Task – Warehouse Management System Design

Functional requirements

A warehouse management system provides logistics support to manage the flow of items and assets in, and across, warehouse storage facilities in an e-commerce company (e.g. Amazon).

The following list of responsibilities provides a brief overview of core functionality of the warehouse management system:

- *Stock management*: For each type of product, the warehouse management system maintains relevant master data, such as the product's name, its description, and the available stock. For each individual product, the system maintains data necessary for correct and efficient order management, such as its sell-by date, its current storage time, and, most importantly, where in the warehouse the actual item is stored.
- *Order management*: The warehouse management system receives two types of orders:
  - *Customers orders*: The company website can submit shipping orders for a specific customer. For orders, the system must first check if the ordered types of products are available in the ordered quantity. If they are, the second step is to decide from where in the warehouse to fetch the item. This decision typically is based on the information the system maintains about each product, such as its sell-by date. Finally, the order management functionality generates specific transportation orders to fetch each product from the warehouse and transport it to a designated shipping destination for further handling.
  - *Suppliers orders*: Suppliers can submit orders through an interface to the warehouse management system. The orders could be replenishment orders for certain product types, and announcements of future receipts and shippings. The order management functionality prepares the corresponding transportation orders, for example by reserving appropriate amount of physical storage and transportation facilities, and schedules them for execution at the designated time.
- *Shipping*: Products fetched from the warehouse must be collected and prepared for shipping, which includes tasks such as quality and quantity checking, updating all master and individual data for the products to be shipped, packing, and printing packing slips. A special task in the context of shipping is picking: a certain quantity of a products is picked manually or automatically from a box or container that contains more items than needed. This task includes the selection of the box or container from the warehouse, its transportation to the picking station, all updates of the master and individual data of the relevant products, and the transportation of the box or container with all remaining products back into its correct location in the warehouse.
- *Receiving*: Products that arrive at the warehouse must be prepared before being stored, which involves unpacking, quality and quantity checking, and entering or updating all master and individual data for the products received. Once prepared, transportation orders are created to store the products in the warehouse.
- *Material Flow Control*: A transportation order for a specific quantity of products created by the order management functionality only specifies the target storage, destination storage, the transportation unit containing the items, and information about the items themselves. However, moving the transportation unit from the target storage to the destination storage can involve multiple legs, each of which can be executed by different transportation facilities. For example, a pallet of boxes could be fetched from the

warehouse gates by a forklift truck and transported to a transfer bin, from where a stacker crane picks it up to store on a high rack. Decomposing transportation orders into legs, assigning appropriate transportation facilities to each leg, and monitoring the execution of all legs is one responsibility of the material flow control functionality. Optimizing the entire material flow within the warehouse to achieve an optimal throughput is the other. The material flow control functionality sends concrete transportation instructions to the respective automation hardware, and receives acknowledgements and status messages in response. The automation hardware includes several devices such as convey belts, stacker cranes, and HCI devices (e.g. tablets).

- *Topology management*: All physical storage in a warehouse, such as different types of bin and high rack, as well as the available transportation facilities such as forklifts, conveyor belts, and stacker cranes, is arranged in a warehouse topology to ensure proper and effective warehouse operation. For example, high racks are organized with respect to aisles and sides in an aisle, and each aisle is associated with one or more stacker cranes and transfer bins from which the stacker cranes can pick up transportation units. The storage in a warehouse is also partitioned according to various storage organization criteria, such as storage for hazardous items, or items that require a certain storage temperature. The system dynamically assigns cartons to divert locations based on defined sortation algorithms.
- *Reporting*: Operational screens (graphical user interface) and functions to facilitate efficient control and management of the distribution warehouse. The screens provide progress and status of each order. In addition, the system can generate weekly, monthly and yearly reports about orders, shippings, and material flow.

Non-functional requirements

Portability. The system must run on multiple hardware and operating system platforms. Windows is typically the prime choice for user devices, while UNIX or Linux is the most likely for machines hosting core functionality. Similarly, the system must be able to use different databases, for instance, Oracle and SQL Server.

Maintainability: The logic and algorithms of topology management need to be flexible to changes by non-technical people. Managers will be able to design different sequences for topology management.

Performance: The retrieval of data storage for stocks and orders need to be efficiently retrieved from different distributed databases.

Constraints

The current data infrastructure is distributed in different locations. For example, the stock data is stored in 3 different databases, while the orders and materials are remotely located.

Task goal

The architect would like to design and decompose the logical architecture of the system. The logical architecture specifies the components of the system, and their relationships. In the current stage, it is not required to specify neither the physical architecture (system components and deployment on servers) nor the technologies.

Propose and model a logical architecture for the system, which fulfils the requirements and constraints. In your design, specify and justify the components, their relationships, and the different architectural solutions (e.g. patterns), which you used in your design.

To perform your task, follow the following steps:

1) Identify possible components of the system and their dependencies. A component could be a user interface component, a database or a processing component.

2) **Use the following solutions to structure the system**:
    a. Service-oriented architecture pattern.
    b. Blackboard architecture pattern.
    c. Data-replications performance architecture tactic.