A's flagship store is quite siloed because of the financial separation. The exchanges that are made consist of a sale between the warehouses, rather than a transfer. BeX supports integration of channels, adding to the fact that the authors identify the possibility of this company expanding its store concept in Europe. This will create a need for proper cross-docking capabilities. Company C had some exchange with their stores when it concerned smaller replenishment orders, but mostly these were served by suppliers. Company D differentiates with their store connected to the warehouse. They are very likely to grow, but it will more likely result in just a bigger warehouse. This is in line with the theory around common "pure-play" e-tailers (Lockton et al., 2013).

TABLE 7.2: Core functions :: Put-away / Location mgmt, Batch &amp; Wave mgmt, Replenishment mgmt

Core function	BeX Support	Company A	Company B	Company C	Company D
Put-away/Location	Shelf location management Location transfer Scanning enabled Dedicated storage assignment policy only No system directed tasks	Bins all products (3 sizes)  BeX barcode on bins Scans at put-away Multiple stock units / bins in one shelf location Random put-away, articles may be spread out Home-made loc. numbering	Shelves and GOH  Only article number on shelf Doesn't scan at put-away Multiple article numbers in one shelf location Brand put-away, articles may be spread out Aisle numbering according to brands	Bins some, mostly loose and without dividers LPN barcode on shelf Scans at put-away Differentiated stores Random put-away, articles may be spread out Standard location numbering	Eaches tightly side by side  BeX barcode on shelf Doesn't scan at put-away Showrooms and give advice Brand put-away, slow articles hogs space Home-made loc. numbering
Batch & Wave	Batch mgmt Filtering on ::  Product group  Size (min, max)  Order type  Date etc	70 orders / batch Uses 1 trolley per batch  Filters out baby trolleys, car seats etc.  Lists overall randomized because of storage policy Automatic assigned order to trolley compartment	More sporadic batch sizes Internal/replenishment and e-commerce orders Brand and product type  Becomes zone-based because of layout	20 orders per batch Uses 1 trolley per batch  Filters out bulky products  Lists overall randomized because of storage policy Automatic assigned order to trolley compartment	Picks order per order More concerned about VAS
Replenishment	No floating location storage support Only manual replenish is possible No FPA support	Need some replenishment, no special buffering Could need both stratification and FPA replenishment Need to re-optimize since fast items create air	Low quantity of each item, little replenishment needs Could need stratification more A lot of vertical shelf space today, need more granular space instead	No replenishment, spreads article across shelves Could need both stratification and FPA	Replenishes from above, not much pick face space Could need both stratification and FPA Could easily calculate optimum replenish level, shelf gives each width and depth

#### 4. Put-away & Location management

None of the companies have any kind of system guidance for the choice of efficient storage location in the put-away process. The process is simply based on a very general warehouse storing policy. The BeX system is limited to dedicated storage and only supports storage of one stock unit of an article. Company A and Company C are the only two companies that utilize scanning equipment and they might receive instructions from the system of where to place an article if that same one is currently located and stored in their warehouse. But this was not based on any criteria but simply on where the product had recently been randomly placed. When inventory levels of that article reaches zero the system will “forget” the location connected to that product.

Company A use a portable laptop scanner for the put-away process and since they have no possibility to scan the different shelves they have to, without error proofing, use manual input of products storage location into the system. Company C have a stationary computer on a portable table, as well as barcodes on the shelves. These can be scanned and have articles tied to them for a specific location in the system. However, all of the companies displayed occasional or frequent lack of location dividers between the positions. This makes it possible for articles to shift positions. Company D has BeX labels to mark the different shelves, but utilizes no scanning process, no shelf dividers or no actual input of article locations in the system. Company B does have some dividers between the shelves but do not tie their products in any way to locations in the system. Overall, this pattern both means they have no possible way of tracking misplaced items, and it means having order-picking activities that are very prone to have a large share of local search.

All the companies use a sort of random (floating) location storage on top of the system’s limited setup. In accordance with theory the storage decisions in floating storage are usually taken by either the system or the operator usually in combination with other storage policies ([van den Berg and Zijm, 1999](#)). For these companies all the decisions are taken by the warehouse workers during the put-away. But since the system can only store an article in one location, the articles tend to lie in clusters close to each other across the sections of a shelf. Company A’s storage is randomized except for a few dedicated storage locations used for bulkier items. All of the companies used family storage of some kind. Company C differentiated with taking into account the similarities in characteristics, dimensions, frailty and handleability. Concepts that are identified in theory ([de Koster et al., 2007](#)), but with a lack of system support for it. Further they try to store more frequent items in convenient locations, but the cluster effect makes an unreasonably large chunk of convenient areas consumed by few articles. According to theory, this is a good case of introducing replenishment theory. However, it is based on the ability to store an article in multiple locations, which the system is lacking.

Company D store their products according to brand. They have no class storage and no decisions based on turnover or pick frequency. Fast and slow movers were stored together in equal quantities, which opens for similar replenishment opportunities as with Company C. This was also seen with Company B who simply divide their entire warehouse into two parts (men and women clothing and have the rest of the storages based on brand). Identified across all companies is a way to take an ergonomics aspect into the picture. The low level shelf systems obviously opened for having either reserve products in the high and low levels. Having slower items placed there would serve as one purpose, which relates to the golden-zone thinking.

There is no real uniformity or system guidance to be found across the different retailers in regards of storing methods. Company A utilizes plastic bins in three different sizes, Company B uses the cartons the clothes arrive in or garments on hangers. Skin city just places the product on shelf in the condition they are at arrival, and Company C just places the products on the shelves or uses garments on hangers.

## **5. Batch & wave management**

All the companies except for Company D utilizes batch picking. The size of the batches constructed and the criteria of filtration between orders for batch assembly will vary however. Company A batched up to 70 orders and filtered out all types of baby trolleys and car seats. These orders were then separated and used to combine smaller batches. In the case of Company B they picked internal store replenishment orders separate and the e-commerce orders were batched into small batches. Company C did batches of less than half the size of Company A's mainly because of their larger and bulkier products. Also in this case as seen at Company A, the largest products like surfboards were kept on separate smaller batch lists. There was a need from these companies to expand the filtering functions based on more possible storage policies. Company D simply picked order by order to be able to ensure that VAS was handled correctly with every order. The companies had to manually estimate the time needed to complete the batches. There is no system support in place for the ability to divide an order-batch into parts so that operators can cooperate in the picking process by picking separate parts.

## **6. Replenishment management**

Because of the lack of support for floating location storage policies, BeX doesn't allow tracking of multiple stock units in a warehouse. This is the essence of replenishment functionalities, since it is based on having stock units reserve area and fast-pick area. The consequence is naturally that none of the study objects used any replenishment theory. However, since it was needed to buffer some items due to their quantity, this was done manually and was very error prone. All of the companies showed evidence of having temporary buffers on top of the shelves.

TABLE 7.3: Core functions :: Pick &amp; Pack mgmt, QA &amp; VAS mgmt, Shipping &amp; Manifesting mgmt

Core function	BeX Support	Company A	Company B	Company C	Company D
Pick & Pack mgmt	<p>Pick route planning, possibility for scanning</p> <p>Order placement indication on trolley</p> <p>Prints shipping labels when batch is registered</p>	<p>Average 500-700 order picks/day</p> <p>Uses pick trolleys with 70 order slots and baskets</p> <p>Store orders and customer orders are picked separately</p> <p>Paper based picking list, Register a completion</p> <p>Packs in plastic bag or box</p>	<p>50-60 order picks/day, peak times 600 products for store replenishment</p> <p>Uses pick trolleys with 70 order slots</p> <p>Store orders and customer orders are picked separately</p> <p>Paper based picking list, register at completion</p> <p>Packs in plastic bag or box</p>	<p>Average 300-400 order picks/day</p> <p>Uses pick trolleys with 70 order slots</p> <p>Separate pickers for different floors</p> <p>Paper based picking list, register a completion</p> <p>Packs in differently sized boxes</p>	<p>Average 500-1000 order picks/day</p> <p>Pick in baskets</p> <p>Register order directly, pick by shiplist</p> <p>Packs in differently sized boxes</p>
QA & VAS mgmt	<p>Internal orders can be placed on items to reserve them from sale</p>	<p>Photography process for new articles</p> <p>Article removed from re-minding stock during process</p> <p>No live models for photography process</p> <p>Items awaiting photo, manually marked kept on a shelf</p> <p>Internal order placed on these items reserve the stock</p>	<p>Photography process for new articles</p> <p>Article removed from re-minding stock during process</p> <p>No live models for photography process</p> <p>Items awaiting photo, manually marked kept on a shelf</p> <p>These items are available for sale</p>	<p>Photography process for new articles</p> <p>Article removed from re-minding stock during process</p> <p>Live models for photography process</p> <p>Items awaiting photo, manually marked kept on a shelf</p> <p>Internal order placed on these items to reserve the stock</p>	<p>Addition of gifts and samples to packages</p> <p>Sample complements order, requires knowledge</p> <p>Gratitude note and decorations included as well</p>
Ship & Manifesting	<p>Prints receipts and freight slips</p>	<p>Places packages in shipping cages, no traceability</p> <p>No alterations from customers allowed at this stage</p>	<p>Places packages in bins, manual traceability</p> <p>Customers were allowed to alter their order until package was shipped</p>	<p>Places packages in shipping cages, no traceability</p> <p>Alterations from customers allowed at this stage</p>	<p>Stacks packages in special area, manual traceability</p> <p>Customers were allowed to alter their order until package was shipped</p>

## 7. Pick & pack management

As mentioned previously, all of the companies' order structures were characterized with small orders that have around 1-2 order-lines. Along with the batching functionality in BeX they can leverage their trivial filtering functions in order to cluster orders, so that these fit their individual purposes and work-flows. An important trait within order-batching theory ([Bartholdi and Hackman, 2014](#); [de Koster et al., 2007](#)). All of the retailers except Company D uses a picking trolley with multiple compartments. Company D picks order by order instead because of their VAS intensive orders. Company A and Company C pick the largest batches, which is understandable because of them serving as mostly e-fulfillment centers. Company B pushes their goods out to the stores, which is why they need to pick a lot fewer e-commerce orders. They divide their picking into two teams, so that one is focused on fulfilling internal orders to stores in the same manner as a normal customer order. However, the system has lack of support for this and has poor visibility in these put-to-store activities.

All the companies use paper-based picking, despite the tablet + miniscanner being supported by BeX. For Company A and Company C, that pick large batches, the amount of paper sheets pile up fairly quick because of the trolleys getting their compartments assigned to each order of a batch. Pickers at these companies usually use their trolley as a portable collection point placed in the cross-aisles to traverse the sub-aisles without it. Processing orders according to a cart zone picking or zone batch picking has been identified as an important trend to adhere to when dealing with these e-commerce type orders ([Napolitano, 2013](#)).

The main pick list is routed according to a predefined route in the system. Although pickers frequently pick according to experience. As mentioned, all of the companies tried to store according to criteria like product characteristics and brand. They also tried to store randomly to avoid getting erroneous picks. Due to the routing not being very modifiable, it has been hard to leverage the benefits it could give. One of the main issues when finished with one pick round was the sorting and distribution of items on to their slot on the trolley, which also resembles the put-to-light activities mentioned in the theory. With the use of barcodes, LPNs and scanners, the trolley could be filled with a set of random order items in the very same way as put-to-light. This would also completely get rid of the use of paper sheets and reduce local search time.

Company A differentiated themselves with their bin storage system, which created a lot of sub-locations on shelves. The same solution could be used in other companies in order to increase their poor fill rates. On one hand it puts requirements on the location management capabilities, but on the other it will require the use of RF, PBV or other scanning equipment. Further that creates a need to not only provide barcodes, but also check digits. With all of the companies, the pick faces were somewhat crammed with labels. This would be acceptable as long as they were all using shelf dividers, so that stock units are not mixed. The visibility issues were caused

by (1) the system didn't support stocking one article in multiple locations in the system, i.e. things got lost and it was error prone, and (2) the companies either registered their orders before or after the pick, i.e. the balance at the position is wrong during some period of time. For these reasons it becomes evident that visibility problems could be reduced by allowing traceability of articles on various locations, as well as utilizing some sort of picking equipment so that the real-time aspect is accomplished. This is supported by both old and newer theory on the subjects (Friedman, 2009; Hoffman, 2013; Landy, 2009; McBeath, 2012).

With Company A and Company D the authors identified kitting and bundling activities, that were carried out without system support. Company A suffered from overselling of parts to the baby trolleys. The kitting functionality, as described in section 4.3 solves this by having item structures of "parent/child" articles. This also puts special requirements on being able to reserve parts of a stock unit on a certain unit load and/or location, as the balance needs to be as correct as possible to be able to promise the fulfilment of a customer order.

## 8. QA & VAS

The photography process is a value added service that all new articles had to complete before being available for sale on the website. The companies experienced quite varying issues within this domain, and they all had their own solutions. Company C saw the photo process as an obstructing process that hindered the put away of unit loads with a new and recently arrived article. They kept the unit in the receiving area most of the times until the processed item could meet up with its constituents. The main problem was visibility related issues, as the system only supports the single stock unit. Processed items were waiting to be handled manually, which led them to the next issue; the staff did not have the system support for automatically getting these items to where they lie best.

Overall, Company D had a superior focus on VAS in comparison of the other companies. It was their business concept to provide a more in-store resembling experience when shopping at their website. There were gifts, samples, skin care advice, and even the possibility of unusually late customer order regrets. This flexible VAS was mainly carried out on a foundation of experienced and knowledgeable staff.

The QA processes looked quite similar at all of the companies. Company A distinguished themselves in this particular area, because of their use of temporary batches to move orders with article shortages to another batch, while the main order-batch can be registered. This was a quite reasonable solution, but the first issue is that batches can not be registered unless they are a whole unit. If order consolidation is to be introduced, parts of orders will have to be allowed to be shipped off to meet the remaining parts of that order. The other issue was the visibility of the orders that went through issues before completion. It had to be done manually

beside the regular order-batch picking, instead of just letting these orders lie as a queue for continuous inclusion in batches.

## **9. Shipping and manifest management**

All companies except for Company D register their orders when they reach the packing stations. This could lead to inventory displaying inaccurate balances while items are still in the pick-phase. When the order is registered BeX will print a receipt and the freight slip. Once the order is packed and placed in cages for shipping, all traceability of the orders disappears for both Company A and Company C. In these cases the orders are placed in a separate shipping areas and the customer can no longer be provided with the service of canceling their purchase. Company B and Company D provided the service to customers to regret their decision up until the point the package actually leaves the warehouse. Neither of these companies have any possibility to trace the orders once they are packed but will manually find the package if required. For Company B this could also mean that products packed and prepared for store replenishment is bought through an e-commerce order and will have to be manually located for repacking. Company B also required to know where in the transport stage a product were when it was sent between warehouses and stores and the product hold no actual physical location. Company A had no actual visibility of the orders after it shipped from the warehouse and this could induce a risk if the freight company lost parts of the shipment since they had no automatic handover information.

## 7.2 Cross case summary

<b>Core function</b>	<b>Issues and opportunities</b>
Fulfillment capabilities	<p>Insufficient granularity and lack of real time inventory visibility</p> <p>Risk of double selling the same items</p> <p>Traceability of products or orders to facilitate order consolidation and expand order fulfillment possibilities</p>
Receiving management	<p>Time consuming labour planning for the receiving process</p> <p>Information regarding shipments required in advance</p> <p>Time consuming and inefficient returns handling</p> <p>Products removed from its main stock became untraceable</p>
Across-the-dock management	<p>Cross docking was usually manually conducted and error prone</p>
Put-away and Location management	<p>Products could only be tied to one single storage location</p> <p>No support for storing by affinity or class</p> <p>No guidance for storage methods regarding choices of bins</p>
Batch and Wave management	<p>Simple batch creation without alternatives for different storage policies</p> <p>No possibility to estimate time and labor requirements for batch completion</p>
Replenishment management	<p>Ability to store on multiple locations to allow for keeping of a reserve stock of certain products</p> <p>Replenishment was done manually and required system guidance</p>
Pick and Pack management	<p>Ability to reserve products included in a kit to ensure fulfillment of those orders</p> <p>Placement of picked products in trolley was time consuming and error prone</p> <p>Dislocation of products in storage and loss of its position</p> <p>More customizable routing options in the system</p> <p>Experience required from workers to decided on appropriate package size for orders</p>
QA and VAS	<p>Articles removed from its main stock for VAS processes lost traceability</p> <p>Issues with possible order consolidation processes</p>
Shipping and Manifest management	<p>Loss of traceability in the shipping process</p> <p>Impossible to ship incomplete batches</p>

TABLE 7.4: Summary: Identified issues, opportunities and systems insufficiencies

# Chapter 8

## Discussion

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*This part will utilize the demands and requirements patterns identified from the case subjects in the cross case analysis in the previous section see. These requirements will, in the first part of this chapter, be further discussed and translated into functionalities and features for a WMS. The second part will discuss the fundamentals for how these functions could actually be realized in the development of an WMS.*

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### 8.1 WMS functionality and features

#### 1. Order fulfillment capabilities

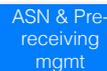
The main requirements from these companies on fulfillment capabilities surrounded the use of pick-up-points and seamless reverse logistics. These were shown in the theory study to be frequently occurring trends for the approach to omni-channel retailing (Forrester Research, 2014; Ludwig, 2014; McBeath, 2012). This type of retailing environment places requirements on the ability to track goods and orders in and across all warehouses and inventory locations (McBeath, 2012), and also in providing accessible, expeditious and inexpensive pick-up and return options (Cole, 2012). However, across some of the companies the authors identified a required expansion of advanced order-fulfillment capabilities, which is especially evident when expanding the use of stores as a strategic means of achieving greater warehouse efficiencies, as suggested in (Fortna, 2014; HighJump, 2015).

The main requirements from this is the ability to execute inbound and outbound orders. It is important that a WMS ensures not only centralized article inventory tracking capabilities (down to every idle and transfer point the item goes through), but also customer-order inventory

tracking. Furthermore, it is important to control the movement of these so that they can be consolidated anywhere in an effective way.

The authors wish to emphasize theory on the importance of having the ability to track units across warehouses, storage locations, stock units and orders, as suggested by (McBeath, 2012; Napolitano, 2013). Further the traceability should include load carriers, unit loads or anything that items could belong to either physically or virtually. With regards to the execution element of fulfillment, the authors identifies partly (1) the real-time aspect and accuracy of the inventory view, but also (2) the need for applying states and statuses to the things that are traceable (Hoffman, 2013; McBeath, 2012). Just so that a system may know what is needed to be done with what, when it falls under a certain set of system defined rules.

## 2. Receiving Management

A blue rectangular button with white text that reads "ASN & Pre-receiving mgmt".A blue rectangular button with white text that reads "Receiving mgmt".

**Appointment scheduling** A need to implement a planning function for the receiving process of goods was identified. A system function such as this could facilitate workforce and labor planning in anticipation of large shipments or peak seasons. If the system can save information regarding the effort needed for the receiving of different sizes of shipments, this information can be used to make more accurate estimations regarding receiving efforts and labour required in the future. This will however require the retailers suppliers to actively send updated and sufficient information regarding their upcoming deliveries. The use of a standardized Web-EDI form, for the passing of delivery information, would make this request more approachable for suppliers.

**Returns management** The utilization of Web-EDI would also be highly applicable for the handling of returns. The paper based return sheet involves a lot of administration. For retailers shipping abroad these were often answered in a customer's native language which required an interpretation process. An XML-based form could allow for customized languages, so that the customers can input their requests and the system can automatically create a scannable document which will efficiently save time and manage the "cause and request" procedure. Since the customer service division always handles repayment of customers funds, items are not available for sale until the desired action have been taken by them. At this point the inventory balance of the article needs to be correctly displayed and should be returned to its corresponding storage location in the warehouse as soon as possible. If temporary storage locations was provided in the returns department and a type of "block and clear items" status functions was included in the system, those locations could be included into pick routes as soon as an item were cleared

for resale. This would decrease both the time a product was deemed unavailable and the priority of returning it to its location in the warehouse. A procedure such as this would have the fundamental requirement of storing articles at multiple storage locations.

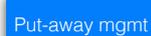
**Receiving of goods** The system need to be able to register parts of a purchase order as you scan through the products included in a shipment. Everything is scanned and then placed in a temporary storage locations and the status of the product should now read on hold or in-transit. When completed, comparison can be made between the items scanned and the bill of lading to identify and discrepancies. If any such are found the items will be collected from the in-transit storage and handled according to a predesigned decision process.

### 3. Across-the-dock management



Since it is highly likely to have flow through activities, a purchase order should also be possible to be matched against an internal order of some kind which will facilitate cross docking activities out to stores. It is equally likely that there are many stores that request parts of an order. This is why it is important that the function works like any other customer order related put activity, i.e. that there *is* one or many internal orders requesting a certain item, whereupon that item is consolidated (randomly or prioritized) to their load carriers or stage positions.

### 4. Put-away & Location management



**Bins and fillrates** The system requires to be able to support different dimensions for incoming articles and also which totes can store which amount of that article. If the system can remember and register fill-rates in master cartons of certain products or product categories previously entered the system, it can provide guidance when that specific type of merchandise is planned for put-away in the future. However, the binning process is not always that easy with variable garments, for instance. When a bin with a new article is filled, the system could ask for input to whether or not the bin is full or not. If it is, the system knows the quantity of that article which equals a 100% fill rate of that specific bin type. In this way, a fill rate database can be built up continuously, which is important to be able to optimize storing.

**Slotting** Overall, the ability to have optimization functionality in both regular put-away and re-optimization picks, seems to be a rather key function in order to continuously look over and adjust the pick faces of storage shelves. Having bins for storage is one way to fragment a pick

face, but it can also be done by introducing other permanent or temporary shelf supports. This puts a lot of requirements on the way these positions are labelled and programmed into the system. The authors identify check digits as one way to avoid pick faces to become crammed with barcode labels. However, there is still a need to create a sense of permanence in the way these are named, so that local search is minimized.

**Customer-order consolidation** In the case of order consolidation it is important that all parts of the entire order can be traced at all times. To realize this to an optimal extent status levels on products are equally essential in this case. Different states should display if an order is partially completed, parts are in transit or waiting for an intercept to take the order to its next step. This means that the different components of a consolidation order can be traced and monitored at all times and the system should be able to alert store clerks or warehouse operatives when all parts of an order have arrived and the order is complete and ready to be shipped.

**Storage assignment policies** The researchers identify the need to be able to store product according to affinity or class ([Lumsden, 2006](#)). Depending on the storage policy decided upon and programmed into the system, recommendations of appropriate storage locations should be contributed by the system in the put-away process. If storing by brand is implemented the most frequently picked brands is placed closer to a depot. Within each brand the most frequently picked products are placed on the most convenient locations on the shelves according to the rules of the golden zones. Very slow moving articles can even be chosen for storage in buffer locations in the least convenient places in the back of the warehouse while still keeping a uniform brand storing policy for the main shelf sections. Storage by product type and pick frequency are also viable alternatives. In particular, more aspects need to be taken into consideration when the system is developing pick routing for order batches. Some products within a category requires to be picked in a certain specific order to avoid damage or to facilitate stackability, which a pick routing in the system must also be able to accommodate.

Some new incoming products immediately have a high turnover rate, e.g. due to a hype or limited supply that creates a high customer demand. To fully utilize the implications of preparing fast moving articles for put-away the system must have a possibility for manual override. If the systems uses pick frequency as storage criteria manually calculated sales projections could be used as input instead allowing these items to receive a convenient storage location directly. This procedure could be utilized in the receiving process as well. Products with a high expected turn-over will be prioritized for handling to make the article available for sale as soon as possible.

Even if the warehouse storage is divided according to brand, types or pick frequency, different storing zones could be utilized in the warehouse and programmed into the system. When goods

are received and scanned the system could display the assigned storage location and/or in which zone that location resides. Specific trolleys in the put-away area are destined for specific zones and products are then placed accordingly. This requires being able to use load carriers like trolleys as storage when goods are in-transit in the warehouse, as well as having the unique load carriers in the system. This may be done with LPNs on both the trolley and its slots.

## 5. Batch & wave management

Batch and  
Wave mgmt

**Order-batching techniques** According to Fortna (2015) batch picking was the most efficient order pick method in an omni-channel environment. But the batching can be made in a multitude of ways. It can be done in single or multiple waves or just as a cluster order pick. In smaller order environments utilizing batch picking could boost pick-rates from 70 order lines an hour to 200 or more depending on the average cubic size of the orders. When the warehouse becomes large enough it might be more optimal to utilize multiple wave picking instead of zone waving (Del Franco, 2006). By doing clustered order picks in batches, divided among multiple workers, waving logic could easily be created. By creating batches in waves a WMS could have the possibility to calculate the time and labor needed to complete a wave, making it possible to allocate sufficient personnel for downstream activity on wave completion (ibid).

The authors identify the need to pick multiple orders at the same time when using a trolley, which is in line with theory on e-commerce retailers. Apart from picking multiple orders, the authors identify a need to pick parts of orders, as well as distribute batches across operators. The first requirement comes mainly from the efficiency gains of not picking an order in the same route, but also from the need to pick parts of orders in advance of an order consolidation. The items of an order that reside in the warehouse that the consolidation is to happen, will benefit from being staged and ready once the rest of the order arrives in the receiving area. The second requirement comes from the ability to cooperate on a batch. This can be done in simultaneous or synchronized zoning waves. The definition of waves can cause mixups here, but the important take-away is that waving logic can be achieved with proper use of storage assignment policies and batch-clustering.

## 6. Replenishment management

Replenishment  
mgmt

**Replenishment** The authors identified replenishment functionalities to take a rather big part of potential improvements as well. The case study objects showed how powerful the batch-picking concept can be. However, their efforts to construct forward and reserve areas were

futile. Some articles were identified as more frequent items and were then moved up near the pack area. But since they were more frequent, the companies sometimes also ordered a lot of these. In the case of one of the companies, this resulted in almost two sections of a home made FPA becoming consumed by one article. We also identified the benefits the companies gained by storing according to brand, but since one brand may have a lot of slow movers, these should obviously get a lot less space. By enabling easier filtering procedures in the systems in combination with data storage of fill-rates of totes, batches with replenishment routes could be created by the system.

## 7. Pick & pack management

A blue rectangular button with white text that reads "Pick & Pack mgmt".

**Kitting / Bundling** The systems requires a kitting function implemented. The researchers identified multiple situations where the option to purchase pre-designed product kits could lead to overselling of items included in the kit and an inability to complete orders. The function would allow the construction of master units and corresponding subunits. If a master unit was to be purchased the sub-units included in the master unit will all be reserved from any additional sale and/or reservation. Even if some companies did not explicitly show a need to have a kitting or bundling function, the authors identified the essence in being able to bundle items and sell them through campaigns, for instance. This would be a compelling concept especially in an omni-channel environment, which has been identified by literature on the subject ([Napolitano, 2012, 2013](#); [Vjestica, 2012](#)).

**Barcodes, LPNs and statuses** The system will also need to be able to use barcodes and check digits to transact items and orders. This creates a need to be able to actually tie orders and parts of orders to logical positions. Positions that are given some LPN, and then having status functions, e.g. hold, to take goods out of sales, from a position to another and knowing when orders are complete and when they are on the right/wrong track.

**Order-picking** The need to pick multiple orders at the same time in batches creates a need to use load carriers. It will most likely demand the use of both hands for carrying orders back to a trolley that will probably have been placed in a cross-aisle. Common solutions involve RF equipment and PBV. The cloud based solution opens other doors, i.e. the use of tablets and smartphones. These are lighter, contain similar informative traits, and are easier to attach at convenient and user friendly places. Although, robustness goes in the favor of RF equipment. When collecting multiple orders at the same time, the risk of inducing errors will occur when the picker returns to the trolley and orders are to be distributed and/or sorted. To avoid this

the system could for instance indicate where orders should be placed on the trolley by scanning the products again once back at the trolley.

**Put-to-store / Internal order-picking** Since it is highly likely to have put-to-stores activities, a purchase order should also be possible to be matched against an internal order of some kind. It is equally likely that there are many stores that request parts of an order. This is why it is important that the function works like any other customer order related put activity, i.e. that there *is* one or many internal orders requesting a certain item, whereupon that item is consolidated (randomly or prioritized) to their load carriers or stage positions.

**Routing** Probably the most important feature identified in a WMS for these typical e-commerce retailers, is a proper routing function that is easy to maintain. Today the routing is rather stale and is not built to take parameters like zones, family groups, or areas into account. If a proper put-away function is to be implemented, with the class, affinity and group storage, the routes will have to be adaptable and scalable with the various combinations of low-level shelves. Shelves may not be uniform in their storage groups, levels, or cross-aisles. And the storage policy may put requirements on the routing that is different from zone to zone. Further, the different use of picking devices, load carriers, and/or paper, will decide the very best way to pick for that specific use. The authors believe there is a lot to gain from a storage and routing model that has the adaptability that meets these goals and requirements.

**Order-processing in stores** A future evolution toward an omni-channel environment could likely be the transformation of all the brick and mortar stores into miniature fulfillment centers. This will mainly require some space for warehouses operations such as a packing station in the back room of the store and storage location registered in the system. This will again require a system that can store articles in multiple locations. These storage spaces can be used to tie orders awaiting customer pick-up or consolidation to a specific status in the system, and make it traceable to an actual physical place. To facilitate the picking process if online orders are transferred out to store, a WMS needs to be operational inside the store and its backroom as well. If online orders are to be picked and shipped from a store, a reserve status needs to be placed on that specific product so that customers inside the store does not buy it in advance of the product being picked. The more functionality and facilitation of the order shipping process a WMS can provide, the less experience and time is needed from the store clerks.

**Packaging management** In the same manner the system could remember fill rates of totes, affinity relationships among articles, and labour requirements in put-away and receiving, the system could also learn some affinity rules for packaging. Specific product sequences in an order

might entail that a certain type of VAS sets in motion and instructions can be given through the systems how this requirement can be fulfilled. This can lessen the demand for product or brand expertise when packing orders.

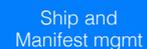
## 8. QA & VAS

A blue square icon with white text that reads "QA & VAS mgmt".

**Inbound VAS** If single products are removed from the rest of the inventory stock for VAS or certain processes, that item needs to be assigned a status and/or location. In this way the progress can be tracked as well as the article. By knowing where separate stock units and unit loads of an article reside, and having different statuses of these, a fairly powerful task management can be created quite easily. Rule-based reasoning would assure that these items get the handling that they require, according to the work image set up.

**Customer VAS** Having flexible VAS is highly suggested in theory related to the omni-channel paradigm (HighJump, 2015). It puts requirements on having a possibility to put up rules in the same manner as the previous feature description. It also requires visibility from things that do not count as the stock, either if it is labels to put on products in the inbound flow, labels to put on packages during packing, or items to add to a customer order.

## 9. Shipping and manifest management

A blue square icon with white text that reads "Ship and Manifest mgmt".

**Staging and shipping** When orders are packed and shipped the need for traceability still remains. Both when outgoing shipments are stored in the warehouse and also when in transport to its destination. There is a need to have an automated dispatch procedure which can provide visibility of an order's locations and statuses. Either scanning or RFID could be used to register that goods are loaded onto vehicles and actually leaving the warehouse. When orders can't be complete due to stock-out of products, the system should allow an override of the shipping constraints to make it possible to send incomplete orders and batches. Either for consolidation elsewhere or for delivery. For consolidation at multiple different inventory locations the possibility to traverse through the supply chain is a fundamental feature. Orders should have the possibility to be checked off as they go, blocked for sales as they go, and not be hindered by a business process. If they need to stay in one place until they are complete there should be a possibility to integrate these in new order-batches, so that trials to fulfill an incomplete orders can happen continuously.

## 8.2 Summary of functions and features

<b>Core functionality area</b>	<b>System functionality requirements</b>
Fulfillment capabilities	Real time inventory traceability in combination with statuses and states for products across all inventories Increased traceability and visibility will facilitate order consolidation
Receiving management	Labour planning function based on previous receiving data XML-based returns forms combined with a hold and release function for products System support for inbound sortation and independent scanning of incoming shipments, hold function applicable here
Across-the-dock management	Match purchase orders against internal orders to facilitate cross docking to stores Cross-docking parts of orders require high traceability for the order consolidation
Put-away and Location management	System recognition of fill-rates of totes for incoming products System recommendations for put-away based on pre-programmed storage policy Optimization functionality in the pick phase, check digits to facilitate the process Utilize status and states for products to facilitate customer order consolidation
Batch and Wave management	Labour planning System support and guidance for dividing order pick waves among operators Tie unfinished orders awaiting consolidation to specific positions
Replenishment management	System supported calculations of turn-over rate for efficient product replenishment Batches for replenishment activities created by the system
Pick and Pack management	Incorporation of master items in the system operating as a kitting function Special combination of products might entail system recommendations regarding packaging System guidance for picked product placement on trolleys Handling and placement of specific orders in logical positions combined with LPNs or barcodes System support for routing by zones adapting to different storage policies
QA and VAS	Special set of products will entail system recommendations regarding VAS, based on rule based reasoning
Shipping and Manifest management	Automated dispatch order to enable visibility and traceability of shipments

TABLE 8.1: System functionality requirements identified

### 8.3 Implications for realization

**Visibility and traceability** have been mentioned as some of the top key benefits with a WMS (Partida, 2012), as well as an essential component in an omni-channel environment (Fortna, 2014). With the development of RF equipment, license plating and RFID technology, these concepts can more easily be incorporated in real-time based operations (Battini et al., 2015b; Vjestica, 2012). The studies conducted showed that some companies took measures with the system to, for different reasons, temporarily remove goods from stock and from sales. This resembled having some sort of reserve and block status system. These goods were also often moved to, or contained in, other locations than what was registered in the system. Be it a pallet in a staging area, in a tote on a load carrier, or just on a shelf location. However, a lack of traceability across these variable ways of storing goods caused inertia in the companies.

Furthermore, the lack of traceability made itself apparent for other things than "goods". The problem was not always about knowing what you had in stock in terms of articles, but also how the parts of different types of orders were distributed in the supply chain. The items of some order waiting to be picked could be lying partly in one warehouse and partly in another. These parts needed to be consolidated somewhere and preferably with the help of a system. Consequently, this requires traceability of orders and their parts, i.e. the ability to trace fictional collections of items (an "order" is not physical but fictional). This is something that is rather more abstract than physical stock. However, it becomes clear that traceability of such an abstract concept is equally important as tracing where just individual articles are located. It is difficult to know where an arbitrary ordered item needs to go if the system only tracks where that item is and is unable to connect it to an order. The order it belongs to might have other items at a specific pallet which the item should go to in order to render the order as complete.

Hence, the bottom line for the omni-channel domain is not *just* visibility and traceability but also the actual execution of operations, which in their most basic terms consists of (1) buffering of material flow, (2) consolidation of products, and (3) value-adding processes and customization (Goetschalckx et al., 2007). The scope of the thesis does not include trying to explain and motivate the most efficient executions of these processes. Instead the authors recognize the value in discussing what *execution* means to a WMS in an omni-channel environment. The companies studied did try to store and move products efficiently as implied by both best practice and trends in the omni-channel domain. But lack of system support made simple tasks cumbersome since the actions regarding the handling of goods were not only carried out by warehouse operators, but also planned by operators. If an article deserved to be stored in a specific location in the warehouse due to its turnover, the decision was made by staff and put-away was carried out by staff. When a returned item re-entered into the system as a sellable item, that item would not be picked unless staff was aware of that the article resided in the return area.

Implications on the construction of a WMS, arisen from the reasoning above, will be discussed in the following three design propositions. They will present some generic concepts and motivate with further reasoning how the accommodation of them will theoretically solve the problems related to visibility, traceability and flow of goods in the omni-channel paradigm.

**Design Propositions:** *“If you want to enable and enhance initiatives on any order-fulfillment program, then support the ability to:”*

1. *“tie logical entities (goods as well as orders) to logical positions and states.”*
2. *“handle partitions of logical positions or entities across hierarchies.”*
3. *“purposefully guide material flow, buffering, and value-adding processes of logical entities.”*

**Design Proposition #1** This feature is concerned with logical entities and how you can tie these to logical positions and put logical states on them, to know where they are located and where they are destined to go. These concepts are created to recognize (1) the multitude of words that are used to depict different collections of products, (2) the various ways they can be stored and (3) handled. As an exemplification of elements and hierarchies involved in an information modeling structure, these concepts are visualized in figure 8.1.

**Logical entities** would refer to any type of goods or orders that represent some collection of items to be stored or moved. These entities could for instance be an **item** (an arbitrary product), **article** (the abstract collection of all items of the same type), **SKU** (a distinct physical unit of goods for sale that has an ID number), a **stock unit** (one physical collection of items with of the same article), etc. It may also refer to any type of **order** (the abstract collection of one or many articles of set quantities that have a common direction), like a customer, purchase or batch order, etc. Other concepts may be invented for the business at hand and mainly plays a role in the data structure of the information system.

**Logical positions** would refer to all abstract or physical locations or containers that goods may reside on or within. This might refer to an area in a warehouse, a rack in some area, a unit load like a pallet, a square in the receiving area, the tote on a load carrier, or just a position on a shelf. Some logical positions may have a LPN placed on them so that logical entities can be tied to them physically, e.g. a tote on a trolley. Other positions just have unique names which can be used to tie logical entities to them virtually, e.g. a shelf or a load carrier (since these are rarely provided with a barcode, but more likely with an indexed name).

The tying of logical entities to logical positions is proposed in order to be able to trace and visualize all kinds of collections of goods and orders. For instance, the different items of an

article should be able to reside at multiple locations, e.g. some at a pallet in shipping, some in a box in receiving area, some on a shelf in the backroom of a store. As with orders, purchase orders are going to be needed to be staged, either for put-away or for cross-dock activities. Another example is batches of orders that are going to be needed to spread out over one or many areas, zones or even warehouses, while the items of these batches may reside in various different logical positions (some items are on shelves, some on trolleys, some in shipping area, etc). But it will still be necessary to be able to trace all these constituents of the batch. The very same thing applies to single customer orders; that may be fulfilled from many warehouses, or may be part of several batches, and be travelling among the nodes of the supply chain system in complicated ways. Omni-channel fulfillment advocates endless possibilities of ways that orders may be fulfilled. This means that no arbitrary way of fulfilling an order should be impeded or even hindered by the system. Consequently this requires a data structure behind a WMS that implements the use of various logical positions and entities to maintain a traceability that is generic and theoretically endless.

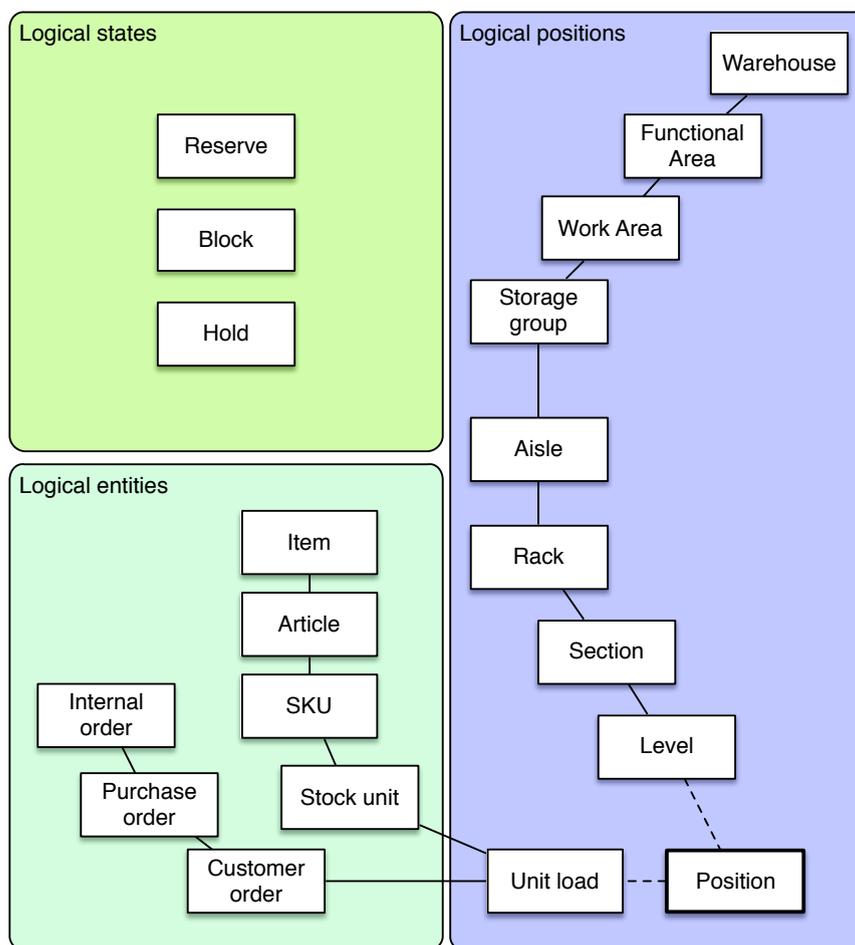


FIGURE 8.1: Diagram that exemplifies hierarchies and elements involved

**Logical states** would refer to labels that may be put on logical entities to imply that they (and their parts) have a certain meaning. It is important to be able to purposefully handle a logical entity and its parts so that they flow as they are intended. To be able to apply rule-based handling of these entities it is crucial to have a proper set of logical states that entities may be in. This is to either force intercepts in order to move these entities on to a next step, or to ensure error-proofing of the material flow. As shown in the cases, an entity is rarely a candidate for one state only. For instance, an item that is in the packing area, may both be waiting to be packed while also removed from sellable stock. This would be two simple, yet crucial, states used by the system to be able to instruct an operator to pack a certain item, as well as it keeps track of an item that is already sold. The accommodation of putting multiple levels of states is important for efficient and handling according to predetermined rules.

It should be possible to define and customize states that fit the material- and work-flow of a specific company. However, there are some fundamental states that the authors have identified in the cases and theory that give the largest impact. The first two are quite related to each other; **reserve** and **block**. There is also the **hold** status. A given factor to fully utilizing all of these states are the use of LPNs and scanning/RF equipment.

**Reserve** concerns items within a stock unit only. This is to allow for one or many items to be reserved when a customer orders a number of an article, and hinders overselling and assures no faulty stockouts. **Reserve** is only triggered by a customer purchase, and is only concerned with the balance of an article in a stock unit. For instance, suppose that the last two items of an article resided on a pallet in the storage area. If one customer purchases one of those items, this stock unit will have a quantity of 1 reserved for pick to this customer. Even though the warehouse has two physical units that haven't been picked yet, thanks to the reserve status a new customer that requests two of that article will not be able to complete the purchase.

**Block** concerns a state that can be put on either a stock unit or on a logical position, so that no sales can be made of those products at a given time. A shelf at the returns department likely stores unprocessed products that should be excluded from sales. But they should be equally traceable as articles since the unprocessed products are received back into the system. With the use of a block state on that entire storage shelf the items that are on it can be excluded from the sellable stock entirely if needed.

Besides these two states the authors have identified **hold** as an important strategic state. It may be used to put logical entities into a waiting position. For instance, an order that needs to be consolidated could be automatically placed in a custom state "Hold-Consolidation", until the remaining articles of the order is placed on the same logical position. Once this has happened a new state can be entered, e.g. "Hold-QA", so that the finished order will have to go through some QA steps before being able to be packed and receive its shipping list, etc. This function is useful in both execution and traceability. However, for productivity tracing an even more

granular traceability could be added. States like “Ready-to-pick”, “Picking”, “Is-Picked”, or “In-transit” would both be powerful in terms of tracing what has happened and what should happen to a set of goods, as well as in terms of keeping track of the time that logical entities spend in transfer, being still or being handled.

**Design Proposition #2** It is important that it is possible to easily modify any given logical position or entity in the system so that it can behave as intended. In the omni-channel domain there are endless ways to store and handle logical entities. There may be family grouping in place, affinity storage, batching, zoning, etc. To be able to put rules and relationships between different types of logical positions and entities, while also maintaining an easy re-modification of these, it is important that it is possible to: (1) traverse freely through levels of granularity for logical positions and entities, and (2) handle partitions of positions in either a longitudinal, latitudinal or transversal manner. To note is that the ability to tie logical entities to positions is a fundamental ability, but it also require the system to handle partitions of positions and entities to even be able to designate a specific shelf to a specific class, for example.

For instance, it can be a powerful concept to easily modify some aspect of the locations of some set but not all of the levels and sections of a rack, e.g. all locations on the 1st to 3rd level on the 1st to 10th section of rack A. Maybe the warehouse structure changes, which should not impede the creation of a new put-away policy or some other consequence it may have on the storing process. It should be possible to assign a family group to a set of storage groups, and it should be equally possible to assign a class to a certain level of a rack. Logical positions could be tied to partitions of other logical positions, e.g. some certain levels on a couple of sections should have only one type of unit load type on them, e.g. a pallet. As with handling across hierarchies of logical entities, it should for instance be possible to handle all the parts of a batch. Some parts may be finished and some are waiting to be consolidated or picked. It may be distributed over a set of operators or even across a set of storage groups, in order to be picked sequentially or simultaneously of these operators. Furthermore, to even be able to apply different states to the set of totes that are on a picking trolley, this theoretical ability of handling across hierarchies is needed.

**Design Proposition #3** The key essence in execution is knowing what should be done in a given instance. The authors have excluded the discussion on *the most efficient* execution of activities and instead focus on the enabling of a wide variety of generic ways of fulfillment activities for e-commerce retailers. This enabling concerns a lot of the previous design propositions, but what ties them all together is how the system can use facts and knowledge about logical entities, positions and states to suggest the next action to take, which should be within the frame of the workflow defined.

Lam et al. (2010) discusses the use of a rule-based reasoning engine in relation to warehouse resource management and order-fulfillment. They present the Facts and Knowledge database as the main elements in inferencing a suitable action. Facts here refers to the “*given instance*”, i.e. the actual attributes of logical entities stored in the data warehouse, including their logical positions and states. Knowledge refers to some domain knowledge that is used for selecting rules for action and/or problem solving. The inferencing is done by connecting a set of facts and rules to some feasible (or determined) actions and solutions. These rules for action are mainly expressed as conditions and consequents (IF-THEN relationships).

This may for instance apply for finding where an article is to be stored in the warehouse, after matching its type and class to where that kind of type and class are to be stored in the warehouse. Another example could be the knowledge that an item belonging to a specific order is currently in receiving area and the rest of the items in the order is on a shelf in the warehouse while having a “Hold-Consolidate” status on them. The rule could be that all items of an order that has a consolidation point should, if possible, be put-away to this location. The inference action would obviously be a distributable task of getting that item from the location it is at in the receiving area and transfer it to the location of the order. The use of barcodes for getting through processes may also be used in navigating through a decision-tree, while also validating and verifying the activity. An example would be handling a returned object according to predefined decision steps, which with the help of barcodes would disconnect the operator with the need to know or investigate the state of product at hand. Altogether, this ability to purposefully handle goods via their states and implied rules is a very important trait of a WMS in the omni-channel domain, since it allows for a very complex supply chain with various ways of fulfilling orders without any operator having to be aware of what action is needed to the item in their hands.

## Chapter 9

# Conclusions

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*This chapter will present the conclusions of the thesis. It will address the research questions and the main findings of the study. Lastly, it will end with considerations on future studies.*

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### 9.1 Findings of the study

**RQ 1: What functionalities should be considered in a WMS solution for efficient warehousing in an omni-channel environment?**

The main aspects for a retailer when working towards incorporating an omni-channel approach is to increase their customer order fulfillment capabilities, be perceived as a unified entity and increase customer service levels. The mapping and analysis of WMS functionalities needed for retailers in this environment ultimately lead to functionalities and features that involved:

#### **Fulfillment capabilities**

To increase the capacity of fulfillment capabilities, which is one of the fundamental aspects of achieving an omni-channel environment, the key criteria was identified to be visibility and traceability. This increased visibility will enable the possibility for shared inventory across storage locations, which will greatly reduce any forms of silos existing in the supply-chain. If all inventory is shared the different channels would entail a unified offering to the customer and be perceived as a single entity. Traceability would enable both order consolidations within and outside of warehouses and would enable reverse logistics through all channels. If orders are sent from DC's to stores the ability to track them and connect to positions in the stores back-room will make them locatable when customers or other products arrive for pick-up or consolidation.

Further, it would be possible to create a more accurate sales offering, since knowing if the last items of a product is out in the store or in the back-room can hinder double-selling.

### **Receiving**

Functionalities need to support intelligent planning of labor for the receiving process. The returns handling was proven to be an arduous and time consuming activity. When incorporating an omni-channel environment the amount of returns through different channels will increase and become more unpredictable. This change is not accounted for in traditional WMS and could result in bottlenecks in the warehouse. By using system support to facilitate this process this could be avoided. To facilitate the receiving and staging process, functionalities of supporting different states of goods need to be incorporated. This is to facilitate various QA and VAS activities, but also to know what to handle when and where. There is a clear need for inbound sortation functionalities that can separate among different types of orders, whether they are regular purchase orders, customer orders, return orders, or even internal orders that are to be pushed down or sideways in the supply chain.

### **Put-away and Picking**

The same type of support for intelligent planning functionalities as in receiving needs to be supported to enable labor and bin usage planning for put-away. To enable storage recommendations according to family, class or affinity the system needs to be able to track movement of goods in multiple locations, dimensions and states. With a highly visible inventory and using batch-picking across operators and parts or whole orders, intelligent routing can carry customer or replenishment orders from their areas and zones in the most efficient way with any given storage policy, equipment or work flow. Intelligent picking functionality, together with functionalities for storage across multiple locations, will also nullify the issues with pick accuracy experienced by retailers using a traditional WMS (and trying to implement miniature fulfillment centres in their stores). If support for applying multiple states on products is incorporated into the system, states such as reserved on picked articles will facilitate the usage of shared inventory and minimize the risk of overselling of products which will increase customer service levels. This is all part of a theoretical decoupling of warehouse operators and managers with all units', products' and orders' individual purposes, which connects back to previous reasoning on using logical states and positions for purposeful handling of any given entity in the warehouse.

### **Packing and Shipping**

By incorporating functionalities for rule-based reasoning the packing process can be facilitated. With system support the packaging of orders can be conducted by any one of the retailers employee in any location. If all VAS activities can be guided by the system the need for knowledge and experience is greatly reduced. This would enable the packaging and shipping from stores operating as miniature fulfillment centres to be conducted by store clerks without

previous knowledge of warehouse operations. If traceability and visibility of orders could be upheld in the shipping process, the customers with complications or issues could be allowed to change their orders until it actually left the warehouse.

## **RQ 2: How can these functions be realized and implemented?**

With a focus on efficient warehousing, with omni-channel retailers in particular, the main design features that the authors believe are needed to implement in a WMS are:

### **Having the ability to:**

1. Tie logical entities (goods as well as orders) to logical positions and states.
2. Handle partitions of logical positions or entities across hierarchies.
3. Purposefully guide material flow, buffering, and value-adding processes of logical entities.

The most important findings within WMS feature design, with respect to omni-channel sales and operations, is to build a foundation on top of random (floating) storage locating that goes beyond tracking balance on positions. It is needed to redefine what visibility and traceability really means when building supporting systems for operations in an omni-channel. The crucial part is having an intelligent and clear data structure that takes into account the fundamental elements of item and order structures, as well as all types of storage positions that these may reside within. The authors call these logical positions, since they may be everything from a box in a load carrier, to a cage in a defined area. The authors also call items and orders logical entities, since they can represent collections of things in many forms, e.g. the items of an article in a stock unit or the items of an order. These logical positions and entities may have several (levels) of logical states placed on them to enable goods to flow through the system without any human intelligence intervention. By allowing the management of entities and positions across internal hierarchies/levels, a richer level of genericness of an information system in this warehousing domain can be achieved.

Here the authors wish to emphasize the reasoning on purposeful handling and decoupling. By knowing what state different entities are in, and having a rule-based decision engine, it could help guide processes that are otherwise tied to or dependent on specific operators. Ideally one would like to delegate the responsibility of a task to an arbitrary operator without requiring any specific insight into the specifics of the task. With high visibility and traceability into different types of entities' given situations, the task can be made a lot easier for an operator since the system simply knows what pre-defined action that needs to be done to each one of the tasks.

By being able to tie goods to multiple different logical positions, articles and orders can be connected to multiple different places in the supply-chain. This condition is a pre-requisite of

completing any form of more advanced order consolidation. If orders or parts of orders can be tied to different logical places throughout the supply-chain, either the system or an operator can determine where to send the remaining goods to complete the order in a proficient place and manner. It will also enable for the development towards more efficient fulfillment options. If more versatile customer pick up points are to be established the ability to tie completed orders to storage locations in the backroom of a store is essential. These orders will then be traceable and retrievable for any operator at any time. To further expand the omni-channel concept it might be desirable to setup the stores as miniature fulfillment centers with shipment directly out to customers from the stores backroom. If articles could be tied to locations in the front and backroom of the store the wms could greatly facilitate the picking and shipping process of customer orders when they arrive to the store.

By being able to apply different states for the orders a rule based engine incorporated in the system can come into action. If the systems knows in which state an order or an article is it can recommend the next pre-programmed step. The logic in the system would be based of the actual flow of goods in the warehouse and the supply-chain in which the system is implemented. That said, the authors don't imply that the system will generate any flow calculations on its own It will however contain a specific set of tools with which common flows of goods can be programmed. This will ensure that the systems is flexible and generic enough to be suitable for retailers in different stages of the omni-channel transaction. The flows will be programmed to follow a waterfall like set of events, where one action or change in state leads to another which will then be given as a recommendation from the system. The prerequisite knowledge required from the operator to handle the goods which are pre-programmed will be minimized. This will as a direct effect relieve certain personnel from specific tasks. Tasks which previously required knowledge based decision making to be completed can now be handled efficiently by any operator in the warehouse with less possibility for errors.

The return handling process in the warehouse is a labor intensive process when operating in an omni-channel environment. Since the omni-channel concept greatly revolves around an increase in the offering of customer services, having free returns is a standard which will increase the amount of daily returns received for the retailer. By combining the ability to tie goods to both logical positions and states articles obstructed in the returns area can be included in the system for facilitated handling. By incorporating a hold function on the article, it will then be released when the article has been processed and further steps may be involved to force the item to be rejoined with other items of its article, e.g. having its location in the return area included in pick lists. This includes minimizing the time the article is unsellable as well as removing the time and labor required to return the article it to its original storage position in the warehouse.

## 9.2 Epilogue and suggestions for future research

One of the main ideas behind the thesis is to give a fundamental understanding regarding the requirements on a retailer if they are to adapt to an omni-channel environment. By fully understanding the concept, with the possibilities that it entails but also with its risks of complications a company will be better prepared to make the transfer into the omni-channel domain. By studying and understanding the study conducted in this thesis and its results, obstacles that will occur might be more easily avoided or overcome. If the thesis is used by software developers or retailers on the verge to transitioning their product or company into the omni-channel domain they will have an advantage whether or not they decided to implement all of the design theories suggested in the thesis. The importance of traceability and visibility shown in the results gives a clear picture of the challenges faced in the omni-channel domain and the importance of developing these aspects for the future.

Inventory visibility and traceability is not a new thing in the WMS software world but with the changes towards an omni-channel environment its importance has greatly been increased. It is now the backbone to any complex function that a company wants to bring into its processes. In regards to omni-channel retailing there may be various combinations order-fulfillment that are justifiable. These are complex by nature and for a company to execute them efficiently the WMS support is crucial. For the WMS, the visibility and traceability of inventory and orders in all parts of the supply chain, are the most important factors.

By understanding why you need to be able to trace orders throughout the entire supply-chain at all times and how it will enable customers to pick up anything and return everything from anywhere, the fundamentals of omni-channel fulfillment will be easier to grasp.

The thesis also shows the impact and consequences of having flexible and functioning system support when trying to achieve the next level of order fulfillment. This thesis has demonstrated the importance of having system support that goes beyond the confinement of the four walls of a warehouse. To be able to offer the customers the new and wider arrangement of services and fulfillment options at a consistent and efficient level by only relying on manual solutions will not suffice in aspects of growth and expansion. By having a WMS that goes beyond just controlling the inventory balance of products in positions within the warehouse, to throughout the entire supply-chain, would make the order consolidations needed to be able to offer the customer combinations of any products from all storage location possible.

Previously it was usually the systems themselves and the lack of technology in these systems that prevented this evolution of order fulfillment capabilities. Older systems with outdated architecture could only store data collected on the specific locations at which it was implemented and these older enterprise information systems have typically had separate implementations on the nodes of the supply-chain. Information exchange this way has been known to be rather rigid

due to siloed data repositories, which has often required large and costly system implementations to solve the issue on collaboration and having enterprise-wide interaction platforms. Due to this fact, some of the more advanced order-fulfillment capabilities have been a costly and complicated endeavour and reserved to the larger corporations with more complex system implementations.

When smaller retail actors now have commenced with cross-channel fulfillment, ordinary manual coordination of flow has solved the problem that originated from an information system “bottleneck”. Restrictions in the system architecture on both client level and business logic level is commonly counter-productive to possible channel integrations. So the outcome was simply to exclude fulfillment programs or to do them manually. With the ongoing transition into cloud-based solutions, the possibility to create an enterprise-wide solution using one common data-sink has been greatly increased. This has facilitated implementation of information systems, and not the least created more swift and flexible solutions that can be accessed by supply chain actors with any role. Furthermore, the system solutions may be centrally updated, which reduces the need for any extensive support functions.

The effect of this development has opened up for smaller actors to implement generic systems with minimal investments and maximum possibilities to solve and enable the inherent problems in both traditional warehouse management and omni-channel related fulfillment capabilities. With infinite data collection possibilities and access to a common data repository, the problem turns into what data to collect and how to use it to solve the problems in a way that have usually only been solved by either the complex solutions or through manual labor. With this thesis the authors hope that inspiration has been provided to what data is interesting, how proposed functionalities may use it, and what common issues they solve.

The theory does not discuss a lot of WMS implementations, as in the actual code and the way data is used. The reality today is that many of the solutions out there solve new problems with old techniques. When the really interesting capabilities become requested by more and more companies, there is an even greater need to have a proper underlying structure and approach of the WMS software. With the emerging trends of information systems, and the fact that the product landscape of OS-vendors like Microsoft are shifting towards these systems, there are many reasons to keep the basic software solutions to oneself. The open source communities within WMS design is relatively scarce, but this is likely to change given today’s landscape of free web apps, public APIs (Application Programming Interfaces), and open government data.

The authors open up for an investigation of more advanced solutions today to see how much of the concluded criteria is implemented in the core. Also how that has impacted the successfulness in implementing WMS functions and their performance. It would preferably be based on a pragmatic approach that investigates both qualitatively and quantitatively how and to what extent the solutions meet different WMS factors.

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The authors also uncovered the need for exploration in the area of *justifiable* order-fulfillments. This thesis was focused on what is needed in the core of a system to accommodate the functions and capabilities needed by omni-channel retailers. This also includes allowing any type of order-fulfillment. But how a company usually distributes orders optimally among its warehouses is through a DOM system connected to the WMS. The WMS could potentially calculate the best order consolidation points on its own, but evidently not all combinations can be economically justifiable. They can be if the customer explicitly demands these combinations. If only a few customers really demand a combination, the company might be better off with offering standardized order-fulfillment capabilities instead. This weighing between these options may be done on a one-time basis, or maybe even continuously with dynamic considerations to the specific goods at hand as well. The essential idea is to investigate how to analyze the financial implication of a certain order-fulfillment setup, both in terms of hard costs and customer loyalty.

# Appendix A

## Requirements specification (SAMPLE)

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*This is the requirements specification chapter, which is excluded for use by all others than representatives of Perfect IT - BeX. It will exemplify how some of the data structures and elements involved could be implemented to facilitate the functions we found to be most important. It will nonetheless list, as exhaustively as possible, the requirements surrounding the ideas we have included. Theoretical solutions of some of the functions and features are also addressed. Further, some ideas will be conceptualized through simple illustrations, so as to include as many requirements and ideas in an easy to understand picture.*

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### System description

BeX - WMS is an innovative way to achieve warehouse efficiencies in the e-commerce retailing industry. The critical functions to to achieve these efficiencies has been discussed abundantly in warehousing research for various industries. Yet there has not been anyone that has presented a solution to the foundation that enables these types of companies to operate with ease in an omni-channel environment. This application is based on a structure that may uphold various workflows, material flows, and types of buffering. It will provide functionality that puts the operational and tactical power in the hands of anyone involved within the internal supply chain, whether it is a store clerk, an order-picker or the warehouse manager.

## Background

In the previous chapter, a thorough elicitation and analysis was made of what is needed from a WMS at four typical and representative e-commerce retailing companies. Ideas to the solution of the identified functions were discussed with a focus on making them work for not just these four target customers, but for situations that may arise in their industry peers as well. Today, customers want to order products whenever they want it and also however they want it. They demand to have it delivered not just in a very short span of time, but also wherever they want it. Whether it is bought online, in the store or on the mobile phone. As for warehouses and stores, with their complex operations, there is a will to both accommodate the customers' omni-channel demands and to fulfill customer orders in more creative and efficient ways.

In order to allow this, the needs and requirements of a WMS go towards expanding the views of visibility and traceability of all entities across the supply chain, as well as expanding the views of order and returns management. The terms are no new concepts, but they need to be implemented intelligently to put the control in the hands of both managers and staff. The propositions made in section 8.3 emphasizes the need create a more granular "omni visibility" of the goods and resources. This, in order to apply more adaptable functionalities and a rule-based control of the disperse and sometimes intricate flow.

Studies have shown that most WMS implementations have only had a few percent improvements of order accuracy on average (Partida, 2012). Albeit they represent a lot of money, a lot of time may have gone into setting up a system. The whole idea with a cloud-based SaaS system is to shorten this time-window and provide with a solution that is running early on and fetches these percentages anyway. Instead of having to customize the system for each new customer, the system needs to be configurable and in the staff's control. In this way the system can be evolved through the feedback that customers have experienced themselves.

## Limitations

The SRS on BeX - WMS currently limits itself to expanding functionalities identified to provide the largest effect for the BeX system and the customers using it. For instance, cycle counting is a really effective functionality, but BeX already provides a proper version of that. In a sense, it becomes unnecessary to bring up all identified functions from literature and industry pioneers, like yard management for instance, if none of the customers are expressing the need either explicitly or implicitly. However, we must consider the fact that some requirements are tacit and they may come from a type of customer not studied. The primary target of this application is e-commerce retailers that have both store-and-hold activities and across-the-dock operations.

## Stakeholders

### Primary stakeholders

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**Stakeholder** Product owner

**Spec** Perfect IT **is** the product owner of BeX and its constituent parts.

**Stakeholder** Warehouse/Store managers

**Spec** Warehouse or store managers that run units on a strategic and tactical level and that will use the system for this purpose.

**Stakeholder** Warehouse or store staff

**Spec** Warehouse or store staff that will use the system on an operational level and hopefully on a tactical level as well.

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### Secondary stakeholders

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**Stakeholder** Customers

**Spec** Customers to the companies through any channel (and customers to be).

**Stakeholder** Suppliers

**Spec** Any upstreams actor to the companies (and actors to be).

**Stakeholder** Freight carriers

**Spec** Freight carriers that are the link to suppliers or customers.

**Stakeholder** MHE manufacturers

**Spec** Any type of MHE manufacturer, who's equipment may be used in the customers' warehouses or stores.

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## Terminology

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**Term** User

**Spec** **User** may be (auth.). Normal user **is** referred to as worker. (auth.) refers to authorized staff.

**Term** Logical position

**Spec** A logical position **is** any storage entity that goods may reside in. It may be a shelf location, a shelf level or even the entire rack and storage group. Logical positions may be areas, otherwise referred to as logical areas. These are either contained areas where activities may occur or where goods can be stored, e.g. a marked square that **is** tied to a LPN and can **hold** data on some goods in it.

**Term** Logical entity

**Spec** A logical entity can refer to many types of things. Either it **is** an item, an article (collection of items with the same number), a stock unit of items of an article, a unit load that **has** stock units of some articles. It can also refer to an order, which relates to some article numbers and items of those articles. These may reside in a logical position, which **is** why also whole or parts of an order can reside in a logical position.

**Term** Logical state

**Spec** A logical state refers to the various status levels that can be configured in the system to help guide the flow of goods. The most evident ones are Hold, Block and Reserve.

- a) Hold can make sure that a collection of some logical entities in some logical positions gets intercepted with some desired action. Other areas of applicability exists.
- b) Block can make sure that goods in some logical position or entity can't be sold or picked/touched. It refers to specific items in a stock unit, and hence suggests that a stock unit **is** separated in to two, if there are only some items that need it. Then a **block** can be applied to entire stock units and **is** easier to implement.
- c) Reserve **is** for picking purposes, where some quantity of an article gets **reserved** at a stock unit. It **is** not tied to specific items of an article, just a quantity of the items of an article at a specific stock unit. This **is** so prevent overselling and overpicking.

**Term** Stock unit

**Spec** A stock unit **is** a set of some items of a specific article. If an article **has** 2 items in one location and 3 in another there are two stock units of this article, one **has** 2 and the other 3 items. If there are 3 items of one article and 4 items of another article in one location, this location **has** two stock units.

**Term** Unit load

**Spec** A unit load will be explained in some places of the SRS. It can refer to a bin or a pallet with a LPN. Or it may refer to just a LPN, which may be placed on anything that can logically contain goods, e.g. a square on the floor. A unit load can have other unit loads, like a load carrier (trolley) with many compartments with LPNs tied to them, i.e. unit loads.

## Basic principles

These basic principles will mention the basic requirements that will form the more detailed requirements. They also kind of work as quality requirements, which is a good complement to this SRS that has been limited to functional requirements and data requirements only. This is to save time and keep us from going too deep.

**Principle** Simplicity

**Status** ELICITED

**Spec** The system should be based on simplicity

**Why** So that it **is** easy to learn and maintain. It should also be so easy that it error proofs in some way. It should be easy in terms of information lead times, since seconds quickly add up to minutes and hours.

\*... Excluded contents ...\*

## Goals

These goal requirements will provide a general list of the areas we wish to make a contribution in, but some requirements will also provide guidance in the future.

---

**Req** Stock visibility and traceability

**Status** ELICITED

**Goal** The applications data structure should allow full visibility and traceability of SKUs, stock units, unit loads/load carriers, orders, batches, waves, and MHEs and the state that they may be in.

\*... Excluded contents ...\*

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## Components of WMS

This is a more extensive mapping of the important components of a WMS, compared to the one in Part III - WMS of the theoretical framework. The reason is that we think it better defines what should be included and taken into account on a fairly high level. It is put into the context of a chronological flow through the warehouse. From the bottom are some enabling technology and keywords to consider. Then are some major concepts that span all stages of the warehouse flow. Location and task management are more of support functions that can be applied in all steps of the flows. Labor and performance management are of more monitoring and planning nature, but this is not excluded in the previous two of course where the rule-based engine is the heart of automatic actions and decision trees. It enables goods to flow as intended and for workers to get through tasks without major experience or knowledge on underlying concepts.

The feature and functionality components have a view that goods need to be coordinated once they get into the warehouse or store. After the direction is set they can be put-away into the area or location that represents the intended direction. The inventory that stays within the warehouse needs to be strategically put-away and managed to ensure accuracy and visibility. Before any outbound flow starts, the warehouse may be planned strategically to optimally meet current or future orders. Once orders arrive inventory need to be allocated. When outbound flow is executed there are various methods of conducting the fulfillment and to ensure visibility up until the point where goods are handed over to the next actor in the chain.

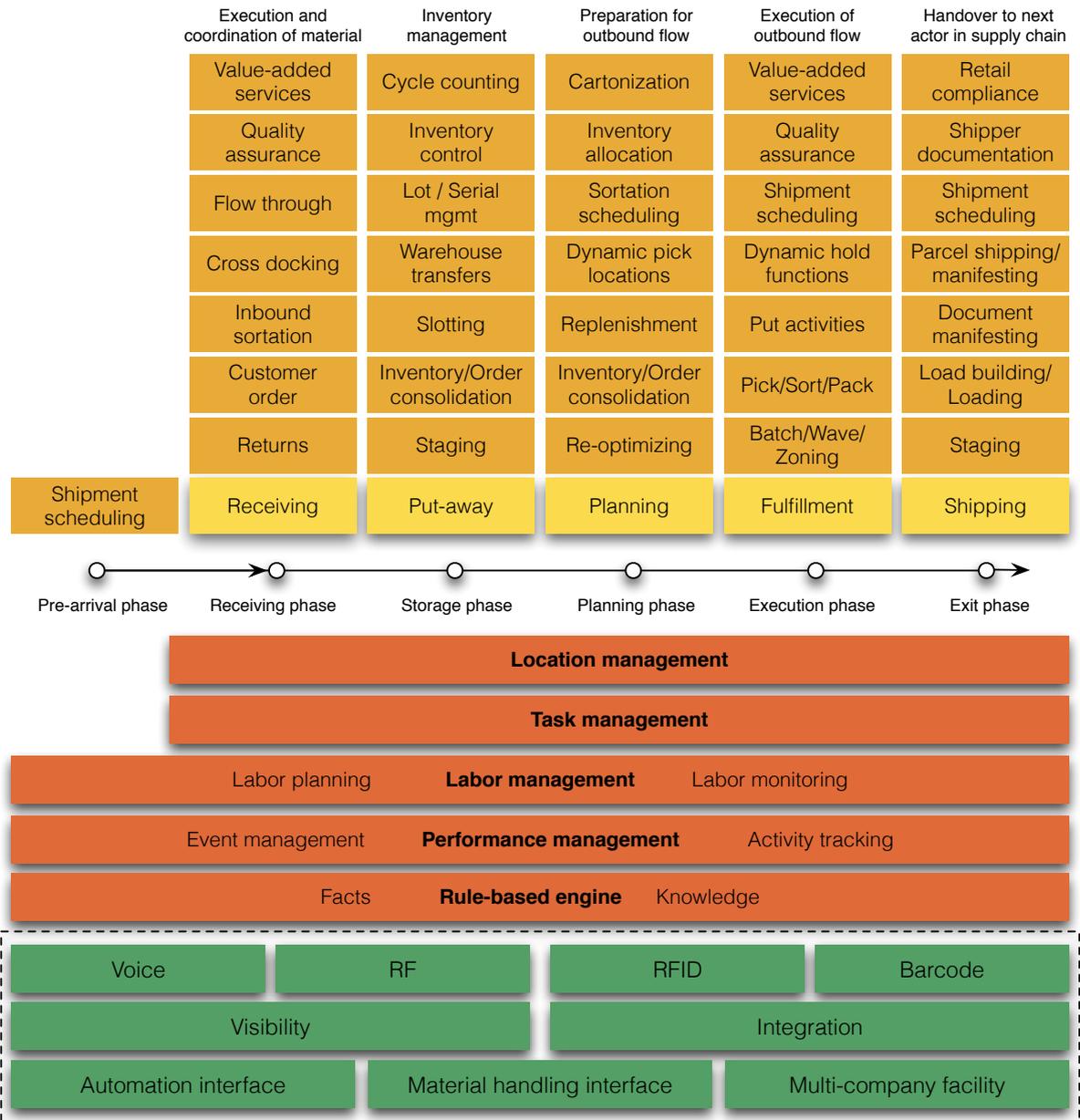


FIGURE A.1: Flow timeline in warehouse in context of WMS components

## Context diagram

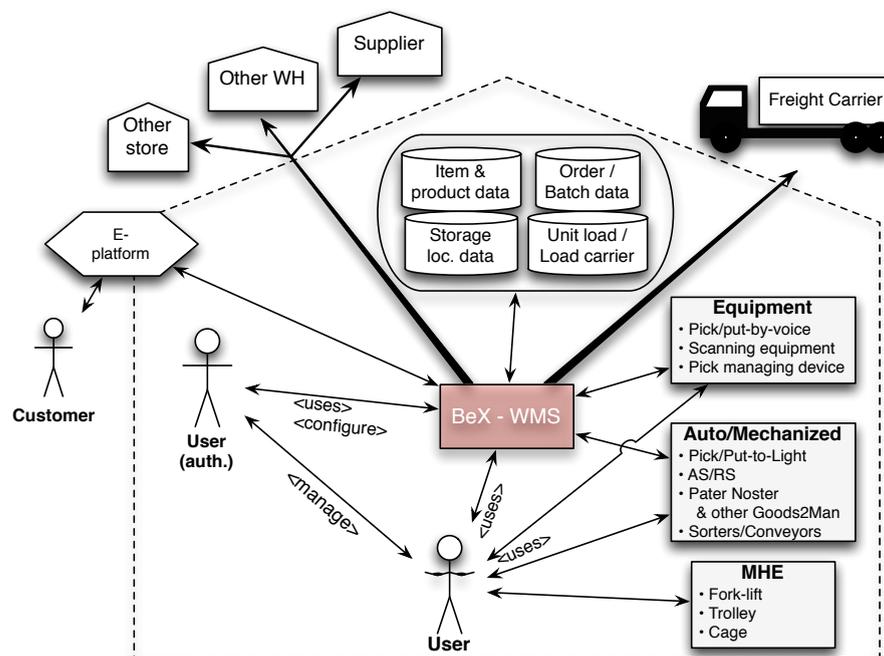


FIGURE A.2: Context diagram supported by system

### Req Context diagram

Status ELICITED

Goal The context diagram should be supported by the system.

Data The application **is** mainly operated by users (employees), which may use some equipment provided by the secondary stakeholders. The warehouse buffers some inventory in order to fulfill some orders and tasks. These rely on:

- Item & product data
- Order / Batch data
- Storage location data
- Unit load / load carrier data

More on this context diagram will be explained in the Master data section, which is put last in the SRS to assist if some expression is unclear, as well as give input on the exact idea on certain concepts when to be implemented.

## Inbound processes

### Receiving

---

**Req** Configurable appointment scheduling

**Status** ELICITED

**Spec** It should be possible to manage a discrete number of appointments by time slot and potentially with dock-door assignment. It should further be possible to determine labor required. Useful and solid KPIs can also be used to assist in planning and negotiating arrangements with key carriers.

**Task** 1. Supplier provides information about shipment. May be done through Web-EDI or EDI.

**Task** 2. **System** keeps track of averages on picking certain types of products and quantities.

**Task** 3. Time can be calculated for shipment  $\Rightarrow$  Labor force can be calculated and scheduled.  $\Rightarrow$  Time slot for carrier can be scheduled.

**Req** Facilitate put-away for store

**Status** ELICITED

**Comment** The application should **support task(s)**: Put-2-store, Cross-dock, Flow-through

**Why** Goods that are requested by stores should be handled in a similar way to customer orders, or at least not worse. They should just be able to be checked off an internal order, much like a customer order.

**Task** Cross-dock / Flow-through

**Comment** Differentiator between the concepts:

- a) Unit size. Cross-docking involves reconfiguration of pallets and cases, Flow-through may include breakdown of case contents to manage redistribution of eaches.
- b) Time. Cross-docked pallet moves through with urgency. Flow-through allows for staging, processing and value-adding activities. Further the goods may reside in a storage location in the wait for processing.

**Spec** Trigger: a) Goods arrive that **is** to be sent to store, b) Internal order request for goods arrives

**Task** 1. Once goods are registered they may be directed to their destination.

**Task** 1b. See inbound sortation or Put-2-Store. Goods may be sorted to the stores according to some predefined criteria or they may be scanned against an internal order, similar to a normal pick-list.

**Task** 1c. The internal orders may be batched and/or waved for an efficient cross-docking activity.

**Task** 2. Goods need to be staged before exiting the warehouse. Proper use of LPNs are needed to know what **is** where in shipping area.

**Task** 3. Hold functionality **is** important for flow-through as it may ask for interception to QA or VAS activities.

**Task** 4. Automatically print shipping documents for cross docked and finished LPNs.

\*... Excluded contents ...\*

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## Appendix B

# Warehouse operations concepts

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*This chapter will provide more insight into some of the basic concepts around warehouse operations that are used in the thesis. This is to prevent from exhausting too much basic material in the theory body and to focus on the major concepts in a broader context.*

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### Inbound related concepts

#### Storage assignment policies

**Dedicated storage policy**, is when a SKU is kept at a predetermined fixed location in the warehouse. If a system can support more policies than this one this usually corresponds to the forward-reserve allocation or fast pick area (FPA), where the goods are put in a convenient height and order to be picked and fulfill orders efficiently. In retail warehouses, this order often matches the layout of the stores so that the goods are picked in the manner that they are unloaded at store shelves.

**Random (floating) storage policy**, leaves the decision to either an operator or system. The original version had an emphasis on randomized allocation to increase efficiency. However, this policy can be used together with other policies to narrow down the selection. In combination with dedicated storage at the forward area, random storage is usually done for the reserve area ([van den Berg and Zijm, 1999](#)).

**Class based storage**, allocates zones to product classes. The classes are created through the distribution of articles based on their demand rates ([van den Berg and Zijm, 1999](#)). It is sometimes referred to as ABC-zoning or Pareto's 80/20 principle, but the allocation can be

based upon any criteria or rule. The most common is turnover rate. The products that sell the most are located at the most accessible locations. Another common rule is the cube-per-order index (COI), which is defined as (de Koster et al., 2007):

$$\frac{\text{Item's required space}}{\text{Nr. trips required to satisfy demand of item}} \quad (\text{B.1})$$

Class-based storage requires more space from the racks than random location storing, but when utilized correctly the picking efficiencies may be improved a lot. As seen in figure B.1 the way the classes are distributed highly affects the way picking needs to be done in order to fully utilize the strategy. It can also be seen the other way around. de Koster et al. (2007) identifies many solutions to the storage-class partitioning problem, but recognizes the lack of a firm rule in defining a class partition for low-level picker-to-part systems.

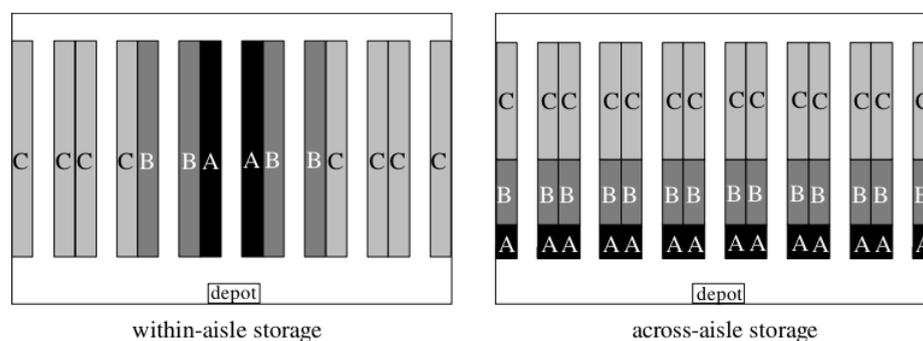


FIGURE B.1: Example of two ways to implement class-based storage (de Koster et al., 2007)

**Family grouping**, this says that articles that have similar characteristics should be stored together. This could be similar dimensions, demanding special handling or safety, or belonging to same product type (de Koster et al., 2007). Some of the reasons could be to get better space utilization, simplifying put-away (both in the warehouse and for the next actor in the supply chain, e.g. the store), or there may just be a need to separate products from one another (Bartholdi and Hackman, 2014). A group is sometimes called a product family, which may be placed strategically according to replenishment theory (see section B) or as a collective class unit, i.e. class-based storage as above.

**Affinity/Correlated storage**, aims at storing products together if they are usually requested at the same time. These kinds of relationships can be calculated using data mining methods (association finding) and have become very popular thanks to facilitating technology (Bartholdi and Hackman, 2014).

## Slotting

Slotting refers to the strategic arrangement of individual cases or master cartons on shelves within the warehouse, so as to compress the space consumed by products and achieve handling efficiencies (Bartholdi and Hackman, 2014). The first is commonly referred to as pick-face optimization, while the latter refers to golden-zone strategies and ergonomic thinking. There is a trade-off between cramming in goods as optimal as possible and the ability to pick goods swiftly. To calculate different ways of slotting there are numerous factors to take into account. The most obvious is the measurements and volume, but there may be policies in storage and picking that affects where the goods are susceptible for being candidates. Bartholdi and Hackman (2014) proposes two heuristics in a 1-dimensional bin-packing problem; Next-Fit and First-Fit algorithm. These are based on a sorted list of SKUs according to the included factors and an iterative removal of these from the list as candidates. These methods are very likely to cause sub-optimizations, but they are easy to compute. However, with today's facilitated implementation of search heuristics in the AI domain, there are heuristics available that can outperform these by far (Byung Soo and Smith, 2012). Some that have been empirically tested in the slotting problem are the (1) Steepest descent neighborhood slotting heuristic (SD), (2) Correlated slotting heuristic (CS), and (3) Simulated annealing slotting heuristic (SA).

## Outbound related concepts

### System characteristics

A major point for distinguishing order picking systems is whether humans or automated systems carry out the pick (de Koster et al., 2007). Layman terms differentiates with *picker-to-parts* and *parts-to-picker* systems (or man-to-goods and goods-to-man). There are two types of picker-to-parts systems: (1) low-level and (2) high-level picking. Low-level picking systems work in the way that the order picker takes the items from storage racks or bin-shelving storages and travels in some way along aisles (see fig. B.2 for a conceptual overview of a low-level system). High-level is typically picking pallets from multiple level pallet racks with a forklift (de Koster et al., 2007). The low-level order-fulfillment systems usually consist of MHEs such as cart/trolley systems, RF/Voice, handheld devices or paper-picks (Bartholdi and Hackman, 2014). High-level order-fulfillment systems mainly use some sort of truck or crane to handle the goods.

Parts-to-picker systems are getting increasingly popular with the use of pick-to-light or put-to-light systems. Previously the use of carousels, pater-nosters, tilt-trays and A-frames were the hype as mechanized systems became cheaper (Gagliardi et al., 2012). A next step in the complexity figure is having automatic warehousing systems, e.g. AS/RS robots that perform the actual pick movement (van den Berg and Zijm, 1999).

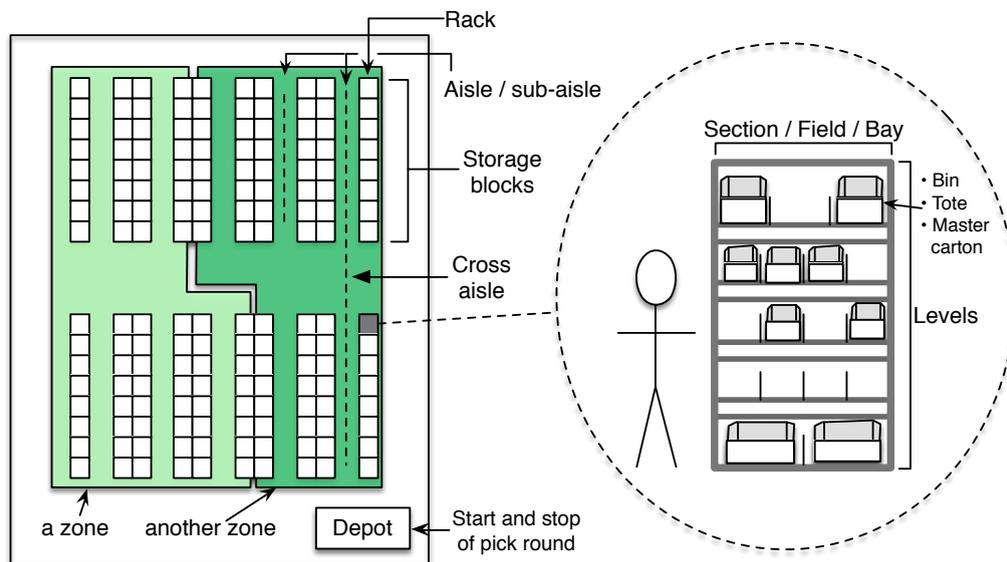


FIGURE B.2: Elements of low-level rack layout design

## Order-picking organization

As with the operational dimensions in fig. 3.4, there is a lengthy theoretical research within each policy, which is why only the main elements will be discussed: (For Storage policies, see section B)

**Batching**, If a worker was to pick each order as they came in there would be a lot more rounds needed to finish them all. But if they were clustered into a group of orders that are “near” each other in terms of physical location or some set of characteristics, then the efficiency per order would increase. This is called batching and is common when the orders are small and frequent (Bartholdi and Hackman, 2014; de Koster et al., 2007). The basic types are to pick by article or by order. If picking by article there is sometimes a need for sorting, which may be done during the pick or after (de Koster et al., 2007). When connected with waving logic, there is usually more focus on the time window of a batch, rather than the proximity of the items.

**Order release modes**, The way that orders are released affects the efficiency of the picking activity (de Koster et al., 2007). The main considerations are the need for order sortation and system response time. Continuous dispatch of orders may be difficult and are often limited to batch clustering from the queue of incoming orders. When there are gains in picking some set of orders simultaneously (to make sure that they are finished at the same time), wave picking is one way to release orders (Bartholdi and Hackman, 2014). A common example is if there is a cluster of orders that are going to the same destination, to which a carrier has its time deadline set.

**Zoning**, Zoning refers to the division of the picking locations into a number of picking zones (see example in fig. B.2). A batch or customer order is split up by the zones and is then either picked across zones simultaneously/synchronized or progressively. The term zone may be used interchangeably when discussing how items are stored and how they are picked. Having class-based storage or family grouping may be seen as a zone, but it is the zone-picking that picks these items in a certain order. The main considerations within zoning is the balancing of pickers within zones and the clustering or consolidation of orders (Goetschalckx and Ashayeri, 1989). In comparison with other issues of planning in the warehouse, zoning literature is scarce (de Koster et al., 2007).

**Routing**, Of all of the components that make up the total time required for order-picking, travel time is usually the largest (Dekker et al., 2004). This travel time is decided by (1) the routing policy and (2) the storage assignment policy. Routing policies are based on how to get from one aisle to the other. There are two ways of doing this; either the current aisle is traversed entirely or the exit is where the aisle was entered. Some of the most common routing methods are seen in figure B.3. The most trivial ones are S-shape, Return and Mid-point, that requires no calculations. Largest gap is a very popular method, which always outperforms the otherwise fairly efficient Mid-point method (Dekker et al., 2004). The combined heuristic mixes the ways of traversal above in deciding the best way to route (Roodbergen and De Koster, 2001). The optimal have the shortest travel distance, but is obviously more advanced and hard to follow on a pick route (Bartholdi and Hackman, 2014).

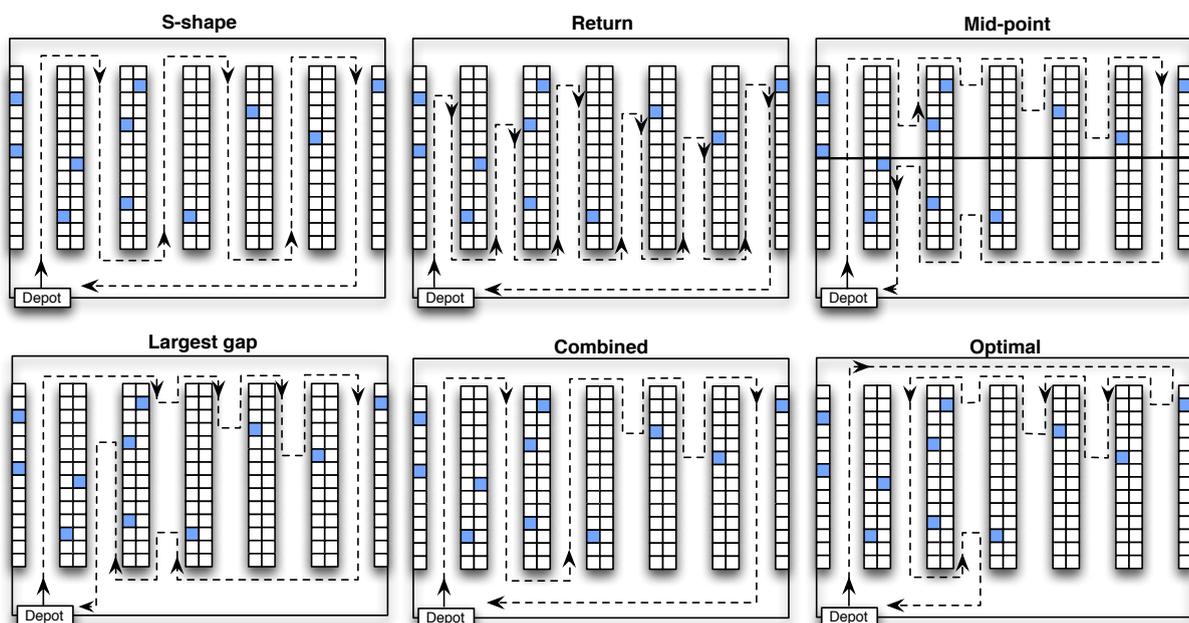


FIGURE B.3: Example of routing methods (de Koster et al., 2007)

Routing policies use some sort of input of shortest distances between locations (Bartholdi and Hackman, 2014), and are calculated with either dynamic programming, some search heuristic or with just a normal routing heuristic (Dekker et al., 2004; Roodbergen and De Koster, 2001). In some routing heuristics there is use of dynamic programming as well, as is the case of *Combined policy*. The search heuristics are from the AI domain, where the branch-and-bound algorithm have received most research attention within optimal routings (de Koster et al., 2007; Roodbergen and De Koster, 2001). However, the ease of implementation of regular routing heuristics has made these the winner in the long run (Dekker et al., 2004).

### ***Replenishment***

Replenishment is a concept usually connected to FPAs (Fast Pick Area). These are sustained through the refilling of the unit position with a lump-sum of units from a reserve position, so that the distance walked by pickers is smaller when that unit is to be picked (Bartholdi and Hackman, 2014). When discussing JIT replenishments and store replenishment, the content is quite similar in terms of taking forecasts and projections into account, but the factors involved aren't on the same micro-level as with FPA replenishment (Chung et al., 2013).

The issues in replenishment are firstly which SKUs to store in a FPA and how much storage space to assign these SKUs (Bartholdi and Hackman, 2014). This leads to a setup which gives some SKUs to put in FPA, some number or required replenishments, some quantities to replenish with, and when these restocks will occur. The two most common replenishment strategies are to either allocate the same volume space to all SKUs or store an equal time supply to all SKUs, i.e. the average number of restocks per item is the same. The fundamental element of this is the flow through the warehouse for an item, which is defined as:

$$flow, f, volume/year = volume/case \frac{\# \text{ items / year}}{\# \text{ items / case}} \quad (\text{B.2})$$

### ***Order processing & Shipping***

Accumulation, sorting and consolidation activities are especially important if the orders have been picked in batches or waves (de Koster et al., 2007). Together with packing, VAS and QA, these constitute order processing activities. It serves to check that goods comply with company policies, are consumer ready and are error proof (Rouwenhorst et al., 2000). QA is important so that none of the following happens;

- SKU *shortage* (customer receives less than ordered, i.e. double parcels needed in order)
- SKU *overage* (customer receives more than ordered, i.e. unnecessary return mgmt.)

- SKU *damage* (customer receives a broken item, i.e. unnecessary return mgmt.)
- SKU *incorrect* (customer receives incorrect item, i.e. unnecessary return mgmt.)

VAS activities could be (re)labelling, tagging, price-tagging, kitting, bundling (“Buy 1 Get 1 for free”, “Buy this basket of products cheaper”), repairing, (re)packaging, etc. (Richards, 2011). The shipping process involves coordinating goods to the right carrier and assuring that the right manifest documents are sent with the goods. Consolidation activities may happen here as well so that goods are stacked on a unit load that the carrier uses, e.g. a pallet (de Koster et al., 2007). Staging and sequenced staging refers to lining the goods up in the shipping area for easy loading onto the carriers vehicle. If done in a certain sequence, it can assure that the offloading of the vehicle can be done according to the route it is traveling along. Since staging usually is not done onto shelves but onto the floor, there is a risk of losing track of the goods until they are unloaded at the next depot. It is common to see structured floor drawings to allow the same order as in the storage system (Freese, 2000).

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