Chair of Economic- and Business Management

Master's Thesis

Future of WMS in e-grocery based on the example of the WMS (WAMAS) from SSI Schäfer

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Scope of Work

Mr. Simon Florian Brockmeier, BSc is tasked to write a master thesis on the topic

Future of WMS in e-grocery based on the example of the WMS (WAMAS) from SSI Schäfer

In the first part of the thesis, the basics for market analysis and warehouse management systems (WMS) shall be prepared. These basics serve as the foundation for the second part of the thesis. There a market analysis with the focus on e-grocery is to be conducted. With the results the future role of WMS in e-grocery must be derived.

The second part of the thesis will transfer the findings from the first part to a particular application case, the WAMAS from SSI Schäfer. For this purpose, the functionality of WAMAS has to be described in comparison to general WMS, and a development need for e-grocery based on the market analysis has to be worked out.

Leoben, March 2019 o.Univ.Prof. Dr. Hubert Biedermann

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AFFIDAVIT

I declare on oath that I wrote this thesis independently, did not use other than the specified sources and aids, and did not otherwise use any unauthorized aids.

I declare that I have read, understood, and complied with the guidelines of the senate of the Montanuniversität Leoben for "Good Scientific Practice".

Furthermore, I declare that the electronic and printed version of the submitted thesis are identical, both, formally and with regard to content.

Date 26.08.2019

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Abstract

E-grocery has a growing impact on the food retail market. More and more customers want to purchase food online. In this master thesis the development of e-grocery is analyzed by conducting market research about the e-grocery. The question is answered if e-grocery business will shape the future of the food industry or not. Based on the result of the market research the impact of a WMS in food retail is analyzed. Finally, the WMS solution of SSI Schäfer is evaluated regarding to the e-grocery requirements. Answers are given about which processes are already available in the standard software of SSI Schäfer for satisfying the needs for a warehousing software in e-grocery. And which processes need to be adapted or are still missing.

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List of Abbreviations

AGV	Automated Guided Vehicle
AS/RS	Automated Storage And Retrieval System
BBD	Best Before Date
B2B	Business-to-Business
B2C	Business-to-Customer
CEP	Courier Express Parcel
EDI	Electronic Data Interchange
ERP	Enterprise Resource Planning
FC	Fulfillment Center
FIFO	First-in-First-out
FMCG	Fast-moving Consumer Goods
FOG	Flow-of-Goods Graph
IMS	Inventory Management System
IP	Intellectual Property
LIFO	Last-in-First-out
LMD	Last Mile Distribution
LU	Loding Unit
MFC	Micro Fulfillment Center
MVP	Minimum Viable Product
OC	Omni-channel
OG	Outgoing Goods
PLC	Programmable Logic Controllers
RF	Radio Frequency

SKU	Stock Keeping Unit
TMS	Transport Management System
WCS	Warehouse Execution System
WhLoc	Warehouse Location
WMS	Warehouse Management Software

1 Introduction

E-commerce in food retail becomes increasingly significant. More and more people are buying electronics, music, fashion items, movies and food via internet. Nowdays even grocery. The market for e-commerce in food retail, so called e-grocery, is growing significantly. Over the last years different concepts for buying grocery online were improving and now it becomes more effortable for the customer and more profitable for the suppliers. For the most challenging parts in the supply chain like the last mile, e-fulfillment and a short lead time, the warehouse management plays an important role. Processes like shipment planning, sequencing, picking and order processing need to be optimized and automated to meet the customer's needs and have lower logistics costs. Therefore, a proper use of warehouse management systems (WMS) is a key to succeed. But of course the demands for a WMS varies for different industries and different business models. As well for e-grocery there are specific processes that are important and need to be adopted compared to a WMS that is only used for normal food retailers.

Problem
SSI Schäfer has already customers that offer the possiblities to buy food online. But the knowledge about specific software requirements for these customers is still missing. Therefore, there are no standard processes in the software product (WMS) that aimes at this e-grocery business yet. Also, SSI Schäfer didn´t make a forecast of the grocery market to understand if the amount of e-grocer customer will rise in the future or not. Only if the e-grocery market will rise and more e-grocers will need a WMS it makes sense for SSI Schäfer to offer a standard software solution that considers e-grocery specifications.

Objective
The objective of this master thesis is to find out if e-grocery will shape the future of the food retail market. Will be e-grocery only a short-term trend or will it influence the grocery market and all its stakeholders also in the future? What are the pains and challenges for suppliers and customers in e-grocery and which business models will be able to find solutions to overcome these pains and challenges the best? Also the WMS will be analyzed and possible adaptations as well as missing processes shall be pointed out and described in detail.

Methodical approach
For analyzing the food retail market a desk research will be performed. A desk research is taken because of the novelty of e-grocery. A lot of information can be found in the internet and especially in surveys of customers buying behaviours and online reports about online grocery. Information about specific requirements for a WMS in e-grocery was gained from the market analysis and the in-depths interviews with leading sales employees from SSI Schäfer that know

what the e-grocery market is demanding from a WMS. Based on that and further information gained from the in-depth interviews, possible adaption and missing processes of the standard product will be analyzed together with experts from the product development and logistics consultant from SSI Schäfer.

Structure of the thesis

The first part of this master theses is describing market analysis in general. It is described how to perform a market analysis and with which methods it can be done. That is followed by a theoretical overview over the core topic WMS. It is described which functions typically covers a WMS and what role it plays for e-commerce in general. In the practical part of this thesis the market analysis of e-grocery is performed. It is analyzed which business models exist for e-grocery, which are pains and challenges for customers and grocers and how the e-grocery market is developing. It is examined, which relevance has e-grocery for customers and grocers in the future. Based on these results the requirements for a WMS in e-grocery are worked out. Finally, based on the findings of the market analysis the WMS software of SSI Schäfer is examined. Offered standard processes of the software (WAMAS) are listed and process that are used already for e-commerce are highlighted. In the end processes that need to be adapted, improved or even new designed to fulfill the researched requirements for e-grocery, will be described.

2 Market analysis in general

In this master thesis a market analysis of the online grocery is performed. Therefore, a short introduction into market analysis is made in this chapter. It will begin with the basics and where to use market analysis. Following a short overview over qualitative and quantitative research methods is given and some of the methods will be described in more detail.

To get a better understand of the topic, the following first section deals with the basics of the market analysis. That includes the different ways of using market analyses, the different data types that can be used and the benefits and limitations of market analysis.

2.1 Basics for market analysis

"Market research provides critical information about your market and your business landscape. It can tell you how your company is perceived by the target customers and clients you want to reach. It can help you understand how to connect with them, show how you stack up against the competition, and inform how you plan your next steps."[1]

The starting point of a market research project is to provide a brief background information to the problem or a statement of what information is required in order to make a decision after the research. It is very important to define the tackled problem in order to solve it properly. Therefore the objective of the survey is necessary to define before carrying out the market research and an according research question that will be answered and the end of the analysis. If this is not done adequately, the effort put into the work will often be wasted. Objectives are statements of what the research will be used for and what specific information is being searched.[2]

Use of market analyses

There are different reasons for carry out market analyses. It can be done for following reasons:[3]

- Market segmentation and achieving of optimum prices
- Brand positioning improvement

[1] The Hart Ford, https://www.thehartford.com/business-playbook/in-depth/business-market-research Why do market research, (Access: 05.06.2019).
[2] refer to Hague et al. (2016), p.12.
[3] refer to ibid., pp. 219.

- Entering new markets
- Launching new product
- Improving customer satisfaction and loyalty

Types of data

In general, you distinguish between primary data and secondary data. As the name suggests, primary data is one which is collected for the first time by the researcher while secondary data is the data already collected or produced by others. The most important difference between this two types is that primary data is factual and original whereas secondary data is just the analysis and interpretation of the primary data. Primary data is collected with the aim for getting solution to your specific problem and secondary data is collected for other purposes. So secondary data is already existing data which has been collected already by a previous researcher.[4]

Primary data:

Table 1: Advantages and disadvantages of primary data[5]

Advantages	**Disadvantages**
+ Recent	- Usually expensive
+ They are collected due to a specific purpose	- Time consuming data acquisition

Examples of primary data:

- In-Depth interviewing
- Surveys
- Focus groups
- Observation

[4] refer to Oluwatosin (2017), pp.2.
[5] refer to Mooi et al. (2018), p.31.

Secondary data:

Table 2: Advantages and disadvantages of secondary data[6]

Advantages	**Disadvantages**
+ Cheaper	- May be outdated
+ Sample sizes tend to be bigger	- Not fully fit the problem
+ Easy to access	- Bad data quality
+ Sometimes more accurate (e.g. data on competitors)	- No control over data collection

Examples for secondary data:

- Government statistics
- Media and publications from industry associations
- Trade publications like periodicals and news articles
- Company websites
- Market research reports
- Science blogs

Benefits and limitations of market research[7]

- Market opportunities – One of the biggest benefits of conducting a market analysis is that it helps to find out various market conditions. One knows the audience nature, personalities, likes, dislikes better. This makes it easier to connect with them and reach out to them.
- Minimization of the risks – Another benefit of market research is that it helps businesses minimize risks by taking actions on certain subjects. It may help to add certain qualities to products that were not seen before.
- Trends and market standing – The market changes continuously and constantly. Market research can help to be up to date with ongoing trends. It makes possible to react on current customer needs and requirements.
- Possible problems –Market research brings out the customer reactions, choices, and preferences. Business can adapt the product to them while it is still in the manufacturing or designing process. Research results help to find problems and to work on them.

[6] refer to Mooi et al. (2018), p.31.
[7] Anastasia,https://www.cleverism.com/market-research-techniques-primary-secondary/(Access: 12.08.2019).

There are two types of methods for carrying out market analysis. The first one described is dealing with qualitative methods for answering the research question. Some possible methods will be desribed in detail and advantages and limits of these methods are highlighted.

2.2 Qualitative methods

"Qualitative methods are used to answer questions about experience, meaning and perspective, most often from the standpoint of the participant. These data are usually not amenable to counting or measuring."[8]

Following two sample methods for qualitative methods are described:

Desk research[9]
Desk research is the study of secondary sources of data. Therefore, information that is already available either in public or within the private confines of an organization itself.

Desk research is quick and inexpensive.It offers possibility to dig out data from a wide variety of sources and to answer many research objectives. Desk research refers in general to secondary data which can be collected without fieldwork.

It is to emphasize that much useful information is stored in computers and files of the very companies that are seeking the data. This information can be found in sales reports, in sales statistics or in a customer-relationship management system. This data could be used to produce a valuable picture. So, one of the most important sources of data within a company is the customer database. This source is always worth an analysis, especially if it is from sales data.

Sources for desk research:

- Internet
- Online market reports
- The press
- Company data
- Government statistics
- Trade and industry bodies

[8] Hammarberg et al. (2016), p.498
[9] refer to Hague et al. (2016), pp.53.

Limits of desk research:
Desk research has its limits and it only provides a part of the needed information of a project. Sometimes a mix of desk and primary research is required. Information is gained by carrying out desk research first and then filling the gaps through interviewing. Some information is also in principle not available from desk research or is not available in the required form. A limitation is also that some found data from desk research could be opinions, attitudes to novel product or views on specific advert.

In-Depth interviews
In-Depth interviewing is a qualitative research technique. It is a conversation with participants on a specific topic. These participants could be government or company representatives. The structure levels of interviews vary and is in its simplest form unstructured and the participants talk about the topic in general. Interviews can also be fully structured, meaning all the questions and possible answer categories are decided beforehand. Most in-depth interviews are semi structured and contain a series of questions that need to be addressed but have no specific structure.[10]

When are in-depth Interviews Appropriate?
In-Depth interviews are useful when detailed information about one person's thoughts and ideas on a certain issue in depth. Interviews are often used to provide context to other data (such as outcome data), offering more complete picture of the researched problem or topic. Depth interviews should be used where focus groups are not adequate because the participants are not speaking openly about a topic or if you want to distinguish the opinion of certain individuals.[11]

Advantage of in-depth interviews:
The primary advantage of depth interviews is that they provide very detailed information compared to other data collection methods, such as surveys. They provide more relaxed atmosphere in which it is easier to collect information as people may feel more comfortable to speak openly compared to filling out a survey.[12]

Limits of in-depth interviews:[13]

- Spoiling: The interviewer has already a certain result or answers in mind. By that the result of the interview will be influenced by the interviewer itself.
- Time-intensive: Interviews is a time-intensive evaluation activity because of the time it takes to conduct interviews, transcribe them, and analyze the results.
- Right interviewing techniques: To gather the detailed and rich data from an interview, the interviewer must make that person comfortable and appear interested in what they

[10] refer to Mooi et al. (2018), p.82.
[11] refer to Boyce; Neale (2006), pp.3.
[12] refer to ibid., pp.3.
[13] refer to ibid., pp.3.

are saying. They also need to use effective interview techniques, such as avoiding yes/no and leading questions, using appropriate body language.

- Not generalizable: When in-depth interviews are carried out, it is not possible to generalize about the results because small samples are chosen and random sampling methods are not used. If the same stories, themes, issues, and topics are emerging from the interviewees, then a sufficient sample size has been reached.

Observation[14]

Observation research depends on watching people what they are doing. Observation research can be defined as the systematic process of recording patterns or behaviors of occurrences without normally questioning or communicating with the people involved. The observation may involve watching people or watching phenomena, and it may be conducted by human observers or by machines (e.g. video cameras). Thus, an observation can be that people are watching people, people are watching phenomena or machines are watching people or phenomena.

Advantages of Observation Research:

The advantage is that firsthand information is not subject to many of the biasing factors associated with the survey approach. The researcher avoids problems associated with the willingness and ability of respondents to answer questions. Some forms of data can be gathered also more quickly and accurately by observation. For example, letting a scanner record all items in a grocery bag is much more efficient than asking the shoppers to enumerate them.

Limits of Observation Research:

In an observation research only behavior and physical personal characteristics can be evaluated. The researcher cannot evaluate motives, attitudes, intentions or feelings. Another problem is that present observed behavior may not be projectable into the future. For example, the fact that a consumer is buying a certain brand of milk after examining several alternatives does not mean that he or she will continue to do so in the future. Observation research is normally time-consuming and costly (if the observed behavior occurs rather infrequently).

Data analysis

In qualitative research, the samples are smaller than in quantitative surveys and the data is more subtle and complex. More open-ended questions are used, and the interviewer will get more useful responses. The interview or discussion can be unstructured, with varying range of topics between different respondents. Some of the types of data analysis can be used for quantitative and qualitative research. The researcher who has carried out the fieldwork should be deeply involved in the analysis, interpretation and presentation, otherwise a lot of information will be lost.[15]

[14] refer to McDaniel; Gates (2013), pp.154.
[15] refer to Hague et al. (2016), pp.216.

The second type that is described deals with quantitative methods for collecting information. The quantitative methods are basically needed when actual facts about topic are needed. There is detailed description of quantitative methods and advantages and limits are highlighted.

2.3 Quantitative methods

"Quantitative research methods are appropriate when 'factual' data are required to answer the research question; when general or probability information is sought on opinions, attitudes, views, beliefs or preferences; when variables can be isolated and defined; when variables can be linked to form hypotheses before data collection; and when the question or problem is known, clear and unambiguous."[16]

Online survey

Email and web-based data collection methods are attractive to researchers in international marketing because of low costs and fast response rates.[17] For carry out an email data collection researcher just need a reasonable list of e-mail addresses, design questionnaire, send it by e-mail and await the responses. So, it is easy to collect data quickly and can access audience no matter of their geographical location.[18]

Advantages of Online survey:

A web-based survey is appropriate for a wide audience, where all the visitors to certain websites have an equal chance to enter the survey but in contrast to email surveys the researcher has less control over respondents entering the web-based survey. Another advantage is the better display of the questionnaire, whereas email software is still limited in terms of design tools and questionnaire methods. The both types of online survey may be mixed to combine the advantages of each.[19]

Limits of Online survey:

An online survey is not suitable for open-ended questions because there is no trained interviewer to explore the answers of the respondents. An online survey is also not applicable for surveys that require respondents who still do not have access to the Internet. For example, elderly people and people who reside in remote areas. Finally, it is a challenge to prevent that an online survey to be spoiled due to people who answer online surveys only for the sake of getting incentives for completing the survey. Then there is no interest to contribute to the advancement of the study.[20]

[16] Hammarberg et al. (2016), p.499.
[17] refert to Ilieva et al. (2002), pp.361.
[18] refer to Hague et al. (2016), p.189.
[19] refert to Ilieva et al. (2002), pp.361.
[20] Online Surveys, https://explorable.com/online-surveys, (Access: 05.06.2019).

Questionnaire[21]

The term 'questionnaire' is used to refer to questionnaires intended to survey instruments intended to be administered by an interviewer, either in a face-to-face interview or by telephone. In other disciplines this is often referred to as an strutcured interview schedule. In a structured interview each subject or respondent is asked a series of questions according to a prepared and fixed interviewing schedule, the questionnaire. In contrast to quantitative resarch interviews there are also qualitative research interviews, where the interview schedule is not fixed. Structured interviews are carried out by using some different data collection media. Interviewers can ask questions face to face with the respondent or subject or interviews can be carried out by telephone.

Advantages of a Questionnaire:

The role of a questionnaire is to provide a standardized interview across all subjects. All respondents are asked appropriateto them questions. Those questions are always asked in exactly the same way. Identical questions asked in the same way to different people is the key to make optimal results and the real advantage for most survey research. If it would be not the case, it would be impossible for the survey researcher to interpret the answers. By tailoring this process, respondents will not be able to communicate to the researcher all of the information that is either relevant or that they wish to convey. With largescale surveys where there is anything more than a few dozen respondents, it is impossible to handle and interpret data without a standardized question format.

Limits of a Questionnaire:

Some of the general problems for surveys and questionnaires outside the direct control of the researcher include:

- Inaccurately asked questions
- Respondent doesn´t understand the question;
- Incomplete or inaccurate record of the reply in the questionnaire
- Respondents are lying
- Respondents are not willing to admit their attitudes or behaviour
- Respondents are trying to influence the outcome of the study

Experimental Research[22]

In experimental research the researcher changes or manipulates one thing (experimental variable) to observe the effect on something else (referred to as a dependent variable). In marketing experiments, the dependent variable is frequently some measure of sales (e.g. total sales or market share), experimental variables are typically price, amount or type of advertising, and changes in product features. Experiments are conducted in a laboratory or a field setting.

[21] refer to Brace (2008), pp.2.
[22] refer to McDaniel; Gates (2013), pp.180.

Experiments in the physical sciences are normally conducted in a laboratory setting and many marketing experiments are field experiments.

Laboratory experiments can control extraneous causal factors—temperature, light, humidity, and so on—and focus on the effect of a change in A on B. In the laboratory, the researcher can effectively deal with a third element of proving causation (elimination of other possible causal factors) and focus on the first two elements. Therefore, laboratory experiments are viewed as having a high internal validity. On the other hand, the controlled and sterile environment of the laboratory may not be a good environment for marketing experiments. Thus, a lower external validity.

Field experiments are conducted outside the laboratory environment, in an actual market environment. Test markets are a frequently used type of field experiment. Field experiments solve the problem of the realism of the environment. But a major problem is that in the field the researcher cannot control all the spurious factors that might influence the dependent variable, such as actions of competitors, the weather, the economy, societal trends, and the political climate. Field experiments have more problems related to internal validity, whereas lab experiments have more problems related to external validity.

Limitations of Experimental Research:

- High Cost of Experiments
  Experiments can be very costly in money and time. In a lot of cases, managers anticipate that the costs of doing an experiment would exceed the value of the information gained. For example, the costs of testing three alternative advertising campaigns in three different geographic areas. Three different campaigns must be produced.
- Security Issues
  Conducting a field experiment in a test market can expose a marketing plan. Competitors can find out what is being considered in advance of full-scale market introduction. This gives competitors an opportunity to decide whether and how to respond. The element of surprise is lost.
- Implementation Problems
  Problems that may occur are contamination problems, differences between test markets and the total population, and the lack of an appropriate group of people or geographic area for a control group.

Data analysis

In quantitative content analysis, if data analysis involves statistical procedures, tools that summarize data in a way that patterns can be found and highlighted efficiently. The goal of a quantitative data analysis is relatively simple. It is about to describe characteristics of a sample or population. For example, researchers may be interested in learning the frequency of occurrence of some particular characteristic to understand a typical or unusual behavior. Researchers focus on highlight patterns of association between characteristics of one thing and

characteristics of another to describe a relationship. Knowledge about previous research and well- focused questions facilitate data collection and are also crucial for good data analysis. Previous research provides knowledge on what variables to focus and on how to collect data to measure them. Finally, effective replication of studies may require using identical measures and data analysis techniques for maximum comparability across studies.[23]

[23] refer to Riffe et al. (2014), pp.138.

3 Warehouse Management System (WMS)

For the beginning it is important to focus on the general warehouse operations and the general logistics framework where it is used. In general, the functions of a warehouse are to optimize logistics performance, the fulfillment of orders by ensuring the readiness for retrieving goods or value-added services like packaging or labeling for sales reasons. It can be used also for maturing or speculative reasons of the stored items. Furthermore, it is balancing the required and delivered quantities and handles a high variety of different goods and different lot sizes. That leads to a more efficient use of transport vessels and therefore to a cut of costs. Also returns are handled within the warehouse.[24]

Warehousing or warehouse management deals with managing all distributing, storing, transportation and picking processes of goods inside the warehouse as well as receiving goods to the warehouse and sending goods out of the warehouse. It deals with processes inside the warehouse. These processes are planned, measured and controlled and of course operated by the warehouse management. Also, topic related to the inventory is management. This management and linking of the processes is happening inside a warehouse management system (WMS).

In the beginning of the following chapter all the important basics for understanding how a WMS functions will be explained. This includes the data structure used in a WMS, the integration in the IT-infrastructure and the used hardware in a warehouse. Based on that information the most important processes which cover a WMS are explained. The last part of the chapter deals with the requirements for a WMS in the e-commerce market in general. In the following first section the basic understanding for a WMS will be built up.

[24] refer to Hompel; Schmidt (2007), pp. 3.

3.1 Basics of a WMS

There is some basic knowledge about the functionality and structure of a WMS needs to be understood. The market analysis of a WMS in e-grocery, beginning with the data structure used in a WMS.

Data structure[25]
The data used in a WMS can be generally divided into master data, inventory data and movement data. All the data that occurs in the WMS belong to one of these three data types.

Master data:
Master data is defined as statical data which is not changed over a longer period of time. The master data contains all basic information about item, loading aid e.g. The most important master data are the item master data because all main functions and control mechanisms warehouse are based on them.
In the item master a description, item number, used loading aid, dimensions, weight, packaging structure of all articles is included. By packaging structure is the for example meant that one of four cans are placed in one carton and eight cartons are placed on one pallet. Also, the partner master data is important to mention. A partner can be a customer, a supplier, freight carrier for example. In this partner master data basic information like address and further configuration concerning the shipment or specific processes is given.

Inventory data:
Inventory data informs about the quantities of items that are stored or provided over a longer period of time. The up-to-dateness and accuracy of this kind of data collection is of special importance to ensure the readiness to deliver. These data are changing continuously, therefore they are also called dynamical data.

Movement data:
Movement data are also dynamical data which represent all main physical warehouse processes. These basic processes are goods receipt and issue and warehouse operations as well as order-picking processes and order execution. This data can include incoming and outgoing goods orders, picking orders as well as transporting orders.

Integration of a WMS in the IT-infrastructure
In the graphic (figure 1: "Warehouse software") you can see the different layers of software in a company. It can be distinguished in different layers, that are managed by different subsystems.

[25] refer to Hompel; Schmidt (2007), pp. 56.

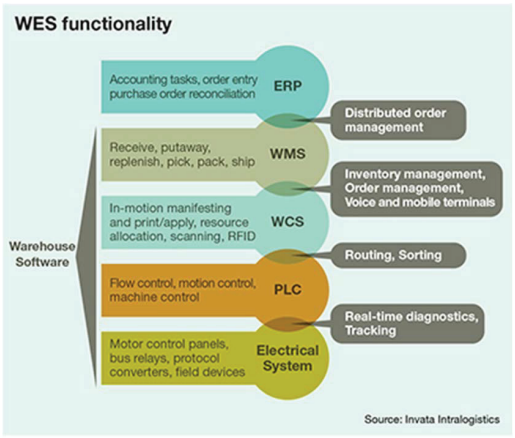

Figure 1: Warehouse software[26]

ERP-System and WMS:

Overseeing all processes in a company there is an enterprise resource planning system (ERP-System). Underlaying the ERP-system is the actual warehouse software beginning with a WMS for managing the processes inside the warehouse. A warehouse execution system (WES) combines the two activities of a warehouse control system (WCS) and a WMS.[27]

Warehouse control system (WCS):

A WCS is an information technology that assists the WMS to manage subsystems to handle material daily activities of put-away, picking and coordinate the equipment to move product from source to destination.[28]

Programmable logic controllers (PLC):

"A digitally operating, electronic system to be used in industrial environments with a programmable memory for the internal storage of user-specific control instructions for the implementation of specific functions such as the logic control, flow control, time, counting and arithmetic functions, in order to control different kinds of machines and processes by means of digital or analogous input and output signals."[29]

Therefore, a PLC is used for controlling the underlaying electrical systems (warehouse automation) and is communicating/controlled by the WCS.

Hardware of a WMS[30]

Following some hardware systems that can be used inside a warehouse and which can be used for a WMS:

[26] Source: Logistics Management, https://www.logisticsmgmt.com/article/wes-solutions-more-than-a-bridge, (Access: 19.03.2019).
[27] refer to Hompel; Schmidt (2007), p. 148.
[28] refer to Ross (2015), p. 677.
[29] Hompel; Schmidt (2007), p. 148.
[30] refer to ibid., pp. 90.

Ground block storage:
Goods are arranged in a compact block, directly one upon another, side by side and one after the other. The space is optimally utilized by this method, with the limitation that only goods in the first row can be accessed. For that it is used for warehouses for beverages or raw materials as well as buffer warehouses in the goods receipt/issue if complete loads are buffered.

Statical racking systems:
Racks are mostly used to optimally utilize the space and height for storing inside of a warehouse. Load units are placed on a separate shelf or a specified bin in a rack. This allows an efficient storage even for not stackable goods. The rack heights range from 2 m (manual operation) to about 50 m.

- Pallet rack
  Pallet racks are the most common type of pallet storage systems and are designed for use of a standardized loading aid. In the classical case the stored unit load (pallet or skeleton box). The load unit is stored lengthwise or crosswise.

- High-bay racking
  High-bay racking is often used to describe high racking systems for a rack height from 12 m onwards. A high-bay racking system has a fixed storage with retrieval machines (S/R). High-bay racks can have a height of up to 50m and may offer space for more than 100 000 pallet bins.

- Cantilever rack
  A cantilever rack contains goods that are placed on cantilever arms which are mounted at vertical or inclined rack props. Cantilever racks are ideal for the storage of long goods (pipes or rods) or boards. Usually these racks have a high loading capacity, therefore it is also used for universal storage purposes.

- Drive-in and drive-through racks
  These are simple static block storage systems. The rack supports form vertical aisles for the rack feeders. When the unit loads are stored and retrieved they are moved slightly above mounted angle profile. The system is operated only with front stackers and is accessed from the side.

Dynamical racking system:
For different reasons, warehouse systems need to be designed dynamical. This offers the following advantages:
– Shorter order-picking distances and high picking performance
– High transshipment with a compact storage
– Using benefits of block and line storage

- Movable aisle systems
  Different kinds of rack systems like pallet, container, shelf or cantilever racks can be mounted on so-called subframes, with a limited height (up to about 10 m). This allows the sidewise moving of single racks so that a compact block is built, and the aisles

disappear. Alternatively single racks can be moved out of the aisle at the front of the block.

- Vertical rotary racks (paternoster racks)
  Turnable troughs are fixed horizontally at two vertically moving chains, that makes it possible to take up small parts but also long goods. A picker is located at a central transfer point. An advantage is that the full height of the room with a relatively large number of articles with a small or medium number per article can be stored in a small space.

- Horizontal rotary rack (Carousel rack)
  Single storages are mounted at a horizontally moving chain to take up a shelf for example. A picker normally retrieves the goods at the turning point at the frontend where several racks are arranged in parallel. For accessing bins the chain is moved until the respective column or field reaches the retrieval point.

- Flow rack
  By adding a conveyor level to a fixed block of racks, load units can be moved within these blocks. Load units are either transferred in a storage channel at the rear end of a rack, moved to the frontend where they are retrieved or are pushed into the channel at the front end where they are also retrieved. Load units are stored one behind the other and can be accessed only from the frontend of a rack. Due to the flow principle, storage and retrieval are separated and independent from each other.

Transport systems:

Transport systems describes technical material flow systems which are mainly used to move articles. Transport systems can be divided in following to categories:

- Conveyors
  Conveyors work continuously and are in most cases stationary. They have a high transport performance measured in items/time units, and generate a continuous transport flow. They offer different routing strategies and the permanent readiness to take up or transfer articles. (E.g. chain conveyor, roller conveyor)

- Transport devices
  Transport devices are single devices which transport single or a few goods from a source to a target destination. Depending on the layout any point along a line, in an area or room can be approached. These devices are ideal to serve a high number of transfer and pick-up points, to transport heavy goods and to cover large distances. (E.g. Fork lifts, stackers, AGVs, cranes)

Sorting systems:

Sorting systems or sorters are automatic devices which are used to distribute a large number of goods according to special criteria within a short period of time. Due to increasing requirements

on throughput times and operating costs and changing shipping structures like frequent just-in-time deliveries of small quantities these systems are of growing importance. (E.g. Cross belt sorter, tilt tray sorter)

Robots:
Robots are automated handling devices which are used in warehouse systems for palletizing and quick and complex order-picking.

- Palletizing robots
  Palletizing robots reduce long processing times and replace monotonous and physically strenuous manual work. In comparison to fully automated facilities they are more flexible and cost-efficient for the handling of small work loads. (E.g. Portal or articulated arm robots)
- Order-picking robots
  Robots are used in order-picking to pick the goods from the shelf or in separate areas where they pick larger standardized units from pallet stacks. They are used for systems that put large requirements on the positioning, decollation and handling of articles and thus demand time-consuming and costly processes.

After gaining a basic knowledge about the data and IT-infrastructure and the possible used hardware in a warehouse, the next section deals with the possible processes that can be depicted in a WMS.

3.2 Processes in a WMS[31]

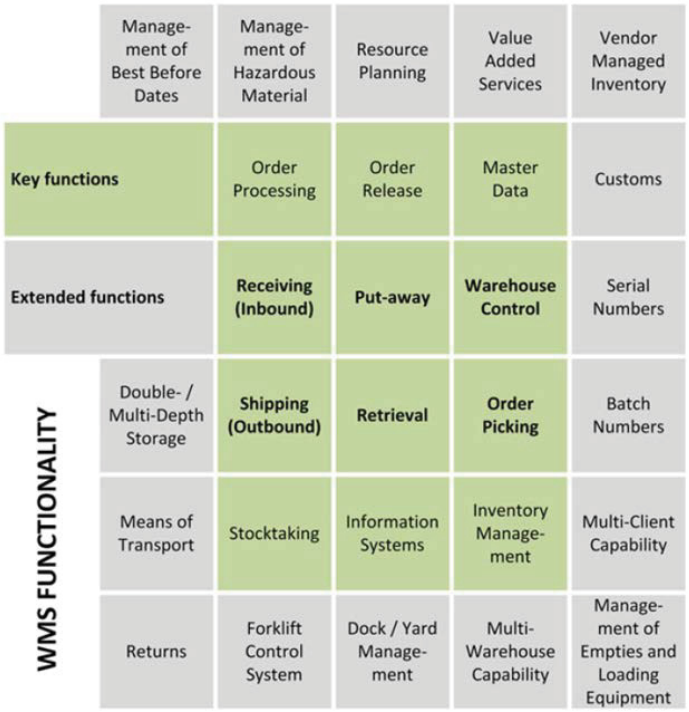

Figure 2: WMS functions[32]

Different WMS softwares provide different functions and IT-infrastructures for managing a warehouse. In general you can say that the following key function as it is also shown in the figure 2: "WMS functions" above will be managed in each WMS:

Goods receiving and put-away

The receiving process is consisting of different steps related to supply orders. These are transmitted via electronic data interchange (EDI) or Web-enabled. The receiving steps consist of receiving of the truck, unloading of the pallets, visual checks of the pallets, building of a loading unit, consisting of the loading aid and the stock object of the delivery, identification and registration the loading unit in the WMS. This is followed by put-away the loading unit to its optimal storage location via a conveyor or manual transport. The optimal storage is found by a storage location search algorithm which considers customer and layout restrictions for the registered goods.

Warehouse control

The WMS controls the goods movements inside the warehouse and manage and save all activities that are happening within the processes.

[31] refer to Ross (2015), pp. 675.
[32] Source: Hompel, Michael ten et al (2015), p.5.

Order Picking

A WMS manages also the order picking itself. It is starting after a customer order was created and a picking activity is needed. The WMS can proceed different picking strategies (e.g. FIFO, LIFO, Shortest way). For the picking process different technologies can be used. For the order picking a goods-to-person work station can be implemented or a person-to-goods principle with pick-by-voice, pick-by-list or picking with a mobile device. With pick-by-voice the picker gets instruction by a voice over his headset and also communicates with different key words with the technology. Strategies like multiple orders; when more than one order can be placed in an order bin or single orders; when only one order is placed in one or more order bins and is not mixed with other orders.

For picking in different areas an pass-on picking strategy can be used when part of the order is picked in one picking area and is passed on to the next picking area to fulfill the picking order.

Outgoing goods (Shipping and retrieval)

The outgoing goods processes consists of creating a load for a customer order and retrieving the customer orders out of the warehouse. An order can be served out of the storage or can be picked from the picking area according to the customer order. The orders that are ready for shipment are sent to outgoing goods area where they are loaded according to the made tour planning. Before the loading they can also be staged. Staging can be that the orders are buffered or consolidated prior loading.

Order processing and releasing

Order management in a WMS tries to improve the order fulfilment by automating picking and shipping functions. It improves processing times and service accuracy. Important functions are order allocation, grouping/batching creating auto-replenishment of picking locations, printing of pick lists and choosing of picking strategies. And finally releasing orders for processing.

Master data

In a WMS the master data including the item and partner master data is maintained. This was already described in the chapter "Basics of a WMS".

Stocktaking and inventory management

Also the stocktaking is a key function of a WMS. All the stock, its properties and quantities are registered in the WMS. Reservations for outgoing goods are done and information about the stock is sent to the host system (ERP) in configured intervals. Stockmanagement includes also the storage optimation and re-allocation of loading units inside the high bay warehouse for a more efficient retrieving of goods. Furthermore, the inventory management is done in a WMS. It can be done on different warehouse area level, or on certain storage locations or even on certain items.

Information systems

Exchange of information with different information systems.

TMS

Transport management systems (TMS) is an own software that is supporting the WMS in the means of tour management and shipment planning. In the past it was part of the ERP but was created due to increasing complexity of global and closely linked logistic chains.
TMS covers the planning and optimization of procurement and distribution structures under the consideration different restriction like costs or time restrictions, the use of multimodal transport chains or the optimization of the delivery transports as well as the control and monitoring of the resulting processes as well as trace and tracking of orders. Also the routes and transports are planned and scheduled.[33]

The described warehousing processes are used in a general warehouse. To get an understanding for the required processes in a WMS in e-commerce the next section analysis the requirements for a WMS regarding e-commerce in general.

3.3 WMS in e-commerce

E-commerce means to perform business activities electronically via digital media. It can be divided into two categories: business to business and business to consumer.[34] B2B is the business made with other stores or companies. That includes normally bigger volumes per order ordered compared to B2C. B2C is serving final customers demands. The growth of e-commerce has also revolutionized most warehouse operations.

Especially the B2C segment face the following requirements for a WMS:

Small orders handling

Most private consumers order rather few order lines each with very few items. This increased shipments and tight delivery schedules which are offered by retailers makes shipping more challenging.[35] Increased shipments typically increase transportation costs while decreasing inventory holding costs. Improved inventory management brings savings in inventory holding costs that can compensate increased transportation costs. Real-time information of the product flow becomes the key factor in terms of trading off transportation and inventory costs.[36]
Due to small sizes it is important in e-commerce to unpack full pallets to bins to store them inside the warehouse in smaller quantity units. That makes it easier to pick them later in the outgoing goods process.

Huge number of returns

In e-commerce a lot of returns coming from the customer that need to be dealed with quickly and efficient.[37]

[33] refer to Hompel, Michael ten et al (2015), pp. 6.
[34] refer to Montealegre et al. (2007), p. 63.
[35] refer to Boysen et al. (2019), p. 1.
[36] refer to Mason et al. (2003), pp. 142.
[37] refer to SSI Schäfer (2018b)

Flexibility and scalability

Due to a high disruptive market flexibility and scalability is needed to reacton future changes in the business structure.[38]

Transportation management optimization

A transportation management system (TMS) can leverage real-time data to make sure you can react on potential disruptions or demand shifts as early as possible. The TMS can adapt to weather conditions to optimizing unloading and loading. Additionally, a TMS offers multiple carrier modes, such as parcel, private fleet, and carrier services.[39] Next-day or even same-day deliveries are promised by many online retailers especially in the B2C segment. This leads to highly time critical order fulfillment processes.[40]

"The same-day delivery is an actual trend which big companies like Amazon can provide. Same-day delivery has extremely high logistics costs and therefore only possible for companies that want to provide a special service. Still same-day delivery loss making business for grocers. But the trend for same-day delivery is growing and more and more companies will offer this service. Especially when the logistics costs decrease it will be a must have for all e-grocers. In that case also the minimum delivery value will decrease. Which is used due to high logistics costs."[41]

A support to deal with tight delivery schedule by changing routes and delivery slots is the possibility to use real-time information.[42]

Engaging workers

Facilitate warehouse process execution on easy-to-use mobile devices or pick-by voice. This increase the picking performance, that is needed for e-commerce. And also these technologies are not that capital intensive as automated systems but also have a sufficient performance for some e-commerce businesses.[43]

Optimizing labor allocation and utilization

Demand forecasting helps you optimize regular, temporary, and overtime labor and to better allocate them across the warehouse for a better workflow and covering order peaks. To handle order peaks is especially important in e-commerce.[44]

Integration of automation systems

To achieve higher picking accurancy, picking rates, picking quality and punctuality in order fulfillment a high degree of automation is needed. Of course this requires a higher capital investement. A WMS needs to be able to integrate the coordination and control of automation

[38] refer to SSI Schäfer (2018b)
[39] refer to Lamphier, E., https://www.manh.com/resources/articles/2018/10/23/surviving-amazons-grocery-disruption-rethinking-supply-chain, (Access: 04.06.2019).
[40] refer to Boysen et al. (2019), p. 1.
[41] Jakob Beer (2019); In-depth Interview.
[42] refer to Mason et al. (2003), pp. 142.
[43] refer to Kuerschner, J., https://www.foodlogistics.com/home/article/12297573/watch-your-wms, (Access: 05.06.2019).
[44] refer to Lamphier, E., https://www.manh.com/resources/articles/2018/10/23/surviving-amazons-grocery-disruption-rethinking-supply-chain, (Access: 04.06.2019).

systems. Or in other words the WCS must be integrated in the WMS to handle high degree of automation without risking errors through two separate systems that needs to adjust to each other to fulfill the level of automation inside the processes. Normally, the WMS and the WCS are separate entities that only communicate with each other.[45] Automated warehouses and automated order-picking solutions can deliver both higher output and more accurate order fulfilment than a manual setup at lower costs to the retailer. An automated warehouse solution can both increases picking speed and picking volumes while decreasing picking inaccuracy because of reduction of human interactions. That makes the system more flexible to handle also late changes of orders. Additionally, robots are not depending on the labor market conditions and can work 24/7 without requiring pensions, health insurance, vacations or breaks.[46]

After getting some understanding about the requirements for a WMS in e-commerce, the requirements for a WMS in e-grocery will be worked out in the next chapter in the end of the market analysis for e-grocery. E-grocery has some more specific requirements compared to traditional e-commerce processes. These requirements are worked out after gaining knowlegde about the differt needs and challenges in the e-grocery market. Furthermore, theses requirements will be the basis for analysing the WMS software from SSI Schäfer.

[45] refer to SSI Schäfer (2018c)
[46] refer to Kukhnin et al. (2017), pp. 5.

4 Market analysis of e-grocery

In the following chapter the online grocery market is analysed to find out if e-grocery is going to be significant for grocers and consumers in the future. Is e-grocery only a short-term trend or will it influence the grocery market and all it stakeholders also in the future? What are the pains and challenges for suppliers and customers in e-grocery and which business models will be able to find solutions to overcome these the best? To answer that questions a desk research is made. A desk research is taken because of the novelty of e-grocery. A lot of information can be found in the internet and in surveys of customers buying behaviours. Specific information from the market will be taken from the in-depth interviews taken with sales employees of SSI Schäfer.

The chapter begins with an overview of the development of the online grocery market, follwed by the different provided business models, best practices and failures. Regarding the e-grocery market an overview over the current development of the e-grocery and the potential growth is done. Furthermore, a conclusion is made on why companies failes and succeed in e-grocery business. After that the challenges and pains of suppliers and customers will be anlaysed. At the end of this chapter a clear understanding of the customers expectations and demands towards e-grocery is provided and on the other hand the challenges for suppliers and why they succeed and failed is shown. Based on these findings and in-detph interviews performed with leading employees of SSI Schäfer in the sales and food retail department the requirements for a WMS in e-grocery are pointed out. Finally, the requirements for a WMS in e-commerce and the requirements of a WMS in e-grocery are compared and the difference highlighted.

4.1 Analysis of the market

Online grocery (or e-grocery) is by far the fastest growing market for groceries today. Latest figures from Kantar's for the global fast-moving consumer goods (FMCG) market as a whole, online sales grew 30% in the 12 months to March 2017, double the figure for the previous year, compared with just 1.3% growth in all FMCG channels. And online grocery is expected to continue to grow much faster than any other channel.[47] This can be seen very clearly in the figure below (figure 3: "Online Growth"). The expected growth for the online grocery was 17.4% from 2017-2022.

[47] refer to Tetra Pak (2018), p. 5.
[48] Source: ibid., p. 5.

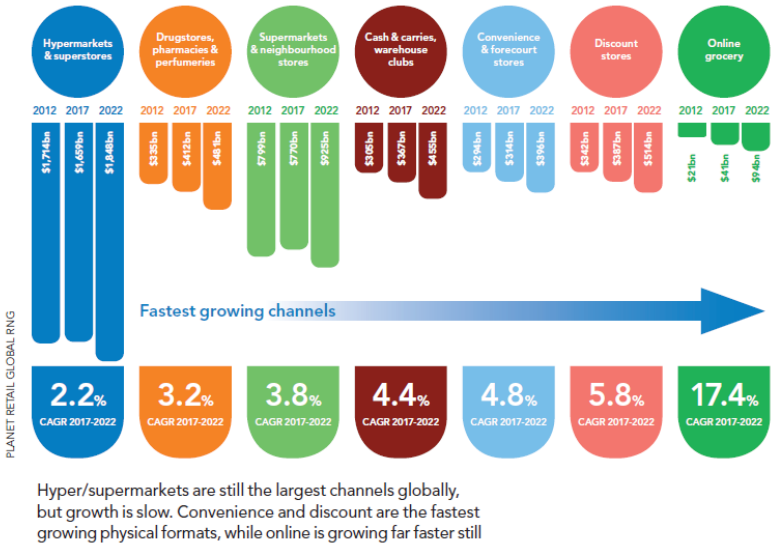

Figure 3: Growth of online grocery[48]

Another survey from "The Digitally Engaged Food Shopper" states that approximately one-fourth of American households currently buying some groceries online and that 70% will engage in online food shopping within the next 10 years.[49] According to Nielsen Global E-commerce and the New Retail Survey one-quarter of respondents say they order grocery products online, and more than half (55%) are willing to do so in the future.[50]

The growth of online grocery does not mean the end of bricks-and-mortar grocery, but it will be highly disruptive. Established players will lose market share, stores will need to close, whereas in many cases the stores that remain may become more profitable than before as local rivals disappear. Even though online grocery certainly poses a threat to a bricks-and-mortar grocer, it also presents an opportunity. Bricks-and-mortar grocers have assets, brands, and experience that can be used to establish an online business more rapidly than a pure online player. Although entering the online business is clearly risky, it can also allow an established retailer to reach new customers. It needs a carefully considered decision of bricks-and-mortar stores to start, grow, and upgrade their online offerings to take advantage.[51]

Recent developments in France illustrate how the e-grocery click&collect delivery model can fuel explosive growth. In France grocers operates some 3,000 drive-through stations.[52] And 42 % of French consumers began using pick-up stations in 2011.[53] Also, the Nielsen Global E-commerce and the New Retail Survey says that just over one-in-10 global respondents say they order groceries online and pick them up in-store or using a drive-through (12% each) possibility. A bit fewer (10%) order online for curbside pick-up. But also, more than half of global respondents are willing to use these online options in the future (57% for in-store, 55%

[49] refer to Inmar (2017), p. 8.
[50] refer to Nielsen (2015), p. 3.
[51] refer to Oliver Wyman (2014), p. 14.
[52] refer to Hübner et al. (2016), p. 229.
[53] refer to Galante et al. (2013), p. 27.

for drive-thru and 52% for curbside pickup).[54] Growing amount of different delivery modes in home delivery and pick-up possibilities concludes that brick-and-mortar stores are still not to replace. Even though the online grocers already provide many different online models. That shows that integrating online and offline operations will become more significant.[55]

Target groups

The growth of online grocery shopping is driven by the maturation of the digital Natives, the Millennials and Generation Z, as you can see in figure 4 below:[56]

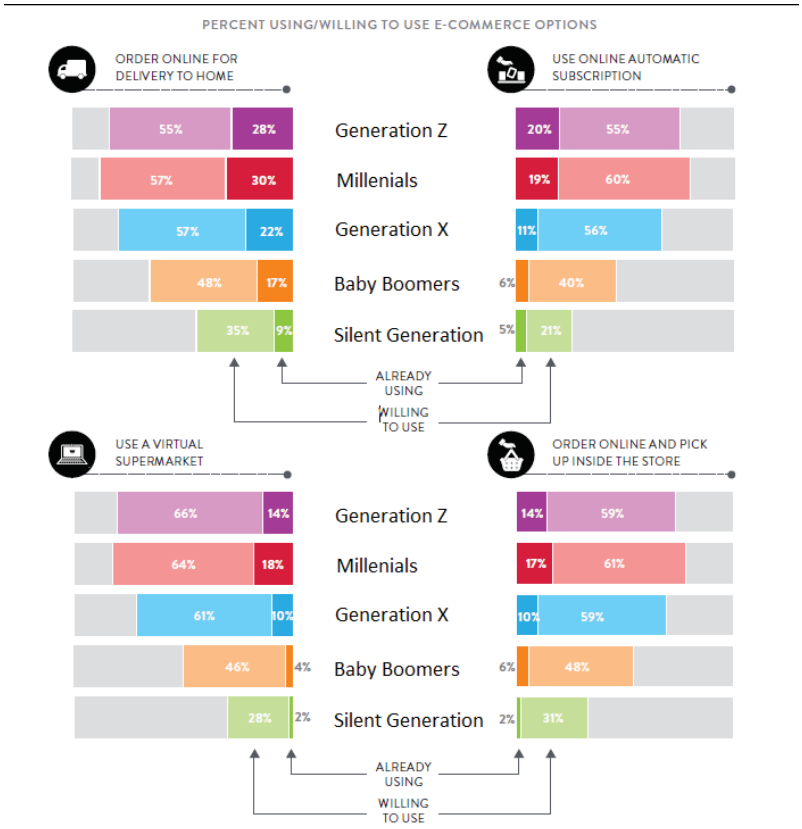

Figure 4: Target groups by age[57]

In the future the Millennials and now the Generation Z will become the most important target groups. Both are consumers who grew up with digital technology. These consumers have new enthusiasm for and comfort with technology, and online shopping is a deep-rooted a slowly grown behavior. The youngest users of e-commerce options are at the same time they made the greatest part of the users of these options (home delivery, in-store, pickup, drive-through pickup, curbside pickup, virtual supermarket and automatic subscription). They are also the most willing to use all the e-commerce options in the future. As you can see in the figure above, 30% of Millennials (ages 25-38) and 28% of Generation Z (ages 15-24) ordering groceries online for home delivery, compared with 22% of Generation X (ages 39-53), 17% of

[54] refer to Nielsen (2015), p. 5.
[55] refer to Hübner et al. (2016), p. 230.
[56] refer to Nielsen (2015), p. 3.
[57] Source: ibid., p. 8.

Baby Boomers (ages 54-68) and 9% of Silent Generation (ages 69+) respondents.[58] According to Patrick Dodd, Chief Commercial Officer for Nielsen, Millenials are now at the beginning of their careers and start forming households, whereas the oldest members of Generation Z graduate and start working now. So, these generations will shape the economy to come and it is essential to understand how they are using technology and how they are shopping in a digital world.[59]

Growing markets

To understand where the strongest growth in online grocery is, it is important to have a look to the Asia-Pacific, Africa/Middle East regions where the desire to use digital retailing options in the future the highest. Whereas the willingness to use digital retailing options is nearly equal in North and Latin America. Europe is still one step behind in using different e-commerce options.[60] The exact data you can find in figure 5 below:

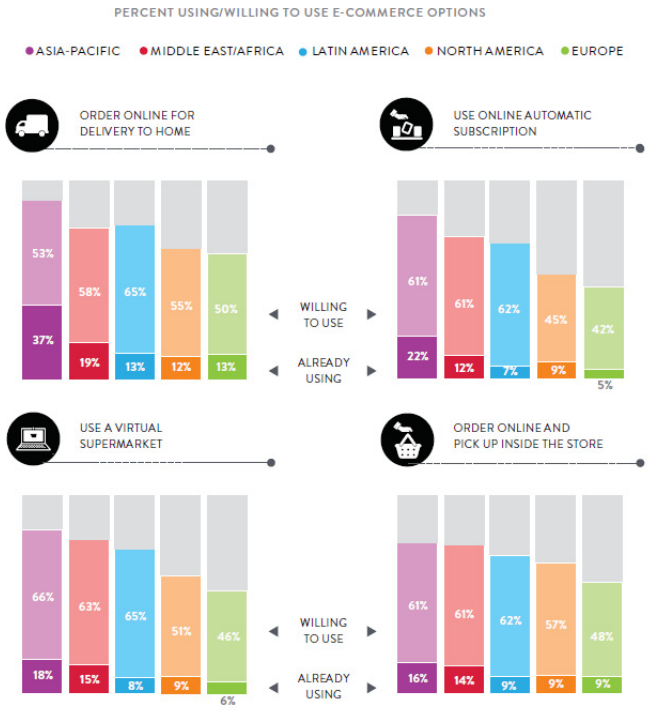

Figure 5: Global use of e-grocery[61]

However, the pioneer countries in online grocery which also includes European countries (France and the UK) still have the lead in using e-grocery options due to rising confidence in online delivery and quality. As it is seen in the figure 6, the online grocery is expected to grow the most compared to modern trade and traditional trade till 2030. The most innovative country for online grocery is still South Korea what can also be seen in the figure below (figure

[58] refer to Nielsen (2015), p. 7.
[59] refer to ibid., p. 7.
[60] refer to ibid., p. 3.
[61] Source: ibid., p. 10.

6: "E-grocers pioneers"). Only China stepping up with an even higher expectation for growth in online groery of 7.3% until 2030.[62]

Traditional trade is happening when people buy products from the raw market and then bring it to markets where the prices are set by individuals and then sold to the public at different rates. Modern trade is happening when no proper owner is sitting on shops, they just open their stores around the world and give it a brand name.

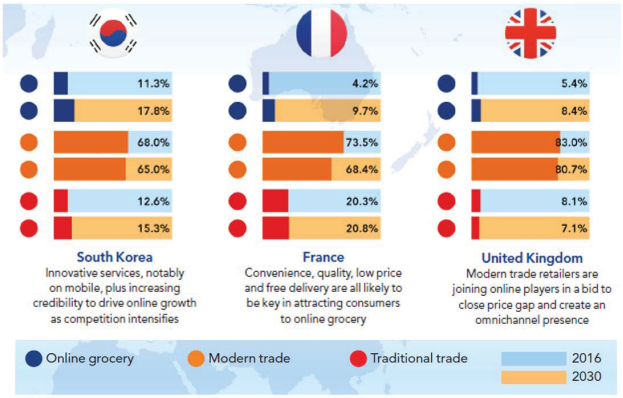

Figure 6: E-grocers pioneers[63]

The Nielsen Global E-commerce and the New Retail Survey stated that more than one-third (37%) of Asia-Pacific respondents, and even more in China (46%), say they use an online ordering and delivery service. Online automatic subscriptions are also particularly high in this region (22% vs. 14% globally), with China once again is leading (30%). Sales data reflect the phenomenal online growth of FMCG purchases in China. Between 2013 and 2014, e-commerce sales increased 40% for 17 major Nielsen tracking categories. E-commerce of food is the primary growth engine which sales nearly doubled in size (+91%) already between 2013 and 2014.[64] Concerning the European market for e-grocery survey that also in Europe the general value at stake is high and the market will change rapidly. Only early movers with an outstanding value proposition, a relentless focus on profit optimization, and a willingness to think big in their strategies will win the race for customers.[65]

"Consumers are no longer shopping entirely online or offline; rather, they're taking a blended approach, using whatever channel best suits their needs. The most successful retailers and manufacturers will be at the intersection of the physical and virtual worlds, leveraging technology to satisfy shoppers however, wherever and whenever they want to shop."[66]

In the next section a detailed view on the actually used business models for e-grocery is given. The different business models will be described regarding the preparation and picking of orders and the different last mile distribution concepts.

[62] refer to Tetra Pak (2018), p. 11.
[63] Source: ibid., p. 11.
[64] refer to Nielsen (2015), p. 9.
[65] refer to Galante et al. (2013), pp. 22.
[66] Nielsen (2015), p. 4.

4.2 Business models for e-grocery

Different to traditional store sales, e-grocery deals with even more complex logistics operations, to meet the customers needs. Not only the right delivery of a product but also for the overall satisfaction of the end customer is a big challenge. To meet the customers' demands for less delivery fees, bigger product assortments and smaller online prices (as it is shown in fig: Customer barriers for buying food online) are the three big challenges of back-end fulfilment and last mile distribution that appear.[67]

4.2.1 Back-end fulfilment

Back-end fulfillment mainly deals with the picking and preparation of an order. In the following (figure 7: Back-end fulfillment) you can see the different approaches for optimized back-end fulfillment:

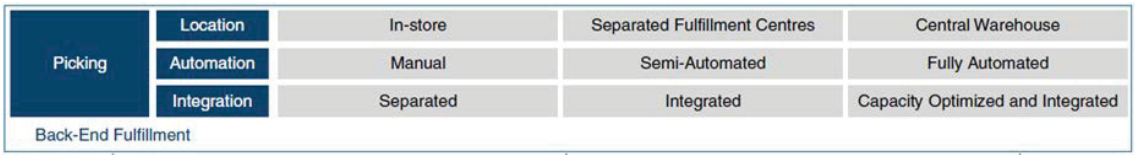

Figure 7: Back-end fulfillment[68]

The average shopping basket in e-grocery contains between 60 and 100 items, that is more than 60 times of a non-food online order. This is complicating the picking and packing procedures. Therefore, the differentiation in parameters for picking location, degree of picking automation and degree of picking integration is made.[69]

Picking location

There are three ways of placing picking orders for the order fulfillment. In-store picking, picking from separated fulfillment centers or from a central warehouse.

In-store:

In-store picking is normally the first option for a bricks-and-mortar retailer who wants to enter the Omni-channel (OC) business. The picking of online orders is done by their employees who collect the groceries directly from the retail shelves. Many retailers use this as an entry model, because it allows them to offer a full product range within the existing structures. That enables them to expand fast without investing in new logistical facilities while future demand is still uncertain. Also it is less costly to modify existing stores or structures than to build new warehouses. However, the picking operation is expensive when it is done inside conventional stores because space restrictions limit the e-fulfilment volume. In addition, professional order pickers or stuff that makes the picking and regular customers can get in each other's way.

[67] refer to Pan et al. (2017), p. 1919.
[68] Source: Hübner et al. (2016), p. 234.
[69] refer to ibid., pp. 234.

The store layout is not designed for picking efficiency. It is designed for displaying products. Customers perceive the shopping experience in a store with a clear layout more convenience than a shop with sophisticated arrangement of products. But that is not necessarily also in the interest of picking efficiency. The existing structures of conventional stores therefore have to be significantly adapted to achieve the required picking efficiency that e-grocery requires. Furthermore there is a significant out-of-stock risk due to the time gap between the order placement and the picking, because other customers can meanwhile buy the item. This uncertainty rises demand planning costs and requires a higher safety stock. Furthermore, retailers need to decide at which store he has to fulfill a customer's order. The retailer has to consider the picking efficiency in each store and delivery distances, delivery times, and delivery costs to decide at which store the online order should be picked and delivered.[70]

Fulfillment center:
In contrast to store-based fulfillment, order picking can be done more efficiently in the fulfillment centres as they are especially designed for picking online orders and it is easier to scale-up for larger volumes. Therefore, it makes it possible to use efficient warehouse configurations like differentiation into slow and fast movers. Furthermore, customer fulfillment centers only stock inventory for the online channel, so it is simpler to provide information on product availability to web shoppers. And unlike central and integrated warehouse systems, in decentralized fulfillment centers, the transportation costs from storage to customer are generally lower as the distance to a customer's home is shorter. In addition, delivery time accuracy can be improved and thus also the customer satisfaction. The disadvantage of this fulfillment centers lays in additional costs for the additional locations needs to be supplied by contractors.[71]

A variant of a fulfillment center is called "Dark Store" or Micro-Fulfillment Center (MFC). They are laid out in a very similar way to a traditional store but there are no shoppers in the store.[72] Fulfilling and picking from these non-customer areas gives advantages of fulfillment centers and stores by using already existing channels and the short lead time because of simpler processes and the short distance to the customer. But retailers have less visibility into inventory levels compared to fulfilling from fulfillment centers. That exposes them to the risk of deliver an incomplete orders, since the short short lead time in the online grocery market leaves no opportunity to replenish.[73]

Central Warehouse:
Picking at centralized warehouses for direct customer distribution and store delivery requires more comprehensive processes. This fulfillment model is usually applied by companies that already have been operating their online grocery channel for some time. With the integration of a central warehouse, more complex picking systems are needed to master store-order and customer-order pickingat the location. Advantages of such a fulfillment models are short-term allocation decisions and synergies via joint deliveries from the supplier. This is operationally effective and, depending on the total online volume, more cost efficient than other models. A

[70] refer to Hübner et al. (2016), pp. 234.
[71] refer to ibid., p. 235
[72] refer to Makan (2019), p.39
[73] refer to Wang (2016), p.15.

single pick is cheaper in a warehouse than in a store for example. Also, in a centralized warehouse, a consolidated inventory leads to a higher turnover, lower inventory costs and requires less links in the supply chain. Since deliveries are made to a single location in larger volumes, inbound transportation costs are lower. But the cost advantages from centralization are still not enough to compensate the higher delivery costs with a longer distance to the customer. Nevertheless, the biggest online grocer Ocado is able to be able to deliver to 70 per cent of the British population from its central warehouse. Ocado also uses an additional hub and spoke network to fulfill these orders.[74]

Picking automation

There are different degrees of picking automation that can be distinguished. A manual picking procedure is used for in-store picking as automation cannot be introduced in a shop. Whether a retailer chooses to pick his orders in warehouses in a manual, semi or fully automated way influences the investment and operating costs significantly. Interviewees confirmed that with a higher level of automation also the picking speed is increasing which leads to savings in operating costs and lower costs per pick. But grocers should not only focus on investing in automation, they also need to pay attention to the layout and design principles of the fulfilment center. Special attention should be paid to the order assembly process.In án in-store picking without automation efficiency is about 80-120 items per hour, in a specifically designed warehouse, picking efficiency can be as high as 150-300 items per hour and even more.[75]

Picking integration

The degree of picking integration is an important question to consider for omni-channel grocery retailers. They can integrate online orders into the picking processes of their regular stores to further utilize existing structures. That requires making design adjustments to prepare locations for efficient online order picking. Online order picking can be done separate, integrated and also in a next step capacity-optimized and integrated. With a capacity-optimized and integrated solution, capacities can be balanced and as well stock-outs and lead-times can be reduced. Shared resources can also lead to reduced overall costs and inbound transportation costs. The difficulty of this kind of integration is to handle inventory and storage systems simultaneously for both channels, online and regular picking.[76]

4.2.2 Last mile distribution

Two methods are commonly available for e-grocery delivery concerning the last mile distribution.

[74] refer to Hübner et al. (2016), p. 235.
[75] refer to ibid., pp. 235.
[76] refer to ibid., pp. 235.

- Home Delivery
- Click & Collect

LMD involves decisions related to the delivery mode, delivery time, area and returns as it is shown in figure 8: "Last mile concepts":

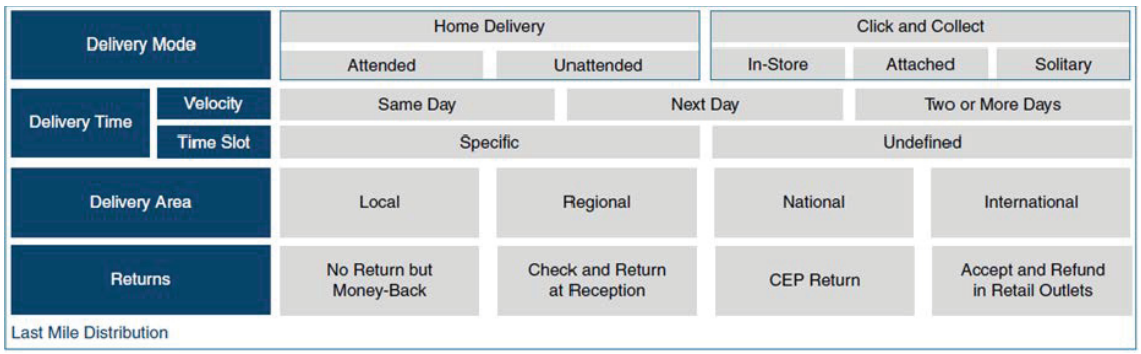

Figure 8: Last mile concepts[77]

Delivery mode

A decision about the delivery mode depends mostly on the geographic situation. The relative efficiency of the different delivery modes varies depending on the population density as well as the local competition. From a logistical point of view, delivery is the only situation where an online customer comes into personal contact with the retailer. Therefore, the delivery mode plays a significant role in terms of customer relationship management. The predominant delivery concepts are home delivery and click and collect (C&C).[78]

Home delivery:

At a bricks-and-mortar grocer the goods are delivered to the store and the customers perform the picking and final delivery to their home themselves. Regional grocers or grocers with a low density outlet network can expand their market coverage with home delivery. An OC retailer who offers home delivery not only needs to cope with picking online orders, but also has additional expenses to cover the last mile. Time savings in online shopping are perceived by customers above all as time not spent travelling to and from the store, rather than a decrease in actual shopping time. As a result, home delivery is a concept that provides additional customer satisfaction . The direct concept offers consumers two models: an attended and unattended model of reception. Attended home delivery means that the customer has to be at the point of reception within a selected timeframe to accept a delivery. In most countries, attended home delivery accounts for the largest share of last mile delivery. Home attendance creates complexity for all participants: On the one hand, the customer is under constraint to wait for his order to be delivered, while on the other, vehicle routing becomes more complex due to customers' time restrictions. Retailers' objectives include maximizing vehicle utilization

[77]Source: Hübner et al. (2016), p. 234.
[78]Ibid., pp. 236

and minimizing transportation costs, while maintaining a certain level of customer service and satisfaction rates.[79]

Different strategies can be developed for deciding which time slots to order to customer. The most basic strategy focuses on feasibility and simply closes a time slot as soon as a certain number of orders for that time slot has been accepted. The limit may be set, for example, based on routing statistics for the zipcode. A more advanced strategy incorporates real-time order information together with information on the already accepted orders and expected future orders.[80]

If the customer is not available for receiving the order within the assigned time, the truck returns without delivering the order, that leads to additional expenses for transportation and handling. Furthermore, the retailer has to set a new date for delivery and an additional tour. Therefore, the unattended home delivery model enables grocers to deliver online orders even if the customer is not at home. The shopping basket is placed in front of the customers home to be collected when he is arriving. Unattended reception eliminates therefore the tight time slots and capacity problems resulting from uneven demand during working hours. The distances to different geographical regions are reduced to a minimum and working hours for the distributor are shortened. Furthermore, the redelivery cost are reduced for the case when the customer is not at home during the selected delivery time slot. Delivery boxes, reception boxes and shared reception boxes are common solutions for unattended reception. The Swiss pioneer in e-grocer LeShop mainly fulfils its orders with cooled delivery boxes, which makes it possible to drop off twice as many orders per shift than an average online grocer can fulfil with attended delivery. Of course, there are higher initial costs for buying the boxes and the additional effort of collecting them afterwards again. Overall the cost that concept saves up to 40 per cent compared to attended home delivery.[81]

A relatively new model for home delivery is crowd delivery service. It allow private citizens to use their own car to deliver packages in exchange for a fee. It is similar to Uber and can potentially increase the level of service, because customers may receive the ordered goods the same day of delivery and at the same price of the standard delivery. When an item is purchased, a driver receives a notification of a purchase and can agrees to deliver the item for the selected time window.[82]

Click & Collect (C&C):

C&C is the other dominant delivery mode in omni channel grocery retailing. The principle is to pick up at the store, a solitary pick-up station or at another pick up location. Anyway, the goods are ordered via the online channel first and then either picked and packed from a central warehouse or in-store and then transported to the pick-up location. The customer can then pick-up the order as he likes. The great advantage of C&C is that the customer carries the full cost of fulfilment on the last mile, that reduces logistical costs by up to 70

[79] refer to Hübner et al. (2016), pp. 237
[80] refer to Agatz et al. (2008), p. 9.
[81] refer to Hübner et al. (2016), pp. 237.
[82] refer to Ghajargar et al. (2016), pp. 1373.

per cent. Of course, the retailer still has to deal with a number of other challenges regarding product availability and the picking process itself. A collection point located in-store is an often-chosen solution from retailers which wants to enter omni channel retailing quickly and at low initial cost. Therefore, a separate booth is installed inside a store for picking up the online orders. The retailer can continue to use its existing assets without major changes with this solution. It is also possible to attach the pick-up point outside the store. In that case a further advantage is that an attached solution mainly offers drive-through opportunities. So it costly than a solitary drive-through station. A solitary drive-through station combines a small warehouse for picking and a pick-up station. The stations work independent from other stores and can be supplied directly and separately from warehouses. On one hand this increases logistics costs with transportation costs but on the other hand simplifies demand planning and inventory control compared to an attached solution. Grocers with a low-density outlet network can expand their market coverage with solitary drive-through stations. However, setting up a solitary station requires more investments.[83]

Delivery time, area and returns

As you can see in figure 9: "Last mile concepts", delivery time can be separated in velocity (same-day delivery, next-day delivery or more days) and time slots (defined, undefined). The most logistically challenging and costly is the same day delivery and defined time slots. It requires more precise planning the supply chain and accurate data from the customer. The delivery area is related to the delivery mode and the customer segments that a company wants to reach and with which strategy. It can be separated in local and regional home delivery and national and international pick and collect strategy. Returns play also a big role in e-grocery because it is handled with perishable products, therefore it is important for retailers to provide fitting return solutions for customers. For home delivery there is no return but directly money back or directly return at reception of delivery. For click and collect it can be by CEP service or at a store next by.[84]

To get a better understanding of which business models are successfully, the best practices will be compared in the next section. Especially interesting is the combination of the different back-end fulfillment approaches and last mile distribution concepts.

[83] refer to Hübner et al. (2016), pp. 236.
[84] refer to ibid., pp. 237.

4.3 Best practice

To understand which business models succeeded on the market, three business models from successful companies in e-grocery are compared.

Ocado

Company profile:

"Ocado Group plc is a United Kingdom-based online grocery retailer. The Company's principal activities are grocery retailing and the development and monetization of Intellectual Property (IP) and technology used for the online retailing, logistics and distribution of grocery and consumer goods, derived from the United Kingdom. The Company offers end-to-end operating solution for online grocery retail based on technology and IP, suitable for operating its own retail business and those of its commercial partners."[85]

Business Model:

Ocado enables shoppers to purchase items online through its convenient web and mobile applications. Items are picked and packed in automated warehouses with their own in-house build software and shipped directly to customers in a one-hour time slot of their choosing. The different time slots have different prices. The biggest advantage of Ocado is the high degree of automation and their own build warehouse management software. Through the high degree of automation with hundreds of robots, the processes are efficient and in high quality. Especially through automation the pick rate, accuracy and pick consistency are much higher. Furthermore, they offer additional customer services like the "use-by" date for fresh food directly on the website while shopping online or you can create directly your past order for delivery. On the website customers can also see real-time stock levels, viewing what is available in their chosen timeslot. Customers can choose their own substitutions, like they were in a store. That avoids also stock outs for the company. Ocado key stats can be seen in figure 9: "Ocado key stats". They have a average basket size of 107 $ with 194 deliverys per van and about 296 thousands orders per week. The manage even with this high amount of orders a delivery punctuality of 95%, order accuracy about 99%, and they reach now more than 70% of the U.K. population. The company´s success is made by their in-house built technology and automation that powers its end-to-end e-commerce, fulfillment, and logistics platform.[86]

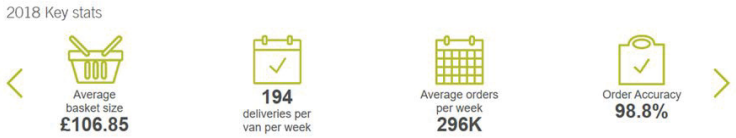

Figure 9: Ocado key stats[87]

[85] Reuters, https://www.reuters.com/finance/stocks/company-profile/OCDO.L, (Access: 26.04.2019).
[86] refer to Google Cloud, https://cloud.google.com/customers/ocado/, (Access: 26.04.2019).
[87] Source: Ocado, http://www.ocadogroup.com/, (Access: 16.04.2019).

Pic Nic

Company profile:

"Picnic is a pure online grocery player that offers an application that enables its users to find and order grocery items through their mobile phone. The products that it markets are vegetables, fruits, meat, fish, sweets, snacks, drinks, dairy, bread, but also non-food items that you can find in any supermarket. Picnic is the most sustainable supermarket with 100% electrical delivery vans and no food waste. It is the milkman 2.0 with lowest prices in the market and free delivery."[88]

Business Model:

Customer orders are picked in two fulfilment centers (FC) in Nijkerk and Utrecht with an equal set-up. Orders are manually picked and afterwards transported to transshipment hubs in the delivery areas. The orders are delivered at home from these hubs by small electric vehicles. Picnic distinguish themselves from other grocery retailers by lack of physical shops (only online) and an efficient distribution model for the home deliveries, resulting in efficient and short supply chain. Picnic offers delivery times within pre-selected time slots dependent on postal codes, instead of freely selectable delivery times with dependent prices. Therefore, ordering with Picnic is like checking a bus schedule to see which ride you will join for minimal costs, instead of calling an own taxi-company which send a private driver at a desired time. That costs the customer a lot more than a bus ticket. Orders placed at PicNic before 22:00 will be delivered on the next day. PicNic promises the customer free delivery, lowest price guarantee, high quality and on time deliveries which creates challenges of to keep its logistic costs low.[89]

Tesco

Company profile:

"Tesco Stores Limited operates retail stores and associated activities. The company's stores provides groceries, including fresh food products, bakery items, cupboard and frozen food products, and drinks; health and beauty, pets, household, and baby products; and home and entertainment products, as well as inspiration and event related products. It also offers clothing and accessories for women, men, and kids. It has 2,660 stores in England, Scotland, Wales, and Northern Ireland."[90]

Business Model:

Tesco enables their customer to place their orders online via computer, smartphone and even virtual shopping walls in subways. Within the UK customers can use "click and collect" and in certain parts of the country also a home delivery based on a customer preferred 1-hour time slot. Tesco offers different click and collect model with placements inside and outside of the store based the existing store structure and the local consumer demands including also drive-through pick ups. In the beginning Tesco fulfilled online orders from dark stores. Customer placed their

[88] Crunchbase, https://www.crunchbase.com/organization/picnic-3#section-locked-charts, (Access: 27.04.2019).

[89] refer to van den Berg (2017), p. 14.

[90] Lawrie, J., https://www.bloomberg.com/research/stocks/private/snapshot.asp?privcapid=5463520, (Access: 27.04.2019).

order during the day and at about 4:00 am of the next day Tesco associates travelled through the aisles with trolleys to pick and pack the customer orders. Delivery vans were loaded in the back room of the store after all orders were picked. That made it also possible to plan the routes as good as possible. That approach was labor intensive an inefficient. Small stores are not able to manage a high volume of online orders. Also, the conflict between online order picker and in-store customer led Tesco to search for a different approach. Tesco chose to use dedicated distribution centers to fulfill online orders with home delivery from that non-automated distribution center. The depot has a similar layout as a retail store with stock items in low height shelving bins and different temperature zones (chilled, frozen and ambient). The pickers cart holds 6 totes to pick up to 6 orders simultaneously. Delivery was performed by a private fleet of vans. The in the next steps Tesco invested in more depots/fulfillment center closer to their market and the regional distribution center to supply the depots to perform procurement and transportation operations more efficient. These fulfillment centers were more automated, using hand mounted RF scanning devices to increase order accuracy. At the end of picking the cart was staged on a conveyor that which transferred the totes to an automated buffer system that released totes after routing of the delivery van was done to a conveyor that transports them further to assigned truck doors. The sequencing of releasing took under account the temperature zone, so that the chilled totes are always placed closest to the nose of the delivery van closest to the refrigeration unit. The latest depot of Tesco has a significant improvement in automation in form of goods to person order picking. Around 70% of the entire ambient product is stored in an automated robotic multi-shuttle system. The manual pick cart is replaced by mechanized conveyor systems to reduce order picking travel time. Now the tote for picking is transferred only into aisles (zones) where a stock item needs to be picked and after completing all needed items from one aisle totes are transferred to the next zone.[91]

Concluding of showing up this three best practice of e-grocery businesses it can said that the key for success for this three companies was a high customer service with different time slots to be delivered and a customer friendly web and or mobile application for ordering the food. Furthermore, automation is a key to improve the quality, accurancy and punctuality of the order fulfillment. Less errors are made with a high degree of automation. Also, an efficient distribution network with different fulfillment centers close the market is a reason for succeeding in the e-grocery business. Concerning a WMS companies don´t share information how their processes and how they adjust their WMS. Especially Ocado developped an own WMS because it is very important for them to coordinate all the automation systems with their used WMS and it is a real market advantage if the warehouse is running efficiently and with low error rate. So, a WMS can be reason for success by facilitating the processes but of course also the corresponding automation hardware is must be provided to fully use the potential of a WMS.

In the following section the reasons for failures of e-grocers are shown and therefore, a whole picture of reasons and failures for e-grocers is shown.

[91] refer to Wulfraat, M., http://www.mwpvl.com/html/tesco_dotcom_uk_business_model_.html, (Access: 27.04.2019).

4.4 Failures

The most interesting example of a failure in establishing online grocery shopping is Webvan. They started in 1996 already its business but went bankrupt in 2001. The second failure that is going to be presented is PepperTap from India.

Webvan
Webvan did major mistakes when establishing their business:[92]

- Wrong Target Audience Segmentation and Pricing Webvan's go-to market strategy in each city was a mass-market strategy. The target audience was price-sensitive. But customers who would have made Webvan profitable would have been people to spend more because of the convenience of home delivery. However, that would have been also a smaller audience than a mass-market audience, but after all, even smartphones started as exclusive products for a small customer segment.
- Complex Infrastructure Model Webvan decided to build up their infrastructure from zero. They built up a highly automated distribution center with complex inventory management algorithms to optimize the delivery routes. But in combination with their price strategy and wrong target group, they couldn´t manage to record figures in black.
- Too Much Money and fast expanding Finally, Webvan's capital raise of $800 million was excessive and ill-spent. Their desire for a big and immediate growth was so intense that they started launching in new cities on the thesis that home grocery delivery would be profitable directly. The capital requirement for their roll out to different cities was over $50 million just to start. So, they signed a $1 billion contract to build several state-of-the-art warehouses worth more than $30 million each. Webvan didn´t give themselves to try out the minimum viable product (MVP) to see if it can become successful.

PepperTap[93]
Peppertap was founded by Navneet Singh and Milind Sharma in Nov 2014 in India to provide on-demand grocery delivery service to tap India's $383-billion food & grocery industry. Peppertap raised $51 million in 4 rounds of funding and even a year after its launch, PepperTap managed to fulfill 20,000 orders daily. But already in 2016 PepperTap needed to shut down their business again due to exceedingly high running costs of their business.

Analyzing the reasons behind PepperTap's failure:

- The Technology Of The Product PepperTap focused too much on pumping money to on-board customers but failed to take care of their technology. The integration of their app with their partner stores was not customer friendly and erroneous.

[92] refer to Relan, P., https://techcrunch.com/2013/09/27/why-webvan-failed-and-how-home-delivery-2-0-is-addressing-the-problems/?guccounter=1, (Access: 26.04.2019).
[93] refer to Incuspaze, https://www.incuspaze.com/the-raise-and-fall-of-peppertap/, (Access: 25.04.2019).

- It Grew Too Fast, Without Proper Scale PepperTap brought too many stores online in a too short time frame and didn't plan the scalability of the product and operations accordingly.
- The Discounts For customer retention PepperTap was spending a lot of time and energy to devise clever sales and discount schemes. To keep the loyal customer base and outpace the competition they were unrealistically spending money on discounts, which burnt their bank balance.
- The Business Model PepperTap business model based an "100% Inventory-less" strategy, which means the company had to pay the products from local stores; bear the cost of delivery, technology and operations and still give the products at discounted price to its customers. There was no way PepperTap could achieve profitability. The business raised $1,000,000 per day with losing $60,000 per day, that clearly didn´t make sense.

When comparing the two companies and reasons for their failure it can be said that they invested to quick to much money in their infrastructure without proving the product and to see how the market will react to their products. The margins are very low in e-grocery and they both burned out in reaching more people with the wrong services. The couldn´t adjust to the customers needs and yet didn´t know well enough what the customer really wants regarding buying food online.

In general the reasons for failures in e-grocery are the following:

Reason for failures in e-grocery

First, the companies ignored the fact that while the grocery sector generates high sales, margins are low. This means the return on hefty investments in technology and infrastructure is painfully slow. A very fast pace of expansion, especially in the case of Webvan, had a severe negative impact on balance sheets and ultimately helped make the ventures unsustainable. Second, the companies overestimated the profitability of online orders. Traditional grocery works financially because the customer puts in most of the effort: coming to the supermarket, picking products from shelves, and taking them home. This offsets relatively low margins. Online home delivery is a completely different model in which the retailer does most of the work. Unfortunately, customers were not willing to pay the real cost of this in delivery and handling fees, so profitability remained elusive. Third, as with most predictions about online back in the 1990s, the impact was dramatically overestimated. Online never ended up revolutionizing the industry; if anything, it remained a very niche part of the market. Indeed, in 1999, online accounted for just over a tiny 0.09% of all grocery expenditure. The early startups had overestimated the potential size of the prize.[94]

[94] refer to Saunders, N., https://www.onespace.com/blog/2018/10/online-grocery-lessons-history/, (Access: 27.04.2019).

Regarding a WMS it can be said that a WMS and its way of managing processes was never a reason for failing an e-grocery business. Only the high investment in the automation and a WMS without considering the markets needs properly can lead to major problems.

The reasons for being successfully and reasons for failures were shown in the previous sections. Now let´s have a look on what customers really want and why people didn´t use any e-grocery services yet.

4.5 Pains for customers

E-commerce is seen to be a possibility for doing business, which promises relative convenience to the customer, given that customers can shop from the comfort of their homes or offices and at their own time and by choosing different ways to pick up their order. So, one reason that makes a customer return is the convenience to shop online. Means the web design and functionality. Features like high-quality photographs of products, clear labeling of brands, prices, and pack sizes and smart search algorithms (previous purchases, product-by-product access to recipes, or the ability to recreate a prior order with a single click) are a key for customer convenience. The online user experience is even more important in grocery than in nonfood categories. Grocery shopping is tiring and time-consuming on a badly designed and poorly functioning Web site and probability is high that the customer is not coming back to buy again.[95] Also, when customer buying food online, they are lacking the sensory experiences, smelling freshly baked bread and seeing and feeling the vibrant color and texture of perfectly ripe strawberries that is virtually impossible to replicate online. Additionally, the power of human interaction and the thrill of unplanned discovery that physical stores can provide is missing online. In fact, the majority of global respondents (61%) in the Nielsen Global E-commerce and the New Retail Survey believe that grocery shopping in physical store is an enjoyable and engaging experience and similar percentage (57%) thinks grocery shopping in a retail store is a fun day out for the family.[96]

Another big topics for the consumers to keep them from buying food online is the skepticism about product quality. Consumers who haven't yet tried grocery shopping online said their biggest concern is not being able to see or touch the actual products before buying it. They want guarantee that their groceries will be fresh and in high quality, no bruised fruit and no wilting lettuce.[97]

Concluding let´s have a look on the results of a survey from the UK were asked what problems they've had with online grocery shopping in the last year (2018):

[95] refer to Galante et al. (2013), pp. 28.
[96] refer to Nielsen (2015), p. 13.
[97] refer to Galante et al. (2013), p. 23.
[98] Source: Denton(2019),https://www.thisismoney.co.uk/money/news/article-6911995/Shoppers-growing-increasingly-tired-buying-groceries-online-missing-items-abound.html, (Access: 10.09.2019).

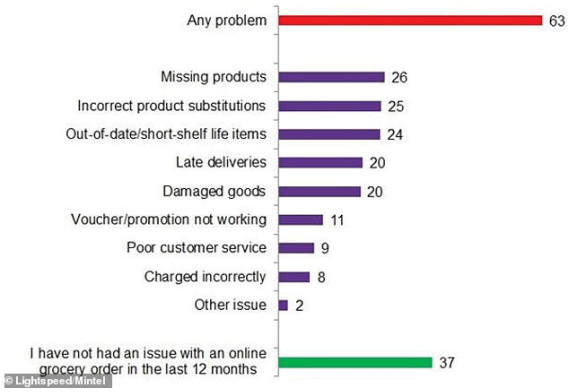

Figure 10: Pains for customers[98]

In the figure 10 above you can see that more than 60% of the people who bought food online experienced problems with the delivery. This shows problems in the order fulfillment and that the e-grocery market still is not satisying the demands from the customers. In 26% of the cases product was missing and each quarter of the asked people also was delivered an out-of-date item. Also the high percentage of cases of damaged goods and late delivery shows that e-grocers still have problem within the supply chain. If a e-grocer wants to be successfull and satisfy the customer needs of having the right product, in the right quality and at the right time, he needs to provide the corresponding logistics beginning from order management to picking and shipping of the goods.

Consumers want to save time for purchasing food. Either by reducing (or even by eliminating) their round-trip time to the store and the time of spent looking for a parking space. Also, the spent time in store by eliminating waiting times at food preparation counters and at the checkout. Here online grocery helps out.[99]

But why suppliers / e-grocers are struggeling to providing the desired services? To get a full picture of the market situation also the challenges and pains for e-grocers will be described in the next section.

4.6 Challenges and pains for suppliers

Selling groceries online creates additional costs regarding labor, delivery vehicles, and fuel which are higher than the fees customers are willing to pay for delivery. Thus, profitability seems to be an unreachable goal. Especially for retailers in markets where gross margins are lower and labor costs are higher.[100]

Last mile

To offer competitive delivery windows against demand and cost is a challenge for all e-grocers. This is to be expected that whenever the customer influences the delivery service and time

[99] refer to Durand; Gonzalez-Feliu (2012), p. 514.
[100] refer to Galante et al. (2013), p. 23.

window, actual delivery cost and driven kilometers increases. Pressure from the customer and competitors has forced some e-grocers to offer one-hour delivery slots. That indicates a huge logistical challenge at home or certain pick-up points within the time window.[101] Therefore, a more effective trucking scheduling within a shorter timeframe is needed.[102]

The order outbound time in the e-fulfilment warehouse is unplanned. Additionally a higher turnover velocity and product types are observed in e-fulfillment warehouses. This occurs due to the ease of customers to place orders at any time.[103]

This ordering convenience rises shorter delivery lead times and increasing numbers of small-sized shipments to customers or pickup points with strong variation in frequency hence it requires an efficient order handling. This leads to single items picking inside the warehouse which requires a higher automation for example picking robots that can deal with picking single items.[104] At the same time the warehouse should also be able to fulfill B2B customers like stores. So, a combined picking possibility (picking single items for online customers and full pallets for stores) is needed.

Concerning the shipment to the customer logistic costs rise due to multiple delivery windows and complex vehicle routing, storage and delivery expenses if customer is not present for receiving the delivery. And the difficulty to make it reasonable for the customer to pay extra for delivery.[105] Also unexpected circumstances such as bad weather, roadblocks, system breakdown and accidents, which all affect on-time deliveries and fails customer expectation which is very high for e-grocery.[106]

Customers' expectations and to keeping customers

The quality expectations of customers in e-grocery are very high and they require the right products to be picked and delivered at the right time by drivers who are smart and presentable. Additionally, e-grocers have to manage customer expectations, which are sometimes unclear, and this can be a big challenge.[107]

On top of that consumers tend to be disloyal as they learn to shop across channels, with 64 percent switching preferred retailers when migrating from brick-and-mortar stores to the Web. The tendency to change the e-grocer when the customer desires are not met is easy and fast. The consequences of a retailer's poor performance in online grocery whether on the Web site itself or as part of the delivery or pickup arrangements are likely to be highly frustrating for customers and will lead the customer to not coming back or to choose a different provider.[108]

Freshness of products

Fresh products have a short shelf-life and therefore, the policy is to pick the longest-dated product. Typically, the difficulty of managing inventory freshness is related to the desire for

[101] refer to Mkansi et al. (2018), p. 17.
[102] refer to Aysev et al. (2018), p. 2.
[103] refer to Hui et al. (2016), p. 2.
[104] Ghajargar et al. (2016), p. 1371.
[105] refer to Hübner et al. (2016), p. 241.
[106] refer to Mkansi et al. (2018), p. 17.
[107] refer to ibid., p. 17.
[108] refer to Galante et al. (2013), p. 23.

an optimum trade-off between quality and service delivery. Chilled and frozen products rely heavily on the functionality of freezers inside the vans. So, it is a costly and organizationally challenge for e-grocery to pick, store and ship products that needs to be fresh and in certain temperature conditions all along the supply chain.[109]

Capital requirements
Finally, it to enter or to scale-up the online business for grocers is capital intensive. Either the grocer needs to invest in new e-fulfilment centers in optimal locations to reach customers or to invest in additional facilities like pick-up points and high automation inside the central warehouse to meet the demand in e-grocery.[110] Beside that it needs to be considered that a large part of online sales will cannibalize the original offline business.[111]

Concluding the biggest challenges for e-grocers are to deal with the last mile and the properties of fresh food and the corresponding handling along the supply chain. And the right set-up of the business model to provide the right value to the customer. It is also worth having a look on reasons what makes business models successfull. Additional services or value added services provide competition advantages and improve the customer services. In the following section some possible value added services for e-grocery business are shown.

4.7 Value added services provided

Value added services are provided services additionally to the primary business. For e-grocers the primary business is to buy food online and to provide the bought food to the customer. Value added services for e-grocers would be:

Meal kit services
A relatively new value-added service from online grocers is to offers consumers a convenient way to cook at home: they just choose from online picture menus, and pre-measured fresh, high quality ingredients along with recipes that will be delivered to their home. This approach is closing the gap between home-cooked meals and takeout, while minimizing food waste. Customer for meal kit are likely to be younger – adults between 25 and 44 are twice as likely to use them as older consumers.[112]

Traceability and tracking including smart packaging
Smart packaging allows each carton to be tracked, monitored and interacted with throughout the supply chain, creating new opportunities for efficient stock management, distribution and automation and new opportunities for the customer to interact with the producer or product. This is done by digital printing, which makes it possible to print a unique digital code on each package. The package can be scanned by both specialist devices and ordinary smartphones, allowing traceability and transparency. Information can be shared with consumers right down to

[109] refer to Mkansi et al. (2018), p. 17.
[110] refer to Hübner et al. (2016), p. 241.
[111] refer to Galante et al. (2013), p. 23.
[112] refer to Tetra Pak (2018), p. 17.

the farm or grove that a product comes from. The package can be also a gateway for customers to engage in programs like a lottery ticket, a unique identifier for an online competition or a loyalty token. It creates a one-to-one channel with individual consumers.[113]

Real-time stock and the due dates

In the future a highly connected supply chain will be reality in which also the customer can see while shopping with his/her app the real-time stock of the provided goods. So, he can see where there is no stock available and which substitution is available like in a physical store. A real-time stock monitoring from customers helps the grocer also to avoid stock outs, because the customer already orders differently. Also, the due date of the provided goods will be shown directly while shopping online. Transparency of the supply chain will be used as value-added service to the customer.[114]

Finally, after the e-grocery market is analysed in detail and relevant information about failures, success factors, challenges and needs from customers and suppliers are pointed out, the resulting requirements for WMS in e-grocery are shown in the next chapter.

4.8 WMS in e-grocery

In the chapter "Warehouse management system (WMS)" in section "WMS in e-commerce" needed requirment for a WMS in e-commerce are described in general. Now at the end of the performed the market analysis also information about the requirements for a WMS in e-grocery are available. It needs to be said that also the already described requirements for WMS in e-commerce affect e-grocery, because it is also a form of e-commerce. But following criteria will be needed in the future especially for a WMS in e-grocery. Of course some other e-commerce sectors could be also interested in useing one of this requirements. A comparation of the requirements for e-commerce and e-grocery is done in the summary after this section.

Connectivity

WMS and inventory management systems (IMS) need connectivity. By being able to communicate up and down the supply chain, with operations software, transportation software, ordering systems the efficiency will increase. The goal is to have orders generated and fulfilled with as little human intervention as possible. And the more automated this process becomes, the easier it is for grocers keep their stores properly stocked continuously.[115] The use of MFC for example makes the order fulfillment more efficiently. Orders can be transmitted to a WMS, directly from the point of sale. It doesn´t matter in which way the endcustomer gives up an order it can be directly assigned to a MFC´s or to a central distribution center from which it is the shortest delivery time and or the lowest handling costs to fulfill the order.[116]

[113] refer to Tetra Pak (2018), p. 17.
[114] refer to Google Cloud, https://cloud.google.com/customers/ocado/, (Access: 26.04.2019).
[115] refer to Demetrakakes, P, https://www.winsightgrocerybusiness.com/operations/taking-stock-inventory-automation, (Access: 05.06.2019).
[116] refer to Thomas Elsner (2019), In-depth interview.

Also, the connectivity between WMS and WES is critical to enable a real-time communication with automation system elements in the facility ensuring WMS efficiency, allowing grocers to better understand the availability of the processing assets. This helps to orchestrate the automation and to integrate workers tasks.[117] This can also include additional SCE-systems like pick up stations. Pick-up stations could be integrated in the WMS to facilitate the outgoing goods process regarding calculation of delivery time, picking sequence, staging, buffering and consolidation on time. The WMS would have information about the occupation of pick-up stations and give the customer exactly the position where the delivery will sent to. Especially in e-grocery customer service is a key for success and this kind of functionality is an competition advantage.[118]

Layout optimization

Optimizing storage locations and allocation capacity through a multi-temperature distribution layout is needed to keep goods fresh and ready for picking.[119] This is important to ensure that the delivered food is in the right quality when arriving at the customer. Different temperature zones are combined during the outgoing goods process and deep frozen goods need to be loaded without any drop of temperature.

Dynamic order management

This is possible by efficient consolidation buffers. Consolidation buffers enable an optimization of order picking algortihms and a resulting higher picking performance. Furthermore, pre-picked orders shall be able to be sent back to the picking areas if an order is changing. Meaning that the order quantity is changing or a differnet item is ordered.[120] Through this workload peaks and fluctuation in demand can be smoothened out more easily and processes can be planned more accurate. It makes it possible for the e-grocer to offer different and tight delivery time slots and also a shorter delivery lead time.[121] The decoupling of delivery and picking process makes the most sense if a e-grocer is offering the possiblity to fill and change the online shopping cart until a certain time of the day. During that the order would be pre-picked and stored in the buffer and if needed it would be possible to change it easily again.

A second aspect of a dynamic order processing is to allow picking orders to be updated even after the respective picking tour has been started. Incoming urgent orders are added to the current picker route and they do not need to wait until the next wave is processed. So, whenever a new order arrives, it has to be decided if this order should be dynamically added to the current tour of a picker. Such a decision would be required if the picking capacity is little and adding a new order necessitates a postponement of earlier orders of the tour. The biggest advantage of this dynamic order processing is the flexibility to quickly process urgent orders, which is especially valuable for the tight schedules of online retailers.[122]

[117] refer to Demetrakakes, P, https://www.winsightgrocerybusiness.com/operations/taking-stock-inventory-automation, (Access: 05.06.2019).
[118] refer to Thomas Elsner (2019), In-depth interview.
[119] refer to Lamphier, E., https://www.manh.com/resources/articles/2018/10/23/surviving-amazons-grocery-disruption-rethinking-supply-chain, (Access: 04.06.2019).
[120] refer to Thomas Elsner (2019), In-depth interview.
[121] refer to SSI Schäfer (2018a), p. 19.
[122] refer to Boysen et al. (2019), pp. 15.

Order Streaming

This concept is combining wave and waveless picking simultaneously. That makes it possible to continue processing grocery store replenishment orders while fulfilling individual e-commerce orders. So, a WMS needs to provide processes for grocery store replenishment and individual e-commerce orders. Picking waves are picking orders that are summarized concerning transport route, quantity of orders, priorities etc. and assigned to pickers. If an order shall be fulfilled waveless, it is not considered in one of these picking waves.[123] The combination of wave and waveless picking is especially interesting for companies that have a omni-channel strategy. That means the combination of fulfilling B2B and B2C orders from the same warehouse. This concepts makes sense a central warehouse because of the high degree of automation and and the provided space to pick and store both order types.

Product traceability and inventory visibility

Visibility of real-time supply chain inventory information for upstream suppliers. This inventory is often temperature-sensitive, and it helps to manage it by maintain and track manufacturer, lot, date, temperature and country of origin-type data at every step of the process. That makes it possible to react on shipping or production issues as soon as possible.[124] And avoid the delivery of out-dated food. This is extremly important concerning the high expectation from the endcustomer and wide range of e-grocer provider. If once an out-dated food is delivered the trust is gone and the endcustomer is taking the online service from anoter e-grocer. Furthermore, the possibility to trace food and to make stock visible can be used for value-added services like smart packaging or real-time stock visibility during the online shopping of food. The endcustomer can therefore directly see which products are out of stock and can directly choose a substitute product without any inconvenience.

4.9 Summary

E-grocery will be shaping the future of grocery shopping significantly. As it is shown in the statistics in chapter 4.1 Analysis of the market e-grocery is the fastest growing market for grocery however still a small market. Reasons why e-commerce is not yet common are the difficulties that occur for the suppliers to deliver perishable, fresh food, at the desired time frame, with the desired quality (e.g. deep-frozen products delivered together with ambient products) to the desired destination. At the same time the margin is very low. Another reason is the wish of consumers to still have a shopping experience and the need to touch and feel the fresh food before buying. That is why brick-and-mortar stores will also not completely disappear. E-grocery was not that quick developing like other online market sectors as electronics or fashion because of its bigger challenges and high expectations from customers. Anyhow the enormous growth rate and the tendency of the "Generation Z" to use technology

[123] refer to Lamphier, E., https://www.manh.com/resources/articles/2018/10/23/surviving-amazons-grocery-disruption-rethinking-supply-chain, (Access: 04.06.2019).

[124] refer to Kuerschner, J., https://www.foodlogistics.com/home/article/12297573/watch-your-wms, (Access: 05.06.2019).

shows its potential for the future. And there is already a big market to satisfy the consumer´s wish to buy food comfortable online at any time or place.

"Looking ahead, our e-retailer survey suggests that the use of technology in order fulfilment and the last mile could cut delivery times to within 10 minutes of purchase by 2025. This would significantly change consumer attitudes to online grocery shopping, driving them to buy in smaller amounts, more frequently, often for immediate consumption; to store less; and to be much more conscious of food waste."[125]

Growing use of automation in the supply chain and connectivity between all players along the supply chain will make it possible to face the logistical challenges but the bigger challenge for retailers will be to meet the customers' needs properly. Retailers need to show shoppers that they deliver format, price, quality, convenience and selection in every interaction, no matter where it occurs.

That includes:[126]

- Quality assurance programs
- Delivery service (time slots, one-day delivery, same-hour delivery)
- Functionality/Design of website and app (preferred products, real-time stock data)
- In-store digital enablement (Scan QR for information/buying, or mobile coupons/shopping lists)

Yet these provided value-added services are not uniform. More business models with different value-add services appear. But all of these models need to deal with the same logistical challenges. It is important to deliver fast at any time in the desired quality and (close) to the desired destination and to be connected all along the supply chain to quickly react to changes like different delivery time/destination, item or delivered quantity. For achieving this, the described business models of home delivery and click&collect (chapter 4.1 Business models for e-grocery) will be relevant for grocery shopping in the future.

After comparing the best practices and the failures of e-grocers it is also important to mention that a well functioning WMS in combination with the respective automation systems is a key for success by making order fulfillment smooth, with a short lead time by ensuring also the desired quality. Regarding the reasons for failure, a WMS was not a reason for failed e-grocers.

Finally, also the requirements for a WMS in e-grocery could be worked out and now it can be compared to the requirements for e-commerce in general and where the differences appear:

[125] Tetra Pak (2018), p. 17.
[126] refer to Nielsen (2015), pp. 14.

Table 3: E-commerce vs. E-grocery[127]

Requirements	**E-commerce**	**E-grocery**
Small orders handling	x	x
Huge numbers of returns	x	
Transportation management optimization	x	x
Flexibility and scalability	x	x
Engaging workers	x	x
Optimizing labor allocation and utilization	x	x
Integration of automation systems	x	x
Connectivity		x
Layout optimization		x
Dynamic order processing		x
Order streaming		x
Product traceability and inventory visibility		x

Regarding the table above (table 3: "E-commerce vs. E-grocery) the requirements for e-commerce in general fits also for all forms of e-commerce like e-grocery. The requirements for e-commerce were described in section: "WMS in e-commerce" and in e-grocery there are the same reason why these mentionned requirements are used. Only the huge amount of returns is not common in e-grocery because food is perishable and therefore it doesn´t make sense to send out-dated, damaged food back, because it is not useable anymore in the most of the cases.

But in e-commerce "Connectivity" is not that important like in e-grocery. In e-grocery the last mile is the most important factor in the supply chain because of the properties of food. It needs to be cooled and is easily damaged and perishable. These factors makes the last mile more challenging than in the other e-commerce sectors.

[127]Source: Own creation

The layout opitmization is important especially for e-grocery because of the temperature sensitive food. In e-commerce in general there are no different temperature zones needed.
Dynmaic order processing is needed because of the services from e-grocers to provide the possibility to shop like in a supermarket. To fill and change the shopping cart until a certain deadline. At this deadline all the orders come in and needs to be handled accordingly. Therefore, the filled shopping cart needs to be pre-picked and changes need to be easily made to deal with order peaks easier.
Also it needs to be easy to decide in very short term which goods are fast and slow moving goods (e.g. beer before a futball game) and it needs to be possible to change these assignments quickly and also in short term. These provided services with an occurig order peak is especially done in e-grocery. This service model would not make sense for normal e-commerce (e.g. electronics or furniture or hygiene aritcles).
Order streaming, meaning the combination of wave and waveless picking is e-grocery specific because of its possible omni-channel strategy of fulfilling standard store orders and online orders from endcustomers simultanously. In e-commerce this combination is not provided from the e-commerce in general.
Finally regarding Product traceability and inventory visibility it is again a particular requirement for e-grocery because of the properties of food. Food needs to be tracked and ensured to be not out of date already. However inventory visibility would be also interesting for e-commerce for providing real-time stock data to the customer (e.g. fashion).

Based on the findings of this chapter the software WAMAS will be analysed and potential improvements will be proposed in the following chapter.

5 Analysis of WAMAS in e-grocery

After analysing the market for e-commerce in food retail and comparing the differences between the requirements for a WMS in e-commerce and e-grocery, an analysis of the actual WMS standard solution from SSI Schäfer (WAMAS) is done in the following chapter.

The analysis and adaption of the WAMAS processes is based on the findings of the market analysis and the literature research of the WMS in e-commerce, company knowledged of SSI Schäfer (internal documents and expert knowledged from consultants and product development) and the performed in-depths interviews. It is analysed which processes are already used for e-commerce and which are also fitting for online grocery and which need to be optimized. Finally also processes that are still missing in WAMAS standard solution are highlighted and divided into proceses/functions that must be included in WAMAS and which can be included. These functions shall facilitate future work in projects and provide SSI Schäfer´s customers an improved value proposition in their standard software (WAMAS) solution. Additional in-depth interviews with e-grocer customers from SSI Schäfer about their WMS were not possible because they didn´t want to share their knowledge about key processes of their business.

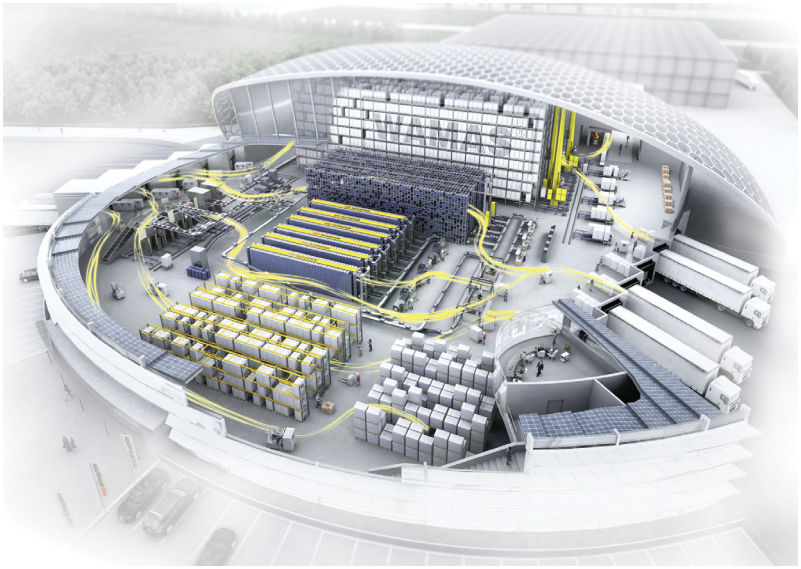

Figure 11: WAMAS[128]

[128]Source: Internal SSI Schäfer document

5.1 Basic WAMAS terms[129]

For a better understanding of the WMS WAMAS a short introduction in WAMAS terminology is given in this section.

Client
A client is a customer or contract partner of a logistics/warehouse operator, or the warehouse operator itself. The client master data describes the characteristics of the various clients.

Partner
A partner is the client's business partner and (at the same time) may be a:

- Supplier
- Customer
- Freight carrier
- Goods owner

Goods owner
The goods owner is also business partner who owns the goods in the warehouse. Maintaining a goods owner is only necessary if the client is not the goods owner. A goods owner can be a client or one of the client's partners (supplier, customer, freight carrier). Every client can have multiple goods owners, but only one default goods owner can exist per client. In WAMAS, a goods owner is characterized by:

- No individual master data such as item or partner master data.
- Individual stocks
- Individual picking locations (some picking locations are shared with other goods owners).
- Inbound and outbound order and/or delivery lines must be created for a specific goods owner.

Loading Unit
A loading unit (LU) consists of a stock object and the loading aid that the goods are stored on. Loading units are normally created during a certain process and deleted after the process was finished. A unique loading unit identification number (LU-ID) identifies each loading unit.

Inbound order
An inbound order corresponds in WAMAS to an order placed on a supplier or a company's own production facility. An inbound order can consist of multiple inbound order lines with different loading units or items.

Inbound delivery
An inbound delivery consists of one or more loading units or items and refers to the total of

[129] refer to SSI Schäfer (2018c)

all goods that are dispatched from a sender to a consignee in one inbound delivery step. An inbound delivery normally contains everything specified in the delivery note and consist of one or more inbound delivery lines with different loading units or items.

Outbound order
An outbound order corresponds in WAMAS to an order placed by a customer. It is an instruction to WAMAS to provide goods for shipping (outgoing goods).

Outbound delivery
An outbound delivery consists of one or more loading units or items and refers to the total of all goods that are shipped to a customer. Outbound deliveries are the result of the planning process in WAMAS.

Advised loading unit
WAMAS also offers the option of creating advised loading units instead of inbound deliveries. As opposed to inbound deliveries, advised loading units already contain information about the LU that was delivered. This simplifies the incoming goods process since the information is already available on the advised loading unit.

5.2 Processes in WAMAS[130]

For analysing the processes in WAMAS for their usability for the e-grocery market, an overview over the processes in WAMAS is given in this section first. Based on these processes optimization and missing processes can be found.

5.2.1 Key functions

Following processes are key functions in WAMAS:
Incoming goods processes
Incoming goods is the process in which delivered goods are added to stock, both physically and in WAMAS. Before they are stored, they are checked for quality and the correct quantity. The process of reveiving incoming goods it is shown in figure 12: "Inbound process" below. The delivered goods may be a delivery deriving from a/an:

- Order
- Production delivery
- Customer return
- Transfer delivery

[130] refer to SSI Schäfer (2018c)

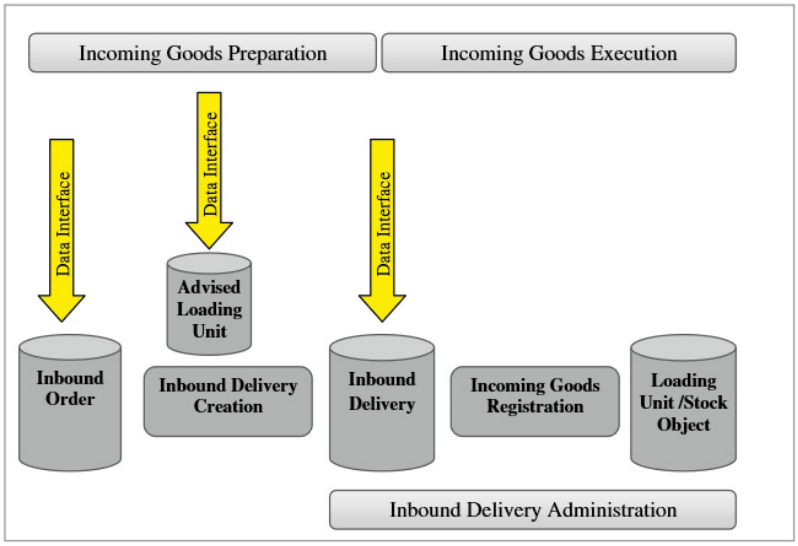

Figure 12: Inbound process[131]

The receiving of incoming goods is done like described in the figure 12:"Inbound process" above. Starting with the Incoming goods preparation following is done:

- Creation of Inbound order/delivery
  The incoming goods process begins with an inbound order, an inbound delivery or an advised loading unit. Inbound orders, inbound deliveries and advised loading units can be either transmitted to WAMAS from a system partner (e.g. ERP system SAP) or created using WAMAS dialogs.

- Releasing (Incoming goods execution starts)
  Once inbound deliveries are released in WAMAS, they are ready to be processed by the employee in the incoming goods warehouse area. That can be done also manually or automatically.

- Processing
  The LU´s of an inbound deliver line can be registered via a mobile terminal or a workstation (Desktop) Not advised LU: The stock object is registered and a corresponding load unit with a suitable loading aid is created. Following a storage location search according to predefined storage strategies is done and a transport order is created. Afterwards the LU is labelled. Advised LU: Advised LU will be directly identified. All the information about the stock object are already in WAMAS. Following a storage location search according to predefined storage strategies is done and a transport order is created.

Replenishment

Replenishment refers to supplying picking locations with an adequate quantity of goods. The quantity of goods that is needed at a particular picking location is based on a replenishment

[131]Source: Internal SSI Schäfer document

demand. The demand specifies which quantity of goods is needed at a picking location at which time. Transport orders are created so that the loading units or stock is moved from the reserve area (replenishment warehouse) or the incoming goods area to the picking location. If replenishment for the same item is requested more than once, the priority of the corresponding transport order is increased in order to be processed faster (replenishment priority management and allocation). WAMAS supports the following replenishment strategies:

- Preventive Replenishment: For preventive replenishment, the stock levels at the picking locations are monitored. If a configurable threshold is reached, a transport order to the picking location is created automatically. A check is performed each time the stock level at the picking location changes and at regular intervals.
- Demand-Based Replenishment: Demand-based replenishment is based on the actual demand caused by picking orders. When outbound deliveries are released for picking, the corresponding replenishment demands are created at the same time.
- Manual Replenishment: If a picker requests replenishment manually.

Kit assembling

A kit refers to the compilation of several items, which, together, form a new item. Items, which are part of a kit, are referred to as kit components. A kit is created from a list of kit components, along with the quantity of each such kit component. Kits are assembled at dedicated storage locations, i.e. work locations, within work areas. The kit assembly process involves the preparation of assembly orders, the actual assembly of kits based on kit components and the assembly order administration.

Work orders

WAMAS offers the possibility to manage and carry out work orders. These include tasks, which exceed the functionalities provided by basic logistical processes such as incoming or outgoing goods. Work orders allow the creation and control of tasks, which are performed at dedicated storage locations in work areas. The work order process involves the preparation of work orders, the actual processing of the work order based on tasks and the work order administration.

Stock management

The purpose of stock management is to have an overview of the current stock of goods. It includes processes for creating, removing or changing stock. It also includes processes that deal with posting and reserving stock. Stock can be managed in terms of quantity and/or loading units.

- Optimizing/Re-sorting storage
  Optimizing Storage in the Warehouse To optimize the storage in the warehouse, it is important to identify unsuitable loading units or quantitymanaged stock objects. WAMAS offers the possibility to enter different search criteria such as height utilization rate,

deviations in ABC classifications, etc. to search for inappropriate loading units or stock objects. The user can then create a transport order and relocate one or more loading units to a suitable storage location. In a flow rack loading units can only be stored behind each other. If necessary, the sorting of flow racks can be changed manually in WAMAS. In WAMAS the ABC-value is taken to classify fast-moving and slow-moving items. This is done by calculating the picks and accesses for certain items. Classically this would be seen as a XYZ-classification.

- Managing Goods Close to Expiration Date
  To optimize how goods are managed in the warehouse, it is important to know which and how many items in the warehouse are going to expire or have already expired. WAMAS provides an overview for stock objects that shows items according to their best-before date (BBD) and their remaining shelf-life attributes. The BBD indicates by which date a certain product should be used, while the remaining life refers to the number of days by which the item should be delivered at the latest. The remaining life date must therefore be before the BBD, so that the BBD is not violated or expired goods are delivered. The following options for searching are available in the stock object overview:

- Expired goods: Lists all items which have already expired.
- Goods expiring in X days: Lists all items that will expire within the given number of days.
- Goods remaining shelf-life expired: Lists all items whose remaining life has already expired.
- Goods should be delivered in X days: Lists all items in the warehouse whose remaining life will expire in the given number of days.

Inventory

In inventory the quantity of stock held by a warehouse is counted, recorded in WAMAS and forwarded to a system partner, if necessary.

- Types of inventory
  Inventory is carried out in different ways depending on the situation it can be done for an specific area, a special item, annually, periodic or over all the inventory in the warehouse.
- The inventory sequence
  It indicates the order for the inventory of the LUs. It is calculated by WAMAS based on the criteria set in the warehouse model, such as the location of the storage compartments within the inventory area.
- Basic inventory strategies
  The basic inventory strategy is determined according to whether specific storage locations or loading units are to be inventoried.

Picking

Picking is the process of collecting the required quantities of ordered goods in order to fulfill an outbound delivery. It can be carried out either as one-stage or as two-stage picking. All picking activities can be divided in full cases (a whole pallet) and single piece picking. Two-stage picking divides the process into two separate steps where goods are picked in a single item manner first and distributed to individual outbound deliveries later on. First, goods are picked per item without reference to an outbound delivery. The picked loading units are deposited at the picking location of the second stage. Afterwards the picking of the second stage can be processed (e.g. via inverse picking) and the loading units for the outbound deliveries are created. The following picking principles are supported by WAMAS:

- Person-to-goods picking: The goods to be picked remain at the storage location. The picker moves from one storage location to another according to the instructions of the picking order and retrieves the goods there.
- Inverse picking (two-stage picking): Inverse picking refers to a picking process, where the goods are divided into loading units for outbound deliveries. This involves the distribution of an LU to previously prepared target LUs.
- Picking by means of a WCS: The picking process is carried out with a Warehouse Control System.

Picking Strategies:

Normally, the picking strategy defines the connection of the individual warehouse areas (picking areas, transfer areas, strategic warehouse areas, etc.) with the outgoing goods area for the purpose of picking. The following picking strategies are supported by WAMAS:

- Parallel picking
  One or more pickers are processing several picking orders belonging to one outbound delivery simultaneously (in one or several areas).
- Chain picking
  Continuous picking across various picking areas. The picker carries out all the picking activities that are possible in a picking area and then moves on to the next picking area.
- Pass-on picking
  Includes the passing-on of a picked LU from one area to another where the items assigned to the respective areas are picked. E. g. a picker carries out the picking activities in one picking area and deposits the picked LU at a transfer area. The picker of the following picking area picks up this LU from the transfer area and continues picking in his area.
- Collection picking
  For collection picking, the goods of a certain picking area are pre-picked and deposited as a so-called collection loading unit at a collection area. This collection area is located within another picking area. The picker of this other picking area starts picking. When

he reaches the collection area, he takes the collection loading unit, consolidates it with the main LU and continues the picking process.

The different picking strategies can be carried out applying one of the following picking kinds:

- Picking on a mobile terminal
- Pick by Voice
- Pick by List
- Picking on a goods-to-person work station

Outgoing goods

The outgoing goods process covers all activities relating to the outbound delivery of goods from a warehouse. As it is shown in the figure 13: "Outgoing goods process" below, the outgoing goods process starts with outbound order/delivery creation and ends with loading of the goods. WAMAS includes outbound delivery planning, picking planning and final process steps after picking such as packing and staging in the outgoing goods process. Picking itself is a separate WAMAS subprocess. The outgoing goods process is used to carry out for outgoing goods customers and for supplier returns.

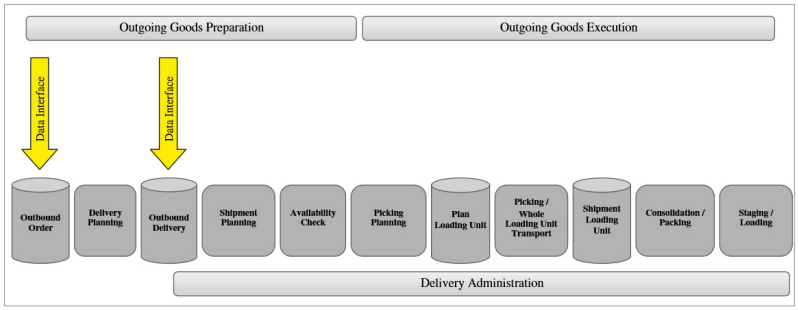

Figure 13: Outgoing goods process[132]

The outgoing goods process starts with outbound order/derliveries. This is done in the following way:

- Creating outbound orders/deliveries
  The outgoing goods process starts with an outbound order or delivery which can be either transmitted to WAMAS from a system partner or created manually using WAMAS dialogs.
- Releasing
  Releasing of outbound orders triggers the outbound delivery planning that can be done manually or automatically. Outbound deliveries can be released for shipment planning, capacity planning and picking planning separately. After that a delivery can be released for picking. Each of that planning steps can be released manually or automatically.

[132]Source: Internal SSI Schäfer document

In the following the planning steps are described in more detail:

- Shipment planning
  During shipment planning, the shipping methods, loading points and freight carriers are determined for the outbound delivery.

- Capacity planning
  During capacity planning, the picking plan loading unitsare created. Picking plan loading units are used to distinguish between transport and picking orders for satisfying the demand of the outbound delivery. Furthermore the required loading volume and the resources in needed in the individual picking areas are calculated.

- Picking planning
  The picking planning process determines in which picking area items are picked. WAMAS calculates the plan LUs (item-accurate) based on the items and quantities that were ordered, the specifications of the picking area and the partner. Additionally, a check is done about how much stock is available in the warehouse. Capacity planning is a part of picking planning. If capacity planning was not carried out yet for an outbound delivery, capacity planning is carried out at the same time as picking planning. Its is also possible to set a delivery frequency and shipment frequency for outbound deliveries.

- Delivery frequency
  The delivery frequency is a cyclical (weekly) delivery schedule for delivering goods between warehouse location and a specific recipient. It defines until when ordered goods are considered for a specific delivery.

- Shipment frequency
  The shipment frequency is a cyclic shipment plan for a warehouse location and defines the time when deliveries leave the warehouse location as well as the time intervals between the departures of these deliveries. Shipment frequencies are maintained for each shipping method.

Packing:
During packing, loading units are created with the picked goods and prepared for shipment. Packing can either be carried out at designated packing locations using a desktop client which is optimized for touch screens or at the respective storage location of the shipment loading unit using a mobile client. The storage location of the shipment loading unit must be assigned to a packing area.

Staging:
During staging, goods are processed prior to loading. Staging includes the following tasks:

- Buffering of shipment LUs: If configured, shipment LUs can be buffered in the OG area before staging for example.

- Consolidation of the shipment loading units (shipment LUs)

- Generation of outgoing goods documents (OG documents)

Loading:
Loading is the physical movement of loading units from the outgoing goods area onto a transport vehicle (e.g. truck). In WAMAS it is possible to create loading orders and to monitor which loading units were already loaded and which ones still have to be loaded. This process is also referred to as system-guided loading. Direct loading of loading units from upstream areas of the outgoing goods process (e.g. the picking area) is not possible. Before loading, the goods must be located in a staging area in the outgoing goods area.

Load management
A load refers to the combination of loading units and consignments, which are transported from a warehouse to a customer by means of a transport vehicle (truck, ship, plane etc.). Due to load management, a system-guided transport of goods can be ensured. The load management process in WAMAS involves the creation of loads based on outbound deliveries respectively consignments, picking planning and picking, as well as final process steps such as staging and loading.

Cross docking
Cross Docking involves the arrival of goods, which have been pre-picked by the supplier at the warehouse. The incoming goods are registered and transported directly to the outgoing goods area of the outbound delivery without being added to stock or being retrieved. In some cases, they might be stored temporarily in the incoming goods area before they can be moved to the outgoing goods area.

Customer returns
The purpose of the customer returns process is to add goods returned by customers back to stock. Common reasons for this include misdirected deliveries, delivery of the wrong items, or damaged goods returns. Customer returns are handled the same as deliveries in the incoming goods process. The inbound delivery type is used to mark an inbound delivery as goods from a customer return.

Supplier returns
The supplier returns process covers all activities relating to the return of goods to a supplier. Common reasons include misdirected deliveries, delivery of the wrong items, or damaged goods returns. The supplier returns process in WAMAS involves outbound delivery and picking planning as well as packaging and shipment of the goods. Supplier returns are carried out in the same way as the outgoing goods process.

5.2.2 Extended Functions

There are some extended functions that are not key processes of WAMAS and so they will be described separately.

Transport

Transport consists of both physical and logical movement of loading units from their source location to a designated destination. The transport process is carried out via transport orders. The transport order is a request to take goods from a source to a destination location at a certain time. First, transport orders are created, that specify the storage locations where the LUs need to be picked up. Then a destination is allocated or selected manually and the shortest route to get there is calculated. Orders are processed either by employees who move the goods using manual transport devices (forklifts, etc.) or by automated transport devices (storage-retrieval machines, conveyors, etc.).

Storage Location Search

Storage location search refers to the process of finding a suitable destination location for a particular loading unit according to the physical and logistical influencing factors and restrictions. So before a loading unit will be stored a storage location search is done. As a result of a storage location search a storage location reservation and a transport order for that loading unit to that reservated storage location is created.

Influencing factors include:

- Warehouse topology (physical warehouse areas, strategic warehouse areas)
- Storage location characteristics: Storage location blocks, storage classes, weight, etc.
- Loading unit characteristics: Loading aids, loading unit cubatures, total weight, etc.
- Stock-specific characteristics: ABC values, homogeneity, time-based access mode of the item (BBD, registration time, production date), etc.
- Filling logic: Even aisle distribution, flow of goods graph, etc.

Consequently, a storage location search is carried out based on the following configurations:

- Strategic warehouse area: By defining a number of empty storage compartments, a maximum filling rate can be maintained per strategic warehouse area and storage compartment type. If configured, the number of empty storage compartments will be considered by the storage location search.
- Flow-of-goods (FOG) graph: It specifies storage strategies in terms of ranking the different strategic warehouse areas. It is used to define the order in which the strategic warehouse areas are included in the storage location search

- Picking location assignment: It defines where items are picked and allows a specific grouping of assignment types per picking area, picking location group or one specific storage location. Only the configured item, packaging version or goods category will be picked at the assigned picking location. However, this also means that stock objects will not be stored at storage locations with a picking location assignment to other items.

Some more optimization criteria can be selected like:

- ABC value: The ABC value of the item and the storage location where the item should be placed should have a similar ABC value configured.
- Distance to picking location: Items are stored as close to the item's assigned picking location as possible in order to facilitate picking.
- Equal item distribution field: Items to be stored will be equally distributed over several strategic warehouse areas (aisles) within a FOG graph.

Strict Optimization Criteria:
In order to find the best suitable storage location, a few standard criteria must be configured:

- Flow-of-Goods(FOG) graph: Specifies according to which order strategic areas are used in the storage location search. It also determines in which strategic areas, picking areas and transfer areas a storage location search is carried out for LUs and according to which sequence the areas are used.
- Maximum number of LUs: Once the maximum stock level is reached in a strategic warehouse area, it may no longer be used for the storage location search. The storage location is calculated separately for every stock object on the loading unit.
- Storage and item classes: Storage classes are used to group storage compartments and can be assigned to multiple item classes. Item classes are used to group items. If you assign storage classes to an item class, only items of the defined item class are stored in storage compartments of the defined storage classes.

Tracking Warehouse data

WAMAS allows users to obtain an overview of warehouse data and capacities. At the same time, it offers the possibility to track item movements across the warehouse. Monitoring Warehouse Utilization WAMAS provides the functionality to give the warehouse staff an overview of the capacities and the utilization of the warehouse. This includes an overview of occupied, empty, reserved and blocked storage locations An important feature in warehouse management is to be able to identify which items are the fast-movers and slow-movers. Since WAMAS tracks the movements of all items through the warehouse, the user can check this information to see which items have a lot of activity and which have not had any movements during a specific time period.

Multi-Warehouse
It is possible to manage several warehouse locations with only one instance of WAMAS. All common warehouse master data will only need to be maintained once for all warehouses. Common multi-warehouse constellations include:

- Main warehouse with external warehouses
  External warehouses usually have different organizational structures than the main warehouse. For example, the main warehouse works with mobile terminals, while the external warehouse works with voice terminals and is used to store goods with a lower stock turnover.
- Globally or regionally-distributed warehouse locations
  The warehouses are located in different countries or regions for easier distribution of goods, but share stock information.

Multiple Warehouses Master and movement data that applies to all warehouses and logistics organizations is centrally managed in WAMAS. It is applicable to every warehouse location. Examples for such data include assortments or goods categories. Data that is specific to a particular warehouse is stored separately as attributes that only apply to the respective warehouse. Examples of item master data that is specific to a warehouse include ABC values, picking locations, or item states. Logistical processes can either be customized for each warehouse location individually, or they can be managed centrally so that the process is the same for all warehouse locations.

External Storage
WAMAS also supports the management of warehouse processes for areas which are physically not directly connected to the main warehouse.

Reports
Some report functions are integrated that give the possiblilty to generate reports of live data or long-term data. Long-term data is data that is not actively used anymore. For example information about an outbound order that is already finished. The reports can be placed easy-to-read in standard dashboards inside WAMAS. Following prefigured reports customers can be used:

- Standard Reports (About key performance indicators like outbound delivery or picking statistics) .
- User-Definable Reports (data on specific areas as defined by the customer)
- Ad Hoc Views (table or a chart that is the answer to a specific business question)

In WAMAS there are already some processes standardly used for e-commerce. These processes can be then analysed if they are also fitting for the requirements for e-grocery and which processes would still needed to be adatped or are still missing.

5.3 WAMAS in e-commerce[133]

The processes that are described below are inside the WAMAS standard and are not only fitting for e-commerce business. All the processes in WAMAS can be used for retail business and for e-commerce. There are just some functions/processes that makes more sense in the online business because its specific requirments.In the end the customer needs to say/decide which proposed solution he wants to take, and with which challenges he has to deal with.

Outgoing goods
Most of the processes that are used in e-commerce can be seen in the outgoing goods process. The outgoing goods process is also the most important in e-commerce due to the reason that e-commerce is all about order fulfilling.

Picking:
The picking process is one of the most important processes concerning the fulfillment of e-commerce orders. In e-commerce in B2C a lot of customers order a small size of orders. So over 80% of the orders only contains one line per order.

Pick by voice with person-to-goods principle is used for business cases where the picker needs to have free hands to handle items. That can be for more heavy items for examples. Process-wise it is used for B2B because in that case more full-cases are ordered. For B2C, mostly piece picking is proceeded in WAMAS for e-commerce. The principles used are

- Goods-to-person picking with pick to tote
  A goods-to-person workstation with pick to tote enables a picking performance of 1.000 picks/h. The tote is conveyed to the workstation where the picker picks the needed itemsinto the tote.
- Person-to-good (with pick by light)
  Pick by Light-supported picking of fast and medium moving products. The display-controlled system guides pickers with exact position indication and quantity to the relevant storage location.

A goods-to-person workstation can be like following:

- The goods are stored in an automated storage and retrieval system (AS/RS) and conveyed to the picking stations operators.
- The operators are assigned to workstations which allow them to perform picking and other necessary tasks in an efficient and ergonomic way.
- Through operator guidance (by light) it is ensured, that all required work steps are carried out to pick the correct goods in the correct quantities. This is based on a process control

[133] refer to SSI Schäfer (2018b)

system in combination with displays, entry options and picking checkscarried out by the system.

A high-performance rate is necessary to fulfill online orders in e-commerce. Therefore, an automatic picking process by an A-frame (Pemat) or automatic picking by a roboter can be used in a lot of cases. This two picking technology are efficient for e-commerce due to the high number of small orders and therefore, an high picking rate is needed. This connection can be seen in figure 14: "Picking performance" underneath. Automatic picking has even a higher picking performance rate than a goods-to-person workstation. Automatic picking can used for fast moving stock keeping units (SKU). A total of 1,200 totes per hour can be processed. Also Goods-to-person technologies like Pick-to-Tote, Piece picking stations and Flow rack picking are suitable for e-commerce due to the high number of processed SKU processed combined with the high performance of up to 1.000 order lines/h. But in general for choosing the right picking technology it also depends on the investments a company wants to make and the physical properties of goods. More automation also means higher invenstment costs and not all goods are suitable for being picked by an A-frame for example.

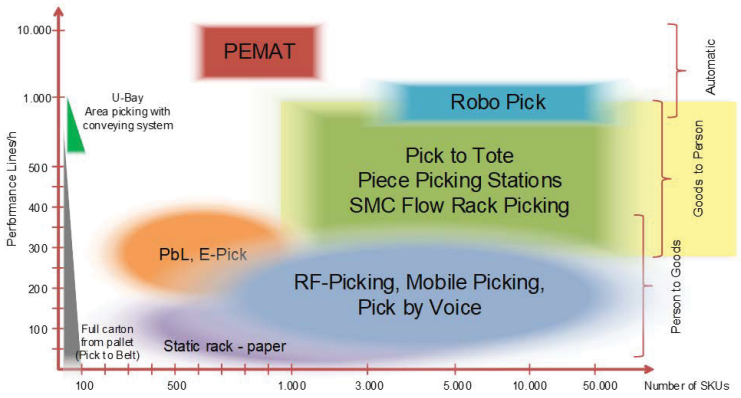

Figure 14: Picking performance[134]

A one-stage picking process is used from single line orders up to four lines. And a two-stage process for lines greater than four via consolidation rack at the side and back of the picker (for person-to-goods).

Picking strategies:
For dealing the best with e-commerce requirements (a wide range of products for a high number of customers and small amount of picking lines per order) in the picking process following strategies in WAMAS are used:

- Parallel picking
  In this case several pickers are processing several picking orders belonging to one outbound delivery simultaneously (in one or several areas) to ensure higher throughput and ideal for a large product range and different storage areas (e.g. temperature zones)

[134]Source: Internal SSI Schäfer document

- Chain-picking
  Chain or zone Picking is used for picking fast moving goods during peak days. The fast movers are picked directly from the pallet whereas slower moversare picked from carton flow racks. Theadvantage is to be able to add multiple pickers per zone. After the picking is done in one area the tote will be transported to the next area. This method enables for higher throughput and optimized picking accuracy and is ideal for small orders with a restricted number of order lines, large product range and fast-moving products.

Consolidation:
At consolidation workstations picked orders can be consolidated from different picking areas for example. Therefore, it can be done in combination of chain or parallel picking process from different picking areas. It is ideal for small orders with a restricted number of order lines and a largeproduct range (different picking areas to pick from).

Buffering:
During buffering items are stored until they are needed for orders. Physically it can be done in anautomated buffer. It enables to decouple previous processes (e.g. picking) from the following processes like packing. That can be used for returns or smoothing picking peaks. And makes it possible to deal with order peaks.

Work station/Work orders
The following work stations are especially interesting for e-commerce reasons.

Depalletizing:
Depalletizing is used to place items from LU´s to totes that are used for conveyorand will be stored in automation storage facilities which are meant for smaller quantities than full pallets. That has following advantages:

- Traceability of items (each tote has unique barcode)
- Density of storage through recapture and compartmentalization
- More efficient for piece picking

In e-commerce there is a high number of small orders and therefore also automation systems with smaller amounts to store are used. And depalletzizing makes it possible to split bigger amounts of items from a pallet to smaller quantities.

Packing:
The packing station is considered a cost-intensive factor in terms of manning and technology combined. Those stations are used for packing of e-commerce and store orders. Totes will arrive at the packing stations for example directly from picking. Then items can be packed in customer boxes. Empty totes are put away again, and the packed customer boxes will be further transported (on a shipping conveyor e.g.).

Customer returns:
In e-commerce a very a high number of customer returns appears. Especially in fashion industry where it is more likely to send products back because of unfitting or displeased clothing.It is important to deal with full cartons or totes of mixed returns. This is done as a specialinbound type in WAMAS. It is important to rapidly make return available again and to avoid additional picking or put away. That can be done through buffer facilities for returns. From where it can be "picked" again or put away from the buffer to the storage after some days.

Integration of a TMS
It is possible to integrate a TMS a system partner in WAMAS to create shipments for delivery routes and loading sequences. WAMAS sends information about the outbound deliveries to the TMS at defined times during the outgoing goods process and the TMS sends back the created loads to be processed (picking, staging, loading) from WAMAS again.

General warehouse tasks
Beside the main processes in WAMAS there is also a general function that facilitate the daily e-commerce business. Tracking warehouse data. Especially for e-commerce it is important to track the warehouse data. The identify items that are fast moving items and can be placed in easier accessible storage locations for example. And also, to see where and at which times in the warehouse is the most work force needed. With this kind of information it is easier to handle order peaks.

Concluding an overview over the fulfilled requirements from WAMAS for e-commerce is given. The requirements were described in section: "WMS in e-commerce" in chapter: "Warehouse managment system (WMS)" and are now cross-checked which WAMAS already fulfill, because these requirments are also needed for e-grocery.

Table 4: E-commerce and WAMAS[135]

Requirements	**E-commerce**	**Fulfilled in WAMAS**
Small orders handling	x	fully
Transportation management optimization	x	fully
Flexibility and scalability	x	partly
Engaging workers	x	fully
Optimizing labor allocation and utilization	x	fully
Integration of automation systems	x	partly

[135]Source: Own creation

WAMAS fulfill the requirments for small order handling by providing improved consolidation and buffering processes. The transportation mangagement opitmization is outsourced to a TMS which is normally provided by the customer. WAMAS offers the possiblity to use different picking techologies like pick-by-Voice or picking with a handheld mobile device to engage workers. Furthermore, WAMAS is able to allocate where and at which times in the warehouse is the most work force needed.
The only areas meantionned in the table 4: "E-commerce and WAMAS" where WAMAS is still not fulfilling the requirements are "Flexibility and scalability" and "Integration of automated systems".
Scalability is given by the software but due to its high complexity and straight forward standard processes adaptions are not quickly and easily implemented. Concerning the integration of automated systems WAMAS is already implementing the WCS inside one WAMAS standard solution where the different picking strategies can be used for different fully automated or semi-automated picking stations like picking robots or goods-to-person picking station which pick-by-light technology. But this is still in the beginning and still needs to be developped to be realy stable to use.

In the following section WAMAS in e-grocery is analysed based on the researched requirements for e-grocery.

5.4 WAMAS in e-grocery

For the following section in-depth interviews with SSI Schäfer employees were carried out. Based on the results of these interviews and the results from the market analysis for the e-grocery market, the WAMAS standard processes were analysed and potencial optimizations will be pointed out.

Following requirements were researched and checked if they are already covered by WAMAS standard:

Table 5: E-grocery and WAMAS[136]

Requirements	**E-grocery**	**Fulfilled in WAMAS**
Connectivity	x	partly
Layout optimization	x	fully
Dynamic order processing	x	not
Order streaming	x	fully
Product traceability and inventory visibility	x	fully

The layout optimization like described in section "WMS in e-grocery" is fully possible in WAMAS. Order streaming and therefore, wave and waveless picking is also possible in WAMAS only in combination with automated systems it often needs further adaptions in the standard. This issue was already described in the previous section "WAMAS in e-commerce" by examining the integration of automated systems in WAMAS. The product traceability and inventory visibility is ensured by the standard solution as well. Inventory and products can be tracked and traced inside the warehouse. And an attribute exists that tracks the remaining time unitl the items is out of date.
Concerning connectivity along the supply chain WAMAS is not providing enough functionalities. This will be considered explained in more detail in the missing process for integration of pick up stations and adaptions for micro-fulfillment centers in this chapter. Regarding dynamic order processing WAMAS has still to improve. Adaptions in the outgoing goods process will be described as optimization, also adaptions for changing the assignmnets for slow- and fast-moving items will be described in this section as a missing process. Two more optimizations were worked out. One is the improving the picking sequence for e-grocery customers, which is a requirement for small order handling in combination with the layout optimization. The second is an improvement for the transportation of temperature sensitive goods, this is belongs to the requirement transport management optimization.

An overview of the researched optimization and missing processes are shown in the table 6: "WAMAS in e-grocery". The different optimizations and missing processes are categorized in "Can criteria" and "Must criteria". "Can criteria" are adjustments in the WAMAS Standard that would meet requirments for e-grocery but they are very specific and only useable for e-grocery businesses or not yet seen as key functions of WAMAS. "Must criteria" are adjustments and functions that the e-grocery market is already demanding from a WMS.

Table 6: WAMAS in e-grocery[137]

Optimization of existing processes		**Missing processes**	
Must Criteria	**Can Criteria**	**Must Criteria**	**Can Criteria**
Micro fulfillment centers (MFC) Dynamic order management	Picking sequence Transport management	Adaption storage assignments	Integration of pick up stations

5.4.1 Optimization of existing processes in WAMAS

Some processes are already available in WAMAS that only need further adaptions to be also suitable for the e-grocery market.

[136]Source: Own creation
[137]Source: Own creation

Micro fulfillment centers (MFC)

Category: Must criteria
Requirement: Connectivity

Why it is needed?
Some E-grocers are useing MFC´s to fulfill their customers order efficiently. Especially for omni-channel fulfillment strategies from grocers it is interesting to use MFC´s in combination with a central warehouse. Stores are delivered from the central warehouse and orders from online customers are fulfilled by the MFC´s. High level of automation and a high throughput rate is reached in the central warehouse. Whereas MFC´s are store-like designed concerning the structure of the picking areas to reach a high picking rate with manual picking. Of course, also semi- or full automated systems can be integrated at the MFC´s. Anyway, it needs to be considered that automated systems have always higher investment costs.

Existing functionality:
It is possible that each warehouse location in one WAMAS instance has its own storage areas, racks, storage compartments, storage locations, and docks and its own warehouse-internal flow of goods. Also, its own working equipment/terminals. Each warehouse location can have different organizational structures. For example, the central warehouse works with mobile terminals, while the external warehouse works with voice terminals and which is used to store goods with a lower stock turnover.

Adjustments in WAMAS standard:
Different warehouse processes need to be synchronized for multiple warehouse locations. This includes the central warehouse and MFC´s for outgoing goods processes and replenishment of stock. The central warehouse is dealing with higher volume for B2B orders and with cross-docking orders to the MFC´s. The MFC´s fulfill online orders and are supplied with needed stock by the central warehouse. Furthermore, fresh and fast-moving items are stored in the MFC´s because of the short distance to end-customers. MFC‘s are situated in urban areas to fulfill online orders from end-customers quickly and with low costs for the last mile.

Order management: Online orders are directly processed in WAMAS and assigned to MFC´s or a central warehouse from where it is the cheapest to fulfill the order concerning transportation costs and handling costs. This is done automatically based on transportation time and cost as well as the availability and ABC-classification of products in the warehouses. So, it is considered to partially pick the order in the central warehouse or MFC and consolidate it in another MFC from which it is the closest to the end-customer.

Order consolidation: Slow-moving and long-lasting items can be picked from the central warehouse and sent to the MFC´s where fresh and fast-moving products can be added. This can be done in way the following way:

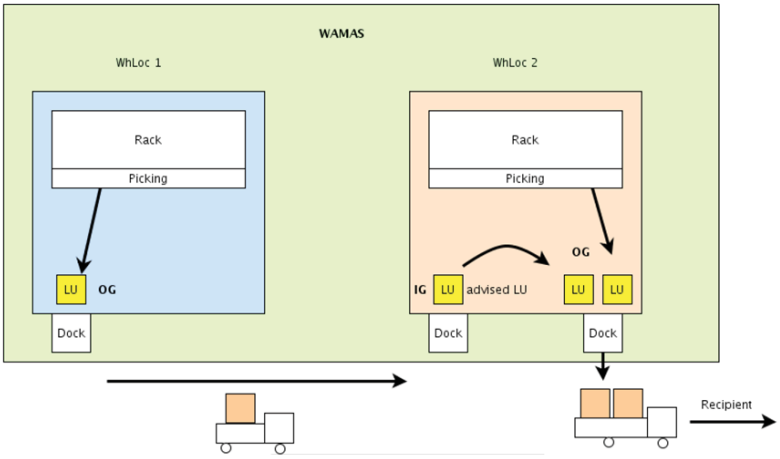

Figure 15: MFC-solution[138]

1. WAMAS creates an outbound order called “Global OBO”.
2. Main outbound delivery that includes order lines with local items and cross-docking items and a second outbound delivery that included only the cross-docking items.
3. Items from WhLoc 1 are picked like a normal outbound delivery and sent to WhLoc 2 as cross-docking items.
4. Process for local items is done like normal outbound delivery in WhLoc 2 (see fig: MFC-solution) whereas cross-docking items are received on advised LU in the WhLoc 2. The local items can be consolidated with the cross-docking items now.

Replenishment: Fast moving items that are stored in a MFC can be replenished automatically when reaching an inventory threshold. An outbound delivery is created automatically for the MFC´s with a preconfigured quantity. For an optimal transport consolidation of replenishment orders and/or cross-docking orders for a certain MFC, it should be considered to place one or both order types in one load. This is done in the TMS. If the volume of the load is too small for an own load until the a defined loading deadline, the TMS sends a notification. The grocer decides to send the load anyway or if it is waiting and postponed to the next delivery cycle.

This requirement is marked as a “Must criteria" because the advanced use of multi-warehouses inside one WAMAS instance is important for synchronizing different warehouse functions across multiple warehouse locations (e.g. replenishment or order consolidation) In the future connectivity along the whole supply-chain will be possible. Also, between different warehouses of the same grocer connectivity is needed to harmonize replenishments and to fulfill end-customer orders more efficiently.

[138]Source: Internal SSI Schäfer document

Dynamic order management

Category: Must criteria
Requirement: Dynamic order processing

Why it is needed?
"E-grocers face the challenge of order peaks that are difficult to handle regarding picking and shipping. To facilitate that WAMAS should pre-picking orders and buffer them in the shipping buffer. Some e-grocers have an online basket, that can be filled until a certain deadline. During that time frame orders can already be pre-picked and placed in the shipping buffer. When the pre-picked LU is changing shortly before delivery, the prepared LU could be taken as return and decanted later. It could be faster to create a new picking order. So WAMAS standard should be able to handle peaks better."[139]

A dynamic order management is necessary for warehouse processes for e-grocers that want to provide their end-customer certain delivery time slots. The filling of the shopping carts can trigger the pre-picking orders. Some business models of e-grocers include a higher pricing when the end-customer is changing the shopping cart. Anyway, the adjusted customer orders after the first filling of the shopping cart and any following changes need to be handled smoothly by WAMAS.

Adjustments in the picking order should be able to be done until a set cut-off time by the grocers. Items can be added and deleted from an order until the cut-off time. In case of deleting items, it could be easier to handle the whole order as return and create a new picking order (especially for order peaks). The return handling can be done after the order peak is over and less orders need to be fulfilled.

Existing functionality:
Order lines can be added until the outbound order is released and then until the outbound delivery is released for shipment planning. After the outbound delivery was released it is possible to reduce or increase the quantity. If the quantity is increased a new outbound delivery is created. The two outbound orders must be consolidated later-on. Increasing and reducing is only possible until the picking planning is released. The exisiting process for the outgoing goods is like in the following figure:

[139] Thomas Elsner (2019), In-depth interview.

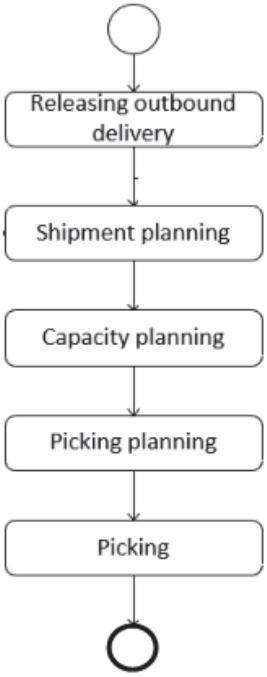

Figure 16: Present OG process[140]

The different steps in the process shown in figure 16: "Present OG process" are described in section: "Processes in WAMAS" subsection: "Key functions". Based on that process adjustments for a more dynamic order management is described.

Adjustment in WAMAS Standard:
Order lines should be possible to be adjusted even after pre-picking. It should be possible to add and remove items as well as increase and reduce item quantity from an order after picking is done. The pre-picked orders are stored in a buffer until cut-off time. It can be decided if full order bins can be changed or not. This can be managed as a check field “Block full bins for order changes“ in the dialog “MD017 Maintain client” tab outbound delivery type. To block full order bins can be part of a pricing strategy of a customer. Picked order shall be able to be re-planned and sent again to the needed picking areas. To start this process an update of the outbound delivery is sent to WAMAS. The connection between the already picked outbound delivery and the updated one is made through the same outbound delivery number. After that the re-planning is done all over again beginning from the shipment planning, capacity planning and picking planning (see figure 17: "OG Replanning"). After the planning is done, the updated outbound order is picked again. If a pre-picked order contains several order bins, only the order bins, that contains changed items will be sent back to the picking areas or handled as customer return.

The physical re-planning process of pre-picked orders is done in the following way: The pre-picked order which contains items to be changed is sent from the buffer to a workstation where the bin to be changed is separated and sent back to the picking areas. The rest of the order goes back to the buffer. When the changed order bin is picked again it will be consolidated

[140]Source: Internal SSI Schäfer document

with theoriginal order and placed again in the buffer. How the re-planning should look like system-wise again as overview:

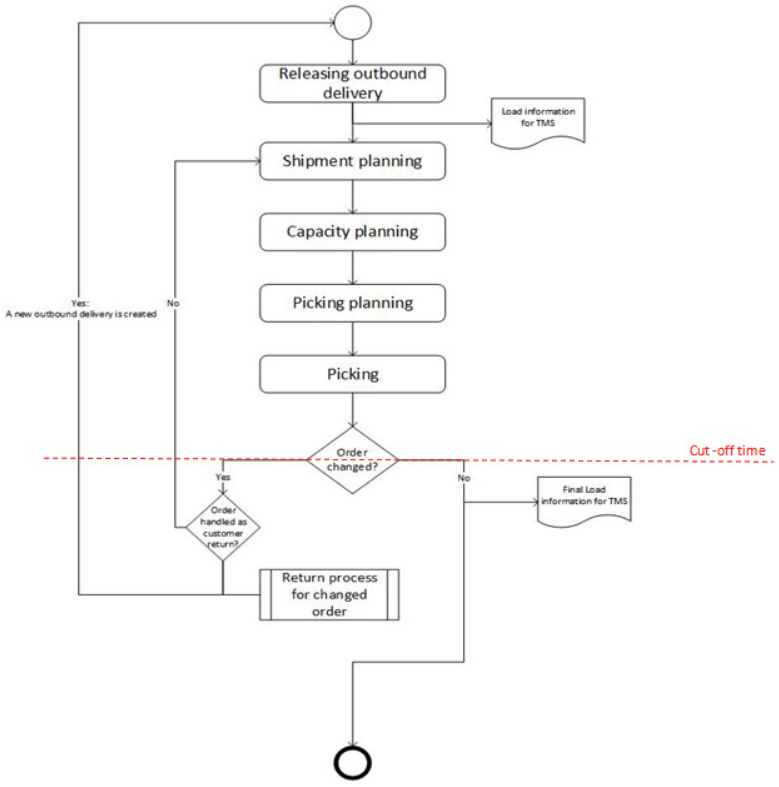

Figure 17: OG Replanning[141]

As already said before pre-picked orders in a buffer should be possible to handle as customer returns if items are deleted and the grocer has a complex order structure with different weight classes for the order bin for example. In the same time a new outbound delivery would be created automatically by the host system.The procedure to handle a pre-picked order as customer return can be done in different ways:

- Manually by right-clicking on the outbound delivery and choosing: "Handle as Customer Return".
- Automatically by setting a checkbox in outbound delivery type tab in the "MD017 Maintain client" dialog. That makes sense if a customer always wants to handle outbound deliveries as customer return when an item is deleted when it is buffered after pre-picking. A new picking order is created automatically.

Information about the planned load is firstly send to the TMS after the outbound delivery was released. It is meant as forecast, that the TMS provider can already plan the approximate volume and quantity of shipments. A final confirmation of the loads to be shipped is send to the TMS after cut-off time.

[141]Source: Own creation

This requirement is marked as “Must criteria" because a dynamic adjustment of orders in e-grocery is highly demanded. In e-grocery it can be a key for success if grocers offer their end-customers the chance to change their orders until shortly before the delivery starts. That is why WAMAS needs to be able to handle changes during the whole outgoing goods process.

Picking sequence

Category: Can criteria
Requirement: Small orders handling & Layout optimization

Why it is needed?
A multi-temperature distribution layout is needed to keep goods fresh and ready for picking. Also it is important to ensure that the delivered food is in the right quality when arriving at the customer. Different temperature zones are combined during the outgoing goods process and deep frozen goods need to be loaded without any drop of temperature. Additionally, goods need to be classified by their weight. There are goods, that need to be placed on the bottom of the dispatch bin (e.g. bottles) and some other should be placed on top (e.g. fruits). Therefore, also weight classifications and different temperature zones should be considered during the picking process.

Existing functionality:
It is always depending on the specific requirements of the customer how this functionality should be designed. WAMAS Standard has a wide range of solutions and can perform appropriate solutions for e-grocery for incoming, outgoing and picking processes. Only some adjustments for fulfilling the customer needs to be done like in the following case:

The picking areas can be structured according to different temperature zones and within the temperature zones the storage location are assigned to storage classes. Each storage class can have one or more item classes. So, the basic configuration in the layout can be done in WAMAS standard to fulfill this requirement for e-grocery.

Adjustments in WAMAS standard:
A new sequence algorithm rule must be created (WH030 Maintain Sequence Algorithm). The sequence algorithm is choosing the picked items inside the picking area ascending regarding the item classes

1. Item class Heavy
2. Item class Medium
3. Item class Light

This is done in WAMAS in the sequence algorithm rule with the Comparatior ID "CompareItemClass" as it is shown in figure 18: "Sequence algorithm".

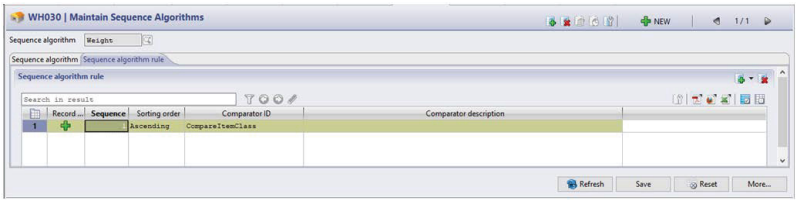

Figure 18: Sequence algorithm[142]

If a picking order is picked from different picking areas and consolidated at a workstation (e.g. Goods-to-person), dialog “WH084 Maintain Work stations”. The workstation process “PTT Consolidation” needs to be adapted in the tab “Parameters” at the position of the red mark in the figure 19: "Work station" below, in the following way: Creating a new record for consolidating items ascending from the item class heavy to medium to light.

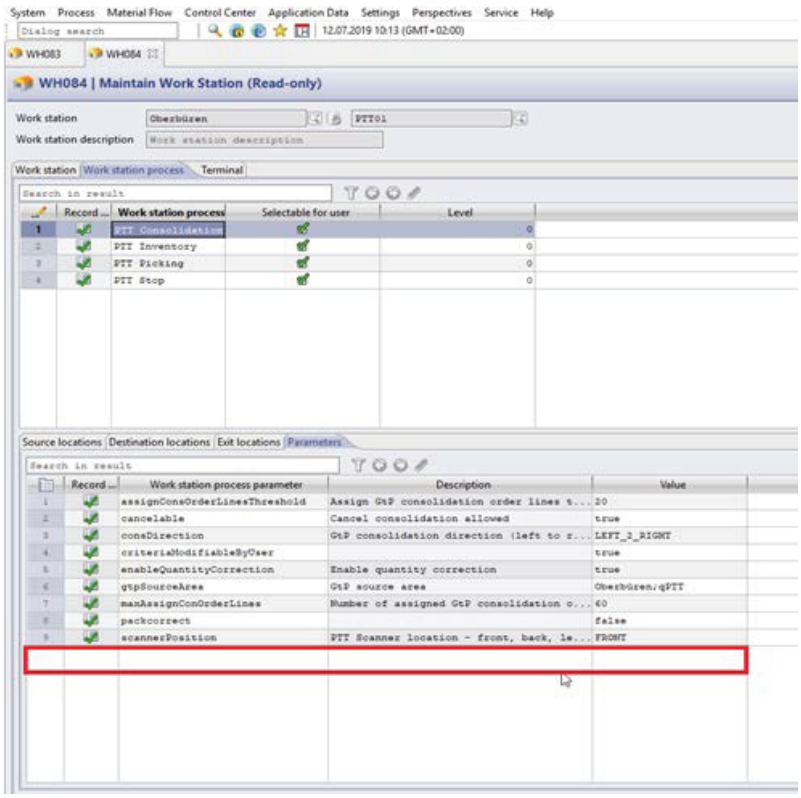

Figure 19: Work station[143]

Concluding it can be said that most of the functions for this e-grocery requirement work already in the WAMAS standard. Only some additional algorithms for considering different item classes for picking and for consolidating would need to be added to the standard solution.

[142]Source: Internal SSI Schäfer document
[143]Source: Internal SSI Schäfer document

This requirement is marked as “Can criteria" because most of its functions are already possible in the WAMAS standard and small adjustments for specific customer needs will always appear for an individualized software.

Transport management

Category: Can criteria
Requirement: Transport management optimization

Why it is needed?
A big challenge for e-grocers is deep frozen or chilled food, that needs to stay in cooled environment during all logistic activities. For B2B customers (e.g. stores) big cooling trucks are available. But there is only the possibility to use a whole cooling truck or not. For B2C customers (online customers) smaller trucks for more urban deliveries are needed. These small trucks are not cooled. Therefore, the delivered food is placed in thermo boxes including enough dry ice to cool down the food for the needed delivery time. For a better handling of the process of adding the dry ice it would be interesting of adding a function in WAMAS to calculate the needed amount of dry ice regarding environment temperature, humidity and delivery time.[144]

Existing functionality:
A workstation for deep-frozen and chilled goods for adding ice packs to the picked goods can be installed. The picked goods are transported to the ice pack station. A work order is created and performed by a worker. The delivered food is placed in thermo boxes and according to the selected partner of the outbound delivery, the needed amount of dry ice for deep frozen products and cooling gel-packs for chilled products is added into the boxes. Furthermore, a lid is added. The thermo boxes can be used for shipping now. Beside the calculation of needed amount of cooling material, the WAMAS standard fulfill the described requirement.

Adjustment in WAMAS standard:
The amount of dry ice is calculated regarding environment temperature, humidity, product type and delivery time to partner. The worker gets the information about the amount of dry ice shown on his screen when starting a work order. The worker adds the displayed amount inside the regarding loading aid, adds a lid and closes the work order.

This requirement is marked as “Can criteria" because the basic function of an ice pack station (a basic workstation in WAMAS) where dry Ice or cooling gel-packs are added is already possible in the WAMAS standard. The calculation of the added amount of dry ice optimizes the used amount of dry ice and cooling gel-packs but are not bringing any further benefit for a grocer process-wise.

[144] refert to Thomas Elsner (2019), In-depth interview.

5.4.2 Missing processes

There are yet some processes that are needed for e-grocery that are not yet covered by WAMAS functionalities. These processes will be also categorized in "Can criteria" and "must criteria" in the following section.

Adaption storage assignments

Category: Must criteria
Requirement: Dynamic order processing

Why it is needed?
Due to the possibility for end-customers to fill their shipping cart during a certain time-frames, order peaks during cut-off times appear. Furthermore, seasonal and event-driven peaks occur (e.g. football games). Always different products are needed the most. Hence, WAMAS standard should be able to handle these peaks better. That is also gained by changing slow-moving items to fast-moving items in short term during certain peaks.

Existing functionality:
In WAMAS items can be set from slow to fast moving items in dialog “MD002 Maintain Item” in Tab “Item ABC classification”. Items are assigned to picking locations which have also a specific ABC value. So, an item with a high ABC value is assigned to picking location with a similar ABC value. The connection between item and a specific picking location is made in a dialog called picking location assignment. Therefore, also the picking location assignment needs to be changed immediately for the newly chosen items when needed. Now it is only possible to change picking location assignments manually for each item and it must be checked if that the picking location is not occupied by another loading unit at the moment. If a picking location is occupied a transport order to another storage location needs to be created for the occupying loading unit manually.

Missing process:
For achieve a dynamic and fast handling of slow- and fast-moving items there is a two-step approach.

1. An additional dialog could be created for peak handling. In that dialog the ABC value for items can be chosen for a certain time span and automatically assigned to a corresponding picking location that is maintained for fast- or slow-moving items. The process is as following:
    - Each item is assigned to a corresponding picking location for the settime span.
    - All chosen occupied picking location are cleared automatically by creating transport orders back to high bay warehouse.

- After the set time span is over the picking assignment is cancelled and the picking locations are automatically cleared again. Transport orders to the high bay warehouse are created again.

For partly used pallets that are sent back to the high bay warehouse, a check is done if partly used pallets with the same item number are inside the high bay warehouse. If partly used pallets of the same item number are existing the two partly used pallets will be consolidated before stored the high bay warehouse at a workstation. This procedure is necessary to avoid a high number of pallets with a low filling degree inside the storage and the picking areas.

2. Especially in e-grocery items can be fast moving items only for specific occasions and therefore, a dynamic handling of changing slow to fast and fast to slow moving items with the corresponding picking location assignments is important. Hence, WAMAS needs to be able to integrate that information via the standard interfaces and perform the needed changes automatically. In order to retrieve the information summarized for all items from the customer, additional fields can be added in the stock adjustments telegrams. These fields include:

   - Item number
   - ABC value
   - Time span
   - $[Optional]$ Own algorithm for picking location assignments (0/1)
   - $[Optional]$ Picking location (if an own algorithm for choosing picking locations is used by customers of SSI Schäfer)

   Some parameters that could be used for an algorithm for choosing picking locations for items might be:

   For choosing the optimal picking locations:

   - Travel times within the warehouse for deciding which storage locations are used for fast-moving items

   For items:

   - Probability of access
   - Picks/orders per time
   - Item dimensions
   - Items classifications
   - Order size

This telegram is exchanged from WAMAS and the host ERP-System and the already installed process for peak handling as described above, is triggered.

Only if a customer prefers to use an own algorithm for deciding which item is at which picking location, a different process is triggered: In that case the items are assigned like in the actual dialog "OG024 picking location assignment". The difference is that it should be possible to automatically assign all the sent items in the stock adjustment telegram at once to the reported picking locations and to clear eventually occupied picking locations automatically. The ABC-value-logic from WAMAS and an own algorithm for assigning picking locations cannot be used together.

The optimizing of peak handling is also interesting for the e-commerce market in general. For certain occasions (Black Friday, Amazon Prime Day) certain items needs to be fast moving items also in other markets than food retail. That is why this requirement is a "must criteria".

Integration of pick-up stations

Category: Can criteria
Requirement: Connectivity

Why it is needed?
"A lot of e-grocers use pick-up stations as delivery model for their online customers. WAMAS can integrate pick-up stations, that are used during outgoing goods process. That connectivity would facilitate the process regarding calculation of delivery time, picking sequence, staging, buffering and consolidation on time." [145]

For the Click & Collect business model could integrate pick-up stations in WAMAS as further storage locations. The information about the capacity of a pick-up station can help WAMAS to decide to which pick-up station an order shall be sent. Also, if a customer defines a special pick-up station WAMAS can give the information at what time the pick-up station is available.

Existing functionality:
There is no present process for integrating SCE-systems like a pick-up station in WAMAS. In general, a normal storage location has also the information if it is occupied or not.

Missing process:
Pick-up stations would be like normal storage locations in WAMAS with the information if it is occupied and for which time frame it is already reserved. So, if an order is about to send to an end-customer, WAMAS can check the availability of pick-up stations and can reserve a pick-up station for the needed time frame. This check would be integrated in the shipment planning process from WAMAS. An own field in the OBD is showing the reserved pick-up station. WAMAS shares the actual information about occupied pick-up stations also with the

[145] Thomas Elsner (2019), In-depth interview.

host ERP-System of the grocer who can use this information to provide their end-customers real time information about where and when it would be possible to pick up an order. An end-customer receives an order from a pick-up station by using a common identification technology (e.g. bar code or numerical code). This triggers a message to WAMAS with the information which storage location is not occupied anymore. The pick-up storage location is then set on "not occupied" and can be used for further orders again.

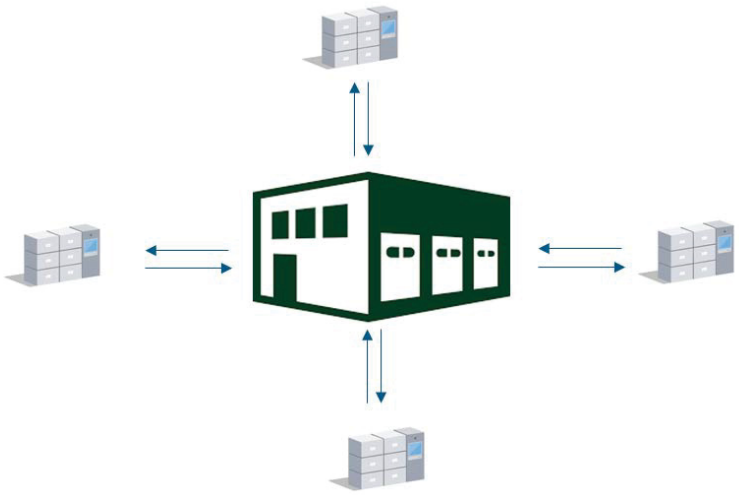

Figure 20: Integration of pick-up stations[146]

This requirement is marked as a "Can criteria" for WAMAS because in general routing and shipment scheduling is a TMS topic and not integrated in WAMAS. However, it would be a competitive feature for WAMAS for e-grocery business. Big players in e-grocery already use pick-up stations. Even they didn't find the right mix of customer relation, proper website/app and pick-up stations yet to meet the end-customer´s needs profitably and on a big scale.

5.5 Summary

Basically, WAMAS can fulfill all customer wishes. As it is an individualized software solution. Concerning the standard functionalities WAMAS also covers already a big range of WMS functionalities as you can see in the table 4 and table 5 in chapter "WAMAS in e-grocery, also important WCS functions are included. Automation device are therefore also included to handle in WAMAS Standard. However, it is in progress to integrate automation devices in WAMAS standard at the moment.

Each customer has different requirements and wishes for their WMS solution. It is impossible to cover all requirements exactly already in the standard as the customer wishes. Regarding further processes that are needed for e-grocery WAMAS Standard can basically fulfill them. But normally that is not enough, and further adjustments are needed due to specific requirements

[146]Source: Own creation

and functions claimed by the customer. Under certain premises most of the requirements from e-grocery can be fulfilled. But customer wishes would deviate from these cases. Adjustments that are often occur in e-grocery are order peak handling (consolidating and buffering), storage and picking in different temperature zones. In that topics WAMAS standard offers yet too static solutions, that are not sufficient for e-grocery requirements. Dynamic adaptations like in order management for adding and deleting order lines until a certain cut-off time. In WAMAS standard there is a straight way from shipment planning to picking and buffering. Decoupling of orders from this straight process would be needed.

There are only some trends that occur in e-grocery business that WAMAS cannot cover as needed for the market. More and more pick-up locations are used in e-grocery Click & Collect models. WAMAS cannot integrate pick-up locations. Also, the integration of MFC´s in one WAMAS instance going along with the connectivity between them like order consolidation and automatic replenishment is not covered in WAMAS standard functionalities yet. These functionalities can make a market advantage in future when more e-grocer have an omni-channel business with central warehouses for B2B and MFC´s next to urban areas to fulfill online orders.

Concluding it can be said, that WAMAS is still too static in the means of quick changes in processes. The software is very complex, and adjustments are not quickly to implement. On the other side the e-grocery market is very dynamic and changes quickly but anyway is demanding high performance. Easy solutions are wanted, that can be adapted quickly. For now, SSI Schäfer is addressing with WAMAS bigger players and companies. For smaller businesses or growing start-ups WAMAS needs to be simpler and easier to adapt to their requirements. The business solutions for e-grocery markets are not yet sophisticated enough for scaling up businesses also because of the high logistics costs. That's way pure e-grocer, which are normal smaller business or growing start-ups need to have simple and dynamic solutions.

6 Conclusion

After carrying out this market analysis about the influence of e-grocery on a WMS in the future it can be said that first-of-all e-grocery will be shaping the future of grocery shopping significantly. E-grocery is the fastest growing market for grocery and the target groups are potential customers that use technologies in all their life situations, also for purchasing food online. "Generation Z" and "Millennials" are the most important target groups for the moment. Generations to come will be even more and more used to technology. Willingness to buy food online rises each day. Challenges for grocers to provide proper business models are low margin of the business, high expectation of the customer towards fresh food and the offered value-added services combined with a still dynamic and growing market. Also, the willingness of the customer to pay more for getting grocery delivered is still not given. High last mile costs, especially for very short delivery time slots like same day or even one-hour deliveries, small order sizes and higher order frequency due to provided flexibility in placing orders are the biggest cost driver for grocers. These challenges need to be handled inside a warehouse, inside a WMS. The way to reduce this complexity for grocers that have also regular brick-and-mortar stores would be to offer only a part of their assortment or certain product types online. An important inside of this master thesis is that the above described challenges inside a warehouse and for WMS will not change in the future. These challenges will appear for whatever delivery variants of home delivery or click and collect. Due to the growing use of automation along the supply chain it will become easier to reduce the high logistics costs. From a customer point of view grocers need to deliver format, price, quality, convenience and selection in every interaction (functionality and design), no matter where it occurs. The right business model doesen't exist yet. The one with a specific delivery method and proper service model to reach the most customers and make the most profit.

Based on these results of the challenges and rise in the e-grocery market the requirments for a WMS in e-grocery could be worked out. There are some requirements that are also requirement for a WMS in e-commerce in general like the integration of automated systems or small orders handling. But there are more specific requirements that are only needed in the e-grocery market. Mostly due to the specific handling and storing of fresh and perishable food. Also due to the provided service models from e-grocers, like offering different time slots for the delivery.

It needs to be said, that it was not easy to gather information about what a WMS in e-grocery should provide. E-grocers are not willing to give interviews because this topic is too sensitive for them. So only the market research and the in-depth interviews with SSI Schäfer employees and expert knowledge from the product development and logistics consultants could be used.

Based on these research requirements for a WMS in e-grocery, the WMS (WAMAS) from SSI Schäfer could be analyzed.
Firstly, WAMAS can fulfill all customer wishes as individualized software. Provided standard solution however needs to be adapted to fulfill all wishes from e-grocers. Only under certain premises most of the requirements from e-grocery can be fulfilled. There are still missing functionalities regarding flexibility and e-grocery specific processes like advanced multi-warehouse functionalities and integration of SCE-systems. Especially for the topics like peak handling and dynamic order management e-grocery market is demanding more functionalities from the WAMAS standard. Regarding flexibility and dynamic processes WAMAS is still too static in the means of quick changes in processes. The software is very complex, and adjustments are not quickly to implement. On the other side the e-grocery market is very dynamic and changes quickly but anyway is demanding high performance. Easy solutions are wanted, which could be adapted quickly. For now, SSI Schäfer is addressing with WAMAS bigger players and companies with straight forward solutions with little degree of flexibility inside the standard solution. For smaller businesses or growing start-ups WAMAS needs to be simplier and easier to adapt to their requirements. The business solutions for e-grocery markets are not yet sophisticated enough for scaling up businesses also because of the high logistics costs. That's way pure e-grocer, which are normal smaller business or growing start-ups need to have simple and dynamic solutions.

Proposed solution for WAMAS standard would be to offer market sector specific solutions in a modular way. The goal would be not to constantly add functionalities to the standard and thus getting it more complex over the time. SSI Schäfer has different market sectors: fashion, food retail, food & beverages, healthcare & cosmetics and industry. All these market sectors need a certain set of basic functions from WAMAS. But each market sector has also specific market requirement for a WMS. These specific requirements could be split in modules that can be easily integrated in a basic software standard that is used for all sectors. Each market sector has the basic functions and additionally some advanced modules regarding specific market solutions. For all the market sectors that deals with e-commerce WAMAS needs to provide more dynamic solutions as already described above. For example, the dynamic order management. One module could be an advanced outgoing goods process. And if a customer that is not having e-commerce business also likes to have this dynamic order management module it is easy to integrate as well. With the described modular solution, the complexity of the software would go down and it would get more flexible for the customer.

Concluding the performed market research on e-grocery and the functionalities provided by WAMAS it can be said that WAMAS is providing all basic functions that will be adjusted for the specific customer wishes in nearly all the cases. And for e-grocery more dynamic processes and e-grocery specific adjustments and processes could be implemented.

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Appendix

.1 In-depth Interview 1

Interviewee: Thomas Elsner
Company: SSI Schäfer
Role: Team Leader IT Sales
Date: 07.06.2019

„How do you see the future of WAMAS in e-grocery“
Basically, for answering that question, it is important to distinguish between established companies and start-ups. Both has different requirements and different company structure. Established companies are more hierarchically structured whereas start-ups are more dynamic and more flat company structure. In the beginning WAMAS was made for food and beverage wholesalers with high quality standards. To ensure that it can take more time. WAMAS is also very complex and therefore not as dynamic as demanded from start-ups that want simple solutions and agile processes. The cyclomatic complexity of WAMAS should not exceed a number of 10 according to some start-ups, but in fact WAMAS has a much higher cyclomatic complexity, it exceeds 50. Here you can see the difference very much. Start-ups want easy software solutions with low complexity, that can be adopted easily and quick, the best if they can do it themselves as they have normally a very sophisticated IT knowledge. That ensures them to adopt to quick market changes and needs and let them have more agile processes. Therefore, SSI also adopt the software and the project management to meet also the demands from start-ups.

“Which differences do you see in the fulfillment strategies of e-grocers?”
Firstly, the big challenge for the customer of SSI in e-grocery is the high demand concerning quality of fresh food and delivery time. End customers in e-grocery demands a high quality and punctuality of their delivery. If the end customer is not satisfied by the fulfillment it is very unlikely that he would order again online at the same e-grocer. Secondly, e-grocers offer very different services to their customers. Some grocers offer all of their product portfolio from their stores also online and some offer only a certain product range, what makes it easier to handle logistic challenges. Also, the offered delivery services and times for their customers can range from order pick-up from certain pick-up points, direct home delivery to same-day or same-hour delivery in certain urban areas. Thus e-grocers have very different demands to meet.

"Concerning the WAMAS standard solution: Does the WAMAS standard solution covering all functions, that are needed by e-grocery customers? If not, which functions are not yet in the standard solution of the recent WAMAS software, which customers in e-grocery really need?" Yet the WAMAS standard solution for e-commerce customers in food retail is often not sufficient. Following functions would be interesting to integrate into the WAMAS standard solution:

- Order streaming (simultaneously order picking for stores and online customer)
  Now it is not possible to perform piece and case picking at the same picking location. That would be interesting when a food retailer delivers to stores and to online customers.

  Hence simultaneously picking of full cases and single pieces is needed. And for the reason, that the same item can be picked in cases or in pieces, it should be possible to do both procedures at the same picking location depending what is needed. Due to the combination of case and piece picking a lot of open load units, that can not be used for full cases anymore, stay at the picking location. That takes a lot of space. Therefore, also a proper replenishment strategy shall be integrated in WAMAS standard to avoid high stock at the picking locations.

- Transport management
  A big challenge of the e-grocers is deep frozen or chilled food, that needs to stay in cooled environment during all logistic activities. For B2B customers (e.g. stores) big cooling trucks are available. But there is only the possibility to use a whole cooling truck or not.

  For B2C customers (online customers) smaller trucks for more urban deliveries are needed. These small trucks are not cooled. Therefore, the delivered food is placed in thermo boxes including enough dry ice to cool down the food for the needed delivery time.

  For a better handling of the process of adding the dry ice it would be interesting of adding a function in WAMAS to calculate the needed amount of dry regarding environment temperature, humidity and delivery time.

- Consolidation
  In e-grocery different temperature zones for storing are needed. That is especially important concerning the outgoing goods process, when different items from different temperature zones needs to be consolidated for the same delivery.

  Thus, a consolidation process that considers different temperature zones just-in time, is needed in WAMAS.

- Concept of Micro fulfillment centers (MFC) or also called Dark stores
  More and more e-grocers use MFC´s to fulfill their customers order efficiently. For WAMAS it is an opportunity to integrate the model of MFC to handle the order management quicker by. When an order comes in WAMAS can direct the order either directly to the

MFC´s or to a central distribution center depending on shorter delivery times. Also, the replenishment of MFC´s could be integrated and be automated by WAMAS.

Therefore, WAMAS expand the multiple-warehouse functions concerning connectivity between different warehouse location concerning order management and replenishment between warehouses.

- Integration of additional SCE (e.g. pick-up stations)
  A lot of e-grocers use pick-up stations as delivery model for their online customers. WAMAS can integrate pick-up stations, that are used during outgoing goods process. That connectivity would facilitate the process regarding calculation of delivery time, picking sequence, staging, buffering and consolidation on time.
- Order management for order peaks E-grocers face the challenge of order peaks that are difficult to handle regarding picking and shipping. To facilitate that WAMAS should pre-picking orders and buffer them in the shipping buffer. Some e-grocers have an online basket, that can be filled until a certain deadline. During that time frame orders can already be pre-picked and placed in the shipping buffer. When the pre-picked LU is changing shortly before delivery, the prepared LU could be taken as return and decanted later. It could be faster to create a new picking order.

So WAMAS standard should be able to handle peaks better. That is also gained by changing slow-moving items to fast-moving items in short term during certain peaks.

"What is your conclusion concerning the future of e-grocery?"
E-grocers are now trying to find the best solutions to fulfill online orders. They specialize on different services and therefore there are best-in practice companies in some fields yet there is not "the one" solution found for e-grocery.

.2 In-depth Interview 2

Interviewee: Jakob Beer
Company: SSI Schäfer
Role: Director Business Development Sales
Date: 26.06.2019

„How do you see the future of WAMAS in e-grocery“
WAMAS is generally made for full case picking and is not basically made for piece picking. What is essential for e-commerce in general. But for omni-channel business WAMAS can be interesting when combining full case and piece picking. For example, when a grocer is running a central warehouse and micro fulfillment centers MFC (or dark stores). In that case WAMAS would run both the central warehouse and the MFC orders will be fulfilled at the location with the least last mile and handling costs. Also, a consolidation which combines both warehouse types will be interesting. A part of the shipping cart can be fulfilled by the central warehouse and shipped to the MFC where the very fresh products will be added.

“Which differences do you see in the fulfillment strategies of e-grocers?”
The same-day delivery is an actual trend which big companies like Amazon can provide. Same-day delivery has extremely high logistics costs and therefore only possible for companies that want to provide a special service. Still same-day delivery loss making business for grocers. But the trend for same-day delivery is growing and more and more companies will offer this service.

“Concerning the WAMAS standard solution: Does the WAMAS standard solution covering all functions, that are needed by e-grocery customers? If not, which functions are not yet in the standard solution of the recent WAMAS software, which customers in e-grocery really need?”
I see the WAMAS Standard as not representative for e-commerce in general. Also for automated processes the Standard is mostly not sufficient.

“What is your conclusion concerning the future of e-grocery?”
In the future when logistics costs decrease, sam-day delivery will be a must have for all e-grocers. In that case also the minimum delivery value will decrease. Which is used due to high logistics costs. In general grocers provide a delivery model with a minimum delivery value with an average of 30-40 order lines per order. In Asia the minimum delivery value is already much lower, and the orders include in average only 6-7 order lines.