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Requirements analysis:
Out of Stock System for Kaufland

Services Computing

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1 INTRODUCTION

This document represents the requirement analysis for a system that recognizes shelf gaps by means of optical recognition and informs the employees about them. In the first step, the implementation should be done in form of a prototype at the Herman Hollerith Zentrum in Böblingen. Since the project is being developed in cooperation with the supermarket chain Kaufland, there are several requirements that need to be considered for the system. As a basis, the second chapter describes the basic concept and framework conditions for such a system. This includes a presentation of the current situation of Kaufland and the intended target state. The last chapter shows the functional and non-functional requirements for the system.

2 CONCEPT AND FRAMEWORK CONDITIONS

2.1 General purpose

Kaufland would like to use technical resources to automatically detect out of stock situations and to inform the responsible employees with appropriate methods. An out of stock situation is referred to a shelf gap marked with a price label that is empty or not filled by enough products during the customer's stay.

Due to permanently filled shelves, the sales department expects growing customer satisfaction and increased sales. To solve the out of stock problem an optical detection is preferred. However, other options or a combination of several methods should not be excluded.

The figure below illustrates an out of stock situation. The areas marked in red show typical empty stocks. Products that are outlined in yellow will be sold out soon.

Figure 1: Out-of-stock situation

2.2 Stakeholders

The following persons / groups are involved in the project.

Stakeholder	Task	Description
The sales force/ warehouse power	Storage and clearing of products on shelves as well as price labelling	Use MDE devices to identify, check in and out products
Cashiers	Derecognition of products	Work with the POS system by which the products are booked out. The derecognized products are logged in the SAP system
IT department	Integration and maintenance of IT infrastructure.	Integrates new software/ hardware components into the existing IT infrastructure and takes care of the maintenance of the systems
Department Manager	Taking orders, planning	Monitors the processes and uses the SAP system to reorder products
Headquarter	Sales planning of products with occupancy in a retail store (fine occupancy plans)	Determines which branded products are placed in which shelf space
Customers	Shopping	Take the products from the shelves and put them back during their purchase. A false occupancy can occur by placing the product on the wrong shelf space

2.3 Environment

2.3.1 IT-infrastructure

Kaufland has several central data centres, which are all connected to several stores. A data centre contains servers with an SAP and SIB system. These are connected through the firewall with the client devices such as cash register system, scales, printer, mde, computers, etc. Each of these devices is addressable via an IP. For security reasons, the devices are divided into different security groups. For example, the cash register system is classified as the highest level of security and the scales or printers are assigned to a low security level. Furthermore, each store has its own local server. The figure below illustrates the IT-infrastructure.

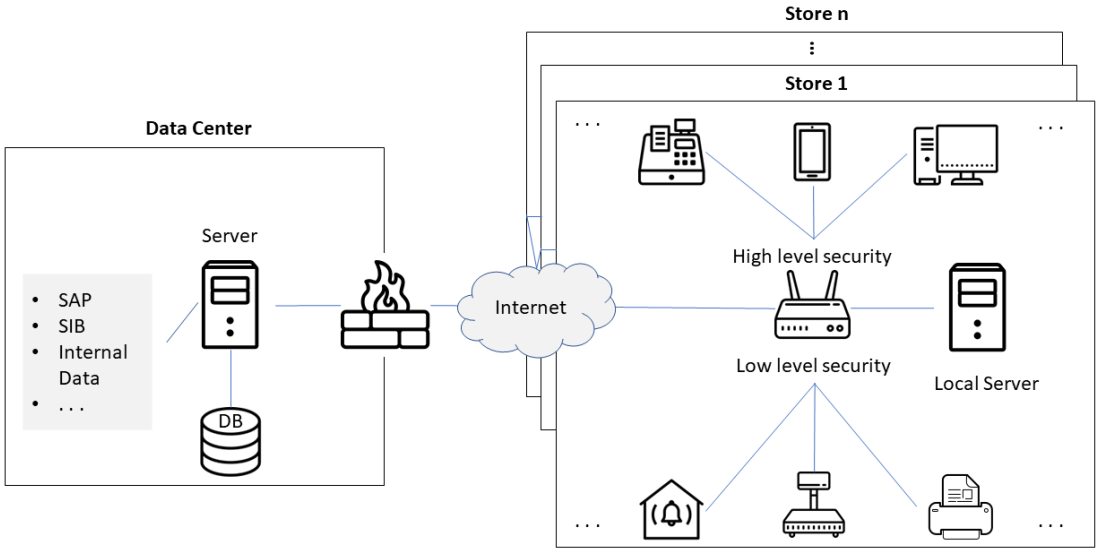

Figure 2: Kauflands IT - infrastructure

Limitations:

- Low data transfer rate between the central data centre and the stores
- Low computing power

2.3.2 Store environment

All Kaufland stores have similar structures and shelf styles. They often only differ in the sales area and number of floors. At the entrance there is always an informational desk for the customers. After that customers can find a fruit and vegetable sales area followed by a bakery sales area. Then cereal products are offered on the shelfs. Fresh goods, frozen and dairy products are always placed adjacently. The household and stationery articles can be found in the middle of the store. Beverages and care articles are often set up in front of the cash registers. The following figure shows a rough structure of the Kaufland store in Stuttgart-Vaihingen.

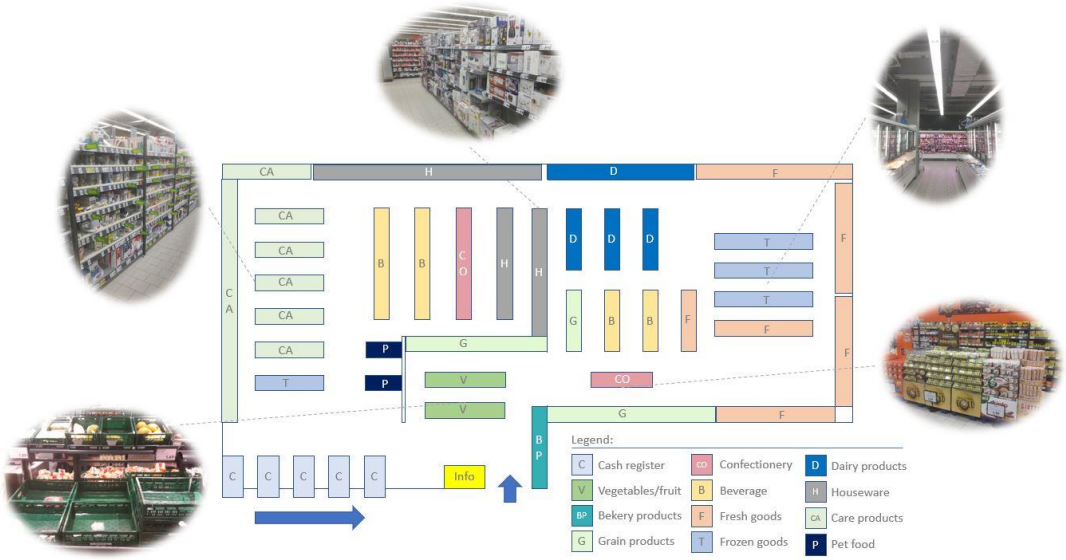

Figure 3: Store environment in Stuttgart-Vahingen

Product packaging and placement:

- Several articles in plastic boxes or cartons (e.g. fruit and vegetables)
- Single articles on shelves (e.g. alc. beverages, household goods)
- Single articles in series in open refrigerated shelves (e.g. sausage and cheese)
- Single articles in series in closed refrigerated shelves (e.g. minced meat)
- Single articles in closed freezer (e.g. fish, prepared meals)

2.4 Current state

To understand Kaufland's current out of stock process we need to have a look at the whole logistics processes. At the very beginning different suppliers deliver their products to Kaufland's central warehouse where they are measured and palletized. Kaufland's headquarter determines the mapping of the products to the single stores by means of detailed plans. After that allocation the products are delivered to the respective stores at night. At the arriving there, the products are recorded digitally in an SAP system and directly placed on the sales area. Remaining products are stored in the warehouse for later needs. Every time a product is sold the stock is updated in the SAP system. This works hand in hand with a cash register system. Due to that stocktaking, some products can be reordered automatically. Kaufland also uses mobile devices (MDE) that hold all product master data. With their help barcodes can be scanned and products can be ordered manually. To check if products on the sales area need to be replenished, employees walk through the corridors and look for shelf gaps. If some are detected the employees restock the products by hand.

2.5 Problem statement

The way Kaufland handles out of stock situations right now leads to several problems. Currently employees are checking which products need to be replenished by walking through the store from time to time. This means that vacancies are not always detected immediately. As a consequence, customers can't buy what they are looking for and Kaufland suffers losses. Unavailable products result in customer dissatisfaction which might even lead to a loss of customers. Furthermore, the current out of stock process requires a lot of work capacity. Improving this process could lead to staff savings and therefore to cost savings for Kaufland.

2.6 Target state

Kaufland desires a better solution regarding their out of stock process. Vacancies should be detected in time so that the products can be replenished before they are completely sold out. The goal is to reduce losses due to unavailable products. Moreover, a higher customer satisfaction is expected as well as staff savings. For an improved out of stock process a technical solution is required that detects shelf gaps and out of stock situations automatically and informs employees about the vacancy. Additionally, the system should be able to show products and price tags

that are out of place. To implement these requirements different technical approaches are conceivable. However, Kaufland prefers an optical solution. In this field there exists a range of possibilities that reach from the use of simple cameras to the use of smart deep learning algorithms. All of these solutions have advantages as well as disadvantages and not all of them are suitable for Kaufland. To find out which optical solution fits best for the company the logistics processes as well as the store structures need to be considered. Furthermore, it would be beneficial to use resources that are already available and combine them with the optical solution.

2.7 Available resources

Resource	Functionality	Description
SAP	Stock management	Available products are recorded, missing products can be automatically reordered
Cash register system	Stock management	Records sold products and sends information to SAP system
Mobile devices (MDE)	Holds product master data	Can be used to scan barcodes and order products manually
Further devices		All devices in a store e.g. printer, scale etc. have their own IP address and can be connected to WIFI
Local server	Internal data exchange	Hosting of software for the optical recognition

2.8 Scope

The optical out of stock solution should be able to detect shelf gaps automatically. Moreover, it should detect products and price tags that are out of place or out of use. As soon as one of these situations occur employees should be informed about it. This way they can replace missing products fast as well as undo misplacements. The out of stock solution doesn’t have to be able to restock products. It should be limited to optical recognition. Employees will still be needed.

3 REQUIREMENT DESCRIPTION

3.1 Functional requirements

This chapter explains the functional requirements for the Out of Stock System, which represent a description of what the system should do or be able to do. In other words, these are the basic functionalities that a user expects from the system in order to use them to solve a problem.

The functional requirements are divided into two sections. The first section contains general functional requirements that are mandatory regardless of the technical implementation. In the second section, extended functional requirements are raised that are desirable but cannot be fulfilled by all possible implementations due to technical limitations. An example of this would be a depth camera, which can be used to determine shelf gaps but not for product identification.

3.1.1 General requirements (mandatory)

The main functionality that the implemented system shall provide is the detection of gaps or free spaces between products using optical detection. This is preferred to other solutions for out-of-stock detection, as further systems should be built on this basis. The system must be able to identify the shelf placement so that the identified gap can be processed and forwarded. For this purpose, a digital site plan should be integrated into the system.

Every time a shelf gap is detected, an entry should be created in a database so that the entire history can be traced. Based on this, it should be possible to generate reports for daily, weekly, monthly and annual periods. Furthermore, an algorithm for predicting shelf gaps is to be developed, whose data mining model will be trained using this database.

If a gap in the shelf or a low stock is detected, the corresponding product is identified using the digital site plan (or the product identification - see extended functionalities). Through a connection to the ERP system, it should be checked whether the product is still available in the warehouse. If yes, the system sends a push notification to an endpoint, which is realized by a mobile device or a fixed information point with a graphical user interface. The notification is made visually and by vibration or ring tone. The target group for the operation of the endpoint are the employees who are responsible for replenishing the shelves.

The graphical user interface should display a list of the replenishment orders which are to be processed. By pressing a button, the employee sets the status of an order to "in progress". This is synchronized with the other endpoints via the backend system. The other employees thus see that the order is already being processed, which avoids any confusion. As soon as the employee has replenished the product, he sets the status of the order to "completed" by pressing the corresponding button.

3.1.2 Extended requirements (not possible for all implementations)

The extended requirements provide additional functionalities that cannot be implemented by all possible implementations of the basic requirements.

The main extension is that the product can be identified directly by the optical recognition, without the need to consult the digital site plan. The recognition should therefore be based on the shape, size and colour of the product. This allows further functionalities to be realized, such as the recognition of misplaced positions or incorrect labelling. A further functionality would be the automated creation of a digital site plan.

Another possible extension is the recognition of the exact number of products at a shelf position. This would allow better inventory management to be achieved through a connection to the ERP system, since store stock (warehouse plus shelf) and shelf stock can be stored separately in a database. An exemplary entry in this database would be:

ProductID	Amount-Store	MinimumAmount-Store	Amount-Shelf	MinimumAmount-Shelf
Snickers	50	20	20	8
Mars	60	20	15	8

The advantage of this would be that employees could replenish the products with a small amount of shelf stock before rush hours or when they have little to do.

3.2 Non-functional requirements

After the functionalities of the system have been described, the non-functional requirements are used to define how they must be achieved. For example, requirements are made for the quality and time behavior of the system, which are the framework conditions for the functionalities.

3.2.1 Usability

In order to describe the usability as a non-functional requirement, the most important aspects required to fulfil the user's goals are considered. The system to be implemented should provide requirements in understandability, ease-of-learning, operability, attractiveness and accessibility to ensure appropriate use.

For the **understandability** it is particularly important that the system can be operated intuitively by the employees. This requirement should be considered especially in the presentation layer of the system, as this is almost the users only contact point with the system. In order to successfully implement the understandability and thus the intuitive operation of the system, every employee should be able to do his work without complicated instructions.

Another important aspect of the usability is the **ease of learning.** The system should be designed in such a way that the training or instruction of new employees in working with the system is as simple as possible. The aim of this requirement is to enable low-cost trainings. This will save many resources during the change to the new system, especially at the training of the old employees. In addition, short-term employees can be quickly deployed without major effort.

Furthermore, requirements regarding the **operability** should be observed. Here a barrier-free operation of the system should be guaranteed. In order to fulfil this requirement, the operation of the system should be adapted to the working environment of the employees. Since the employees wear gloves when filling the shelves to protect them from cuts that can occur when cutting the pallets, it is a great advantage if the end-devices of the system can also be operated with these gloves. This makes the work more efficient and avoids unnecessary removal of work equipment.

The **presentation** layer of the system, especially the presentation on the end devices, should also correspond to a modern design. This enhances the attractiveness of the system and further facilitates the intuitive operation of the system. The design can be based on currently known and widely used applications. The recognition value thus additionally facilitates the usage.

Accessibility also plays a huge role for usability requirements. Since the employees are constantly on the move and are responsible for filling the shelves in larger areas, the mobility of the system is very important. The employees should be able to receive notifications about gaps in the shelves anywhere in the store. This can be implemented, for example, by extending the MDE units that employees carry with them.

3.2.2 Reliability

An important aspect in the definition of non-functional requirements is the reliability of the system. To describe the reliability, we consider requirements for maturity, exactness and recoverability.

Maturity describes the frequency of system failures. Such failures can be initiated by both the software and the hardware. The software should be developed in such a way that as few logical errors as possible can occur that could lead to system failures. Furthermore, the choice of hardware should be made as reliably as possible. The battery life and a secure internet connection within the store should be taken into account, for example, with the MDE devices. This ensures a reliable continuous data exchange between the system and the employees.

The **accuracy** of the detection of gaps in the shelves should be maximized by various aspects. The notification of employees about probably implausible optical recognition results can initially be withheld until they are confirmed in another inspection process or diagnosed as an error. To identify implausible results, an algorithm can be applied which, for example, questions a completely empty inventory that was completely full five minutes ago and retains the result until the second check. This avoids unnecessary walking of the employees to a false report. If a gap that does not exist is still reported by the optical recognition system, the employee can delete the false report via the MDE unit and initiate error handling. In another scenario, the optical system does not recognize an existing gap in several test runs. In order to avoid such a vacancy, the employees should check the shelves manually at times despite the optical recognition. If the employee finds a gap in the shelf that has not been detected by the optical recognition system, this can be recorded and reported again via the MDE unit.

In case of a complete failure of the system, the recorded data should be retained. For this purpose, requirements are specified for **recoverability**. Even after a failure, it should be possible to restore the system's data stock. This can be realized for example by periodic snapshots.

3.2.3 Efficiency

Time behaviour and resource utilization of the system are considered to define the requirements for efficiency.

The system should at least exceed the manual inspection time when detecting gaps in shelves. In the best case, the gap or lack of stock of a product in the shelf is detected directly. However, having the optical system constantly checking the shelves would be inefficient. It is therefore sufficient to detect and eliminate the lack of stock until the next customer arrives. Based on the estimate that every

five minutes a customer is interested in a product, the process of gap detection from employee notification to filling should not take more than five minutes.

Efficiency is also important considering the usage of bandwidth. Since resources are limited, optical recognition should access local resources first. Data exchange via the intranet or the Internet cannot be completely avoided but should be minimized in this order.

3.2.4 Performance

The operation of optical recognition generates a large **amount of data.** This data must be stored in order to continuously improve the algorithms and also to develop new algorithms or train data mining models on the basis of this data. Therefore, a database system is necessary that can store such a large amount of data quickly and reliably. Depending on the implementation, either the current DBMS can be used, which is extended for the purpose of optical recognition. If the current DBMS does not correspond to the requirements, for example, a new NO-SQL DBMS with better performance could be built.

In addition to storing data efficiently, the system should also enable **efficient data analysis**. The data analysis depends on the design of the database, which collects the data from the optical recognition. In case of a classical data warehouse OLAP techniques can be used or data exploration and big data tools are implemented for an unstructured storage.